COMPETE

Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States

Annex 3 to

COMPETE Final Report

Country reports on congestion and delay measurement and their assessment in the EU and the US

Version 5.0

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Contents

1 Introduction

This document contains country reviews for the 25 EU Member States, Switzerland and the US on the measurement, state and perspective of congestion and delays in all modes of transport. The country dossiers are ordered according to their number of inhabitants, starting with the US as the largest individual state as presented by Table 1-1.

The country reports generally follow a standard structure going along modes (inter-urban road, rail aviation, waterborne transport) and within each mode along the four basic research questions:

- Measurement of traffic demand and traffic conditions
- Current situation of congestion and delays
- Forecast of traffic conditions and delays
- Policy plans to improve traffic conditions.

The country reviews form the basis for identifying best practice of congestion and delay monitoring, to derive recommendations for a harmonised approach for Europe and to draw a Panorama of Congestion comparing Europe to the US. A summary of the methods for estimating congestion costs, of the situation in the individual countries and of the literature reviewed is presented in detail in Annex 2 and in brief in Chapter 3 of the main report of the COMPETE study.

The reviews of individual countries are supplemented by specific case studies on European and US airports and seaports. Due to their wider geographical scope and modal focus these case studies are part of Annex 2 of the COMPETE final report.

Table 1-1: Work progress by country

Country	Code	Inhabitants (1,000) in 2005	Chapter
United States	US	296,404	2
Germany	DE	82,501	3
France	FR	60,561	4
United Kingdom	UK	60,035	5
Italy	IT	58,462	6
Spain	ES	43,038	7
Poland	PL	38,174	8
Netherlands	NL	16,306	9
Greece	GR	11,076	10
Portugal	PT	10,529	11
Belgium	BE	10,446	12
Czech Republic	CZ	10,221	13
Hungary	HU	10,098	14
Sweden	SE	9,011	15
Austria	AT	8,207	16
Switzerland	CH	7,415	17
Denmark	DK	5,411	18
Slovak Republic	SK	5,385	19
Finland	FI	5,237	20
Ireland	IE	4,109	21
Lithuania	LT	3,425	22
Latvia	LV	2,306	23
Slovenia	SL	1,998	24
Estonia	EE	1,347	25
Cyprus	CY	749	26
Luxemburg	LU	455	27
Malta	MT	403	28

2 United States

2.1 Overview

The average American does not perceive congestion as a major problem. The mean one-way commute has remained below a half-hour for decades. Abundant land and relatively cheap fuel (even in these times of >$3.00/gallon gasoline) mean that firms and households always have the option to relocate to less congested areas within the same metropolitan region, or to another region altogether. Relatively uniform laws, customs, and cultures make interstate relocation in the United States far easier than international relocation within the EU. These factors and others are reflected in the fact that, as the National Household Travel Survey showed for 2001, only 28% of respondents cited congestion as a major or severe problem; even in large metropolitan areas (>3 million), only 39.5% of respondents cited identified congestion as such (FHWA/FTA 2006).

However, congestion has worsened considerably in the past two decades. Between the 1990 and 2000 Censuses, the mean one-way commute increased from 22.4 to 25.5 minutes.[1] In the nation's twenty most congested urban areas, as determined by the Texas Transportation Institute for 2002, congestion cost $50 billion in terms of wasted time and fuel alone. Nationally, the percentage of travel undertaken in congested conditions in urban areas increased from 21.1% in 1987 to 30.4% in 2002, while congested ("rush hour") periods increased from 5.4 to 6.6 hours per day over the same span. Interestingly, it was small and midsized urban areas—defined as those with metropolitan populations between 500,000 and 3 million—that experienced the biggest increases in congestion. Whereas those regions with populations over 3 million saw a roughly 20% increase in average annual hours wasted to congestion, wasted time roughly tripled for those in the small and midsized urban areas (FHWA/FTA2006). This suggests that the ability to relocate in order to escape congestion may have diminished.

Economic restructuring and globalization have vastly increased the volume of international trade. As a percentage of US GDP, the sum of net exports and imports increased from 16.8 % in 1991 to 25.0% in 2001.[2] The U.S. is the world's largest maritime trading nation; the value of water-borne goods shipment exceeds all other modes of transport of international merchandise freight, accounting for about 37% of all US international merchandise trade value (Bureau of Transportation Statistics, 2001). Freight flows by all transportation modes have increased. Total US ton-miles of freight increased from 2,421 billion in 1993 to 3,138 billion in 2002 (Bureau of Transportation Statistics 2006). Truck and air transport have increased faster than other modes, with trucks carrying about 80% of all domestic freight in terms of value.[3]

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1 http://www.census.gov/prod/2004pubs/c2kbr-33.pdf

2 Bureau of Economic Analysis (http://www.bea.gov/), using chain-weighted real GDP figures.

3 http://www.bts.gov/publications/national_transportation_statistics/2005/html/table_03_07.html

The following sections examine the state of congestion, and ongoing or proposed policy responses to it, for highways, rail freight, ocean shipping, and transit.

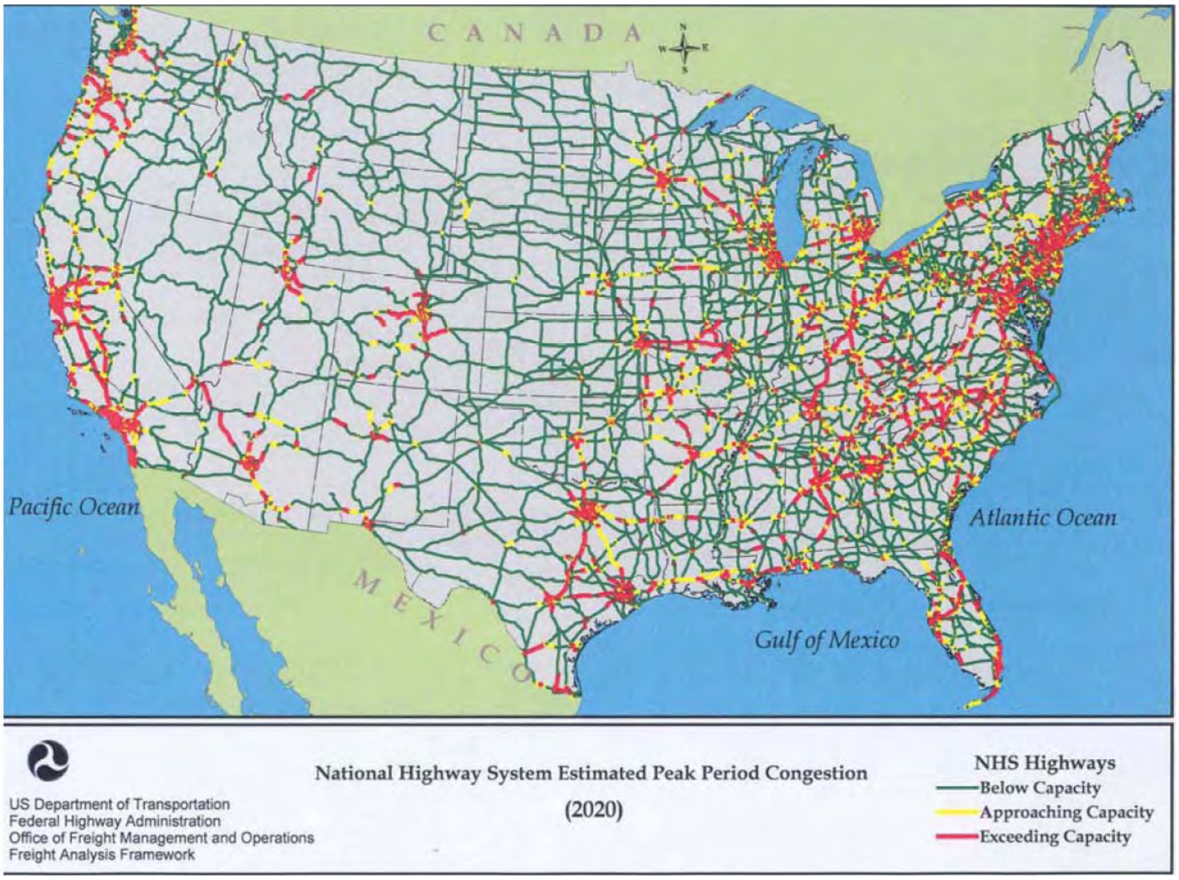
2.2 Highways

Various factors have contributed to the rapid geographic expansion of most American urban areas over the past three decades, resulting in enormous increases in demand for private vehicle travel. Simultaneously, advances in information technology, globalization, economic restructuring, distributed production systems, and "just-in-time" methods of manufacturing and distribution have fueled a surge in demand for truck travel, as well. For goods movement, congestion costs tens of billions of dollars each year: a conservative estimate of the annual direct cost of recurring truck congestion caused by bottlenecks at highway interchanges and on arterial roads is $7.8 billion (Cambridge Systematics 2005). Table 2-1 presents time losses by location and type of delay and Figure 2-1 provides an overview of the potential evolution of bottlenecks until 2020.

Table 2-1: Truck hours of delay by highway freight bottleneck

Bottleneck Type			National Annual Truck Hours of Delay, 2004 (Estimated)
Constraint	**Roadway**	**Freight Route**	
Interchange	Freeway	Urban Freight Corridor	123,895,000
			Subtotal **123,895,000***
Steep Grade	Arterial	Intercity Freight Corridor	40,647,000
Steep Grade	Freeway	Intercity Freight Corridor	23,260,000
Steep Grade	Arterial	Urban Freight Corridor	1,509,000
Steep Grade	Arterial	Truck Access Route	303,000
			Subtotal **65,718,000‡**
Signalized Intersection	Arterial	Urban Freight Corridor	24,977,000
Signalized Intersection	Arterial	Intercity Freight Corridor	11,148,000
Signalized Intersection	Arterial	Truck Access Route	6,521,000
Signalized Intersection	Arterial	Intermodal Connector	468,000
			Subtotal **43,113,000‡**
Lane Drop	Freeway	Intercity Freight Corridor	5,221,000
Lane Drop	Arterial	Intercity Freight Corridor	3,694,000
Lane Drop	Arterial	Urban Freight Corridor	1,665,000
Lane Drop	Arterial	Truck Access Route	41,000
Lane Drop	Arterial	Intermodal Connector	3,000
			Subtotal **10,622,000‡**
			Total 243,032,000

Source: Cambridge Systematics 2005



Source: Cambridge Systematics 2005

Figure 2-1: Potential highway bottlenecks 2020

Increasing congestion reduces travel time reliability, as well as adding to travel time. Firms seek to minimize the time product is held before being sold (e.g. "just-in-time" manufacturing practices). Reduced reliability or increased transit time must be compensated by increased inventory, adding significantly to production costs.

The Interstate Highway System construction program effectively ended with the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Planning for new highways is the responsibility of states and metropolitan areas. In central cities and inner suburbs, where congestion problems are most severe, adding highway capacity is nearly impossible due to environmental concerns, lack of right-of-way, regulatory constraints, and opposition of local residents. ISTEA linked transportation planning with air quality planning, requiring regional transportation plans to be in conformity with air quality plans. For metropolitan areas that do not meet federal air quality standards—including fast-growing regions like Los Angeles, Houston, and Atlanta— transportation plans must contribute to reducing vehicle emissions. This makes it quite difficult to add highway capacity, even in the peripheral developing suburbs.

Stagnant fuel tax revenues add another difficulty. Historically the US Interstate Highway System was funded by an earmarked fuel tax. The buying power of the fuel tax has declined, and there is no political support to significantly increase it. States and localities have consequently turned to other funding sources—sales taxes, revenue bonds, federal loans, and highway tolls—to fund road maintenance and expansion. There is growing use of innovative financing for infrastructure, including public-private partnerships to build facilities (both expansions of existing routes and all-new roads), and even a few private highways. SAFETEA-LU, the most recent transportation authorization bill (passed in August 2005), encourages such innovation. There are planned "demonstration projects" to convert underused High Occupancy Vehicle (HOV) lanes to High Occupancy Toll (HOT) lanes that charge congestion-dependent prices to single-occupancy vehicles, allowing more efficient use of existing highway mileage. State transportation agencies have also proposed truck-only toll (TOT) lanes as part of freeway reconstruction projects in badly congested areas such as Atlanta and Los Angeles.

2.3 The urban mobility study

The Urban Mobility Report is carried out annually on behalf of the US Department of Transport, Federal Highway Administration (FHWA) for a sample of 85 urban areas. These are grouped into 13 very large, 26 large, 30 medium sized and 16 small areas. For each sample city the study determines a number of mobility-related indicators by modelling recurring and incident-related delays.

Congestion estimates are restricted to pre-defined peak periods lasting from 6:00 – 9:30 am and from 3:30 to 7:00 pm. This period is assumed to carry 50% of daily traffic. The real prevailing condition in off-peak is not considered by the study indicators. The reference speeds for delay estimates are 60 mph (96 kph) on freeways and 35 mph (56 kph) on major streets.

Recurring delays are computed from vehicle traffic per lane and traffic speed equations for peak hours using network inventory and traffic density data mainly from FHWA's Highway Performance Monitoring System (HPMS) and from the states. Real speed measurements are not used as most cities do not provide such data in sufficient quality. However, the database of speed records is currently improved in many agglomerations by the Federal Highway Administration's Mobiity Monitoring Programme (TTI/CS 2004).

Incident-related delays are computed from recurrent congestion by incident-delay-ratios for freeways and for principal arterial streets. The incident-delay-ratios for freeways are determined site-specific by detailed incident statistics. The ratios range from 0.6 for San Diego to 2.5 for Pittsburgh and others. For principal arterial streets the incident delay ratio is set to a country-wide constant of 1.1 as here local differences are not that striking.

The Indicators computed are:

- Total annual travel delay (hours) = the daily number of vehicle-hours of delay times 1.25 persons per vehicles times 250 working days.
- Annual delay per traveller (hours) = Total annual travel delay divided by the number of inhabitants.
- Travel time index (TTI) = the weighted average of the ratio between travel rates (h/km) in peak and in free-flow conditions relating to all delay purposes.
- Excess fuel consumption (gallons): Average fuel economy in congestion (gallons/km) = 8.8 – 0.25 * Average peak period congested system speed (mph). Total fuel wasted =

total daily travel delay, average peak period system speed times average fuel economy.

- Congestion costs (US$) consists of the three components passenger vehicle delay costs, passenger vehicle fuel costs and commercial vehicle operating costs.
- Delay (hours) and congestion costs (US$) saved by operational treatments
- Delay (hours) and congestion costs (US$) saved by public transportation

For all indicators rankings among the 85 areas are given. Annual delays per traveller and the travel time index are tracked from 1982 to 2003. Table 2-2 shows the results of the two main indicators “Annual delay per traveller” and “Travel time index” for 2003 across all 85 areas.

Table 2-2: Key mobility measures in US cities 2003

Urban Area	**Annual Delay per Traveler**		**Travel Time Index**	
	2003 Value	**Rank**	**2003 Value**	**Rank**
85 Area Average	**47**		**1.37**	
Very Large Average	**61**		**1.48**	
Very large (13 areas)				
Los Angeles-Long Beach-Santa Ana, CA	93	1	1.75	1
San Francisco-Oakland, CA	72	2	1.54	3
Washington, DC-VA-MD	69	3	1.51	4
Atlanta, GA	67	4	1.46	5
Houston, TX	63	5	1.42	6
Dallas-Fort Worth-Arlington, TX	60	6	1.36	19
Chicago, IL-IN	58	7	1.57	2
Detroit, MI	57	8	1.38	12
Miami, FL	51	13	1.42	6
Boston, MA-NH-RI	51	13	1.34	21
New York-Newark, NY-NJ-CT	49	18	1.39	10
Phoenix, AZ	49	18	1.35	20
Philadelphia, PA-NJ-DE-MD	38	27	1.32	25
85 Area Average	**47**		**1.37**	
Large Average	37		1.28	
Large (26 areas)				
Riverside-San Bernardino, CA	55	9	1.37	14
Orlando, FL	55	9	1.30	28
San Jose, CA	53	11	1.37	14
San Diego, CA	52	12	1.41	8
Denver-Aurora, CO	51	13	1.40	9
Baltimore, MD	50	17	1.37	14
Seattle, WA	46	20	1.38	12
Tampa-St. Petersburg, FL	46	20	1.33	23
Minneapolis-St. Paul, MN	43	22	1.34	21
Sacramento, CA	40	25	1.37	14
Portland, OR-WA	39	26	1.37	14
Indianapolis, IN	38	27	1.24	32
St. Louis, MO-IL	35	31	1.22	35
San Antonio, TX	33	33	1.22	35
Providence, RI-MA	33	33	1.19	42
Las Vegas, NV	30	39	1.39	10
Cincinnati, OH-KY-IN	30	39	1.22	35
Columbus, OH	29	42	1.19	42
Virginia Beach, VA	26	46	1.21	39
Milwaukee, WI	23	48	1.21	39
New Orleans, LA	18	54	1.19	42
Kansas City, MO-KS	17	57	1.11	60
Pittsburgh, PA	14	63	1.10	64
Buffalo, NY	13	65	1.10	64
Oklahoma City, OK	12	68	1.10	64
Cleveland, OH	10	73	1.09	69

Source: Schrank and Lomax (2003)

Table 2-2: Key mobility measures in US cities 2003 (continued)

Urban Area	**Annual Delay per Traveler**		**Travel Time Index**	
	2003 Value	**Rank**	**2003 Value**	**Rank**
85 Area Average	**47**		**1.37**	
Medium Average	**25**		**1.18**	
Medium (30 areas)				
Austin, TX	51	13	1.33	23
Charlotte, NC-SC	43	22	1.31	26
Louisville, KY-IN	42	24	1.24	32
Nashville-Davidson, TN	37	29	1.18	48
Tucson, AZ	36	30	1.31	26
Jacksonville, FL	34	32	1.18	48
Oxnard-Ventura, CA	33	33	1.23	34
Memphis TN-MS-AR	33	33	1.22	35
Bridgeport-Stamford, CT-NY	32	37	1.29	29
Salt Lake City, UT	31	38	1.28	30
Albuquerque, NM	30	39	1.17	52
Raleigh-Durham, NC	27	43	1.19	42
Birmingham AL	27	43	1.17	52
Omaha NE-IA	23	48	1.18	48
Honolulu, HI	20	50	1.19	42
New Haven, CT	20	50	1.13	58
Sarasota-Bradenton, FL	19	52	1.25	31
Grand Rapids, MI	19	52	1.14	55
El Paso, TX-NM	18	54	1.17	52
Allentown-Bethlehem, PA-NJ	17	57	1.14	55
Richmond, VA	17	57	1.09	69
Hartford, CT	16	60	1.11	60
Fresno, CA	13	65	1.14	55
Albany-Schenectady, NY	13	65	1.08	72
Toledo, OH-MI	12	68	1.10	64
Tulsa, OK	12	68	1.10	64
Akron, OH	12	68	1.09	69
Dayton, OH	11	72	1.08	72
Rochester, NY	7	80	1.07	77
Springfield, MA-CT	7	80	1.06	80
85 Area Average	**47**		**1.37**	
Small Average (16 areas)	**13**		**1.11**	
Small (16 areas)				
Colorado Springs, CO	27	43	1.19	42
Charleston-North Charleston, SC	25	47	1.20	41
Pensacola, FL-AL	18	54	1.12	59
Cape Coral, FL	15	61	1.18	48
Salem, OR	15	61	1.11	60
Beaumont, TX	14	63	1.07	77
Spokane, WA	10	73	1.08	72
Little Rock, AR	10	73	1.06	80
Eugene, OR	9	76	1.11	60
Boulder, CO	9	76	1.08	72
Columbia, SC	9	76	1.06	80
Laredo, TX	8	79	1.08	72
Bakersfield, CA	7	80	1.07	77
Corpus Christi, TX	7	80	1.05	84
Anchorage, AK	5	84	1.05	84
Brownsville, TX	4	85	1.06	80

Source: Schrank and Lomax (2003)

Table 2-3 shows the development of a wide range of urban congestion indicators for the whole country.

Table 2-3: Time-serices of US urban congestion indicators

Measures of…	1982	1993	2002	2003
… Individual Traveler Congestion				
Annual delay per peak traveler (hours)	16	40	47	47
Travel Time Index	1.12	1.28	1.37	1.37
Number of urban areas with more than 20 hours of delay per peak traveler	5	37	50	51
… The Nation's Congestion Problem				
Total hours of delay (billion)	0.7	2.4	3.6	3.7
Total gallons of "wasted" fuel (billion)	0.4	1.3	2.2	2.3
Cost of congestion (billions of 2003 $)	$12.5	$39.4	$61.5	$63.1
… Travel Needs Served				
Daily vehicle-miles of travel on major roads (billion)	1.06	1.66	2.09	2.14
Annual person-miles of public transportation travel (billion)	22.9	35.1	43.7	43.4
… Expansion Needed to Keep Today's Congestion Level				
Additional lane-miles of freeways and major streets	7,638	6,459	4,927	5,002
Additional daily public transportation riders (million)	8.6	8.2	7.2	7.3
… The Effect of Some Solutions				
Hours of delay saved by				
Operational treatments (million)	NA	NA	301	336
Public transportation (million)	269	696	1,097	1,096
Congestion costs saved by				
Operational treatments (billions of 2003 $)	NA	NA	$5.0	$5.6
Public transportation (billions of 2003 $)	$4.6	9.0	$18.2	$18.2

NA – No Estimate Available
Pre-2000 data do not include effect of operational strategies and public transportation.
Travel Time Index – The ratio of travel time in the peak period to travel time at free-flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak.
Delay per Peak Traveler – The extra time spent traveling at congested speeds rather than free-flow speeds divided by the number of persons making a trip during the peak period.
Wasted Fuel – Extra fuel consumed during congested travel.
Expansion Needed – Either lane-miles or daily riders to keep pace with travel growth (maintain congestion).

Source: Schrank and Lomax (2005)

The Study summarises its results as follows: Congestion continues to grow in America's urban areas. Despite a slow growth in jobs and travel in 2003, congestion caused 3.7 billion hours of travel delay and 2.3 billion gallons of wasted fuel, an increase of 79 million hours and 69 million gallons from 2002 to a total cost of more than $63 billion. The solutions to this problem will require commitment by the public and by national, state and local officials to increase investment levels and identify projects, programs and policies that can achieve mobility goals. The 2005 Report shows that the current pace of transportation improvement, however, is not sufficient to keep pace with even a slow growth in travel demands in most major urban areas.

The long-term trend from 1982 to date is described as follows:

- Mobility problems have increased at a relatively consistent rate during the two decades studied. Congestion is present on more of the transportation systems, affecting more of the trips and a greater portion of the average week in urban areas of all sizes.
- Congestion affects more of the roads, trips and time of day. The worst congestion levels increased from 12% to 40% of peak period travel. And free-flowing travel is less than half of the amount in 1982 (Exhibit 1).
- Congestion has grown in areas of every size. Measures in all of the population size categories show more severe congestion that lasts a longer period of time and affects more of the transportation network in 2003 than in 1982. The average annual delay

for every person using motorized travel in the peak periods in the 85 urban areas studied climbed from 16 hours in 1982 to 47 hours in 2003 (Exhibit 2).

- The delay statistics in Exhibit 2 point to the importance of action. Major projects, programs and funding efforts take 10 to 15 years to develop. In that time, congestion endured by travelers and businesses grow to those of the next largest population group. So in ten years, medium-sized regions will have the traffic problems that large areas have now, if trends do not change.

The trend described is illustrated by Figure 2-2.

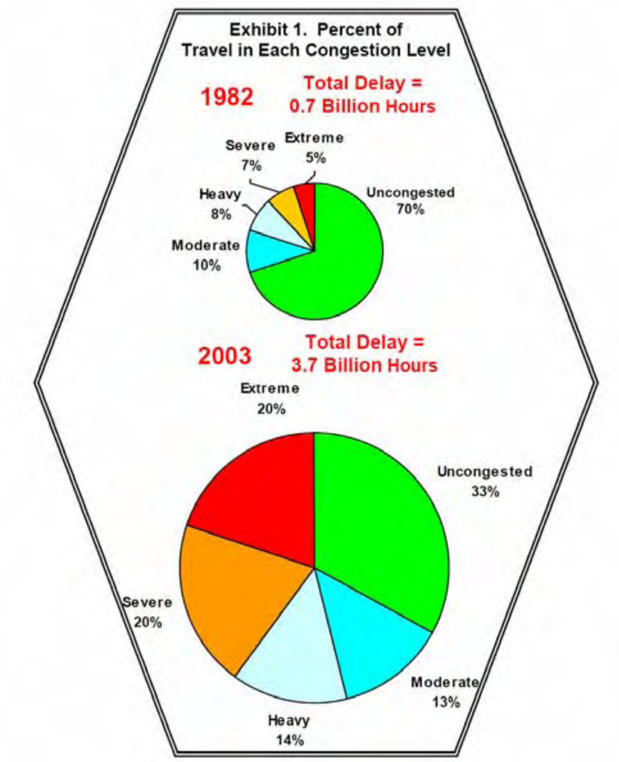


Figure 2-2: Percent of travel by congestion level in US cities 1982 and 2003

Figure 2-3 presents the corresponding time series of the travel time index. The graph shows tha tthe development is not monotinic, but underlies some fluctuation over time.

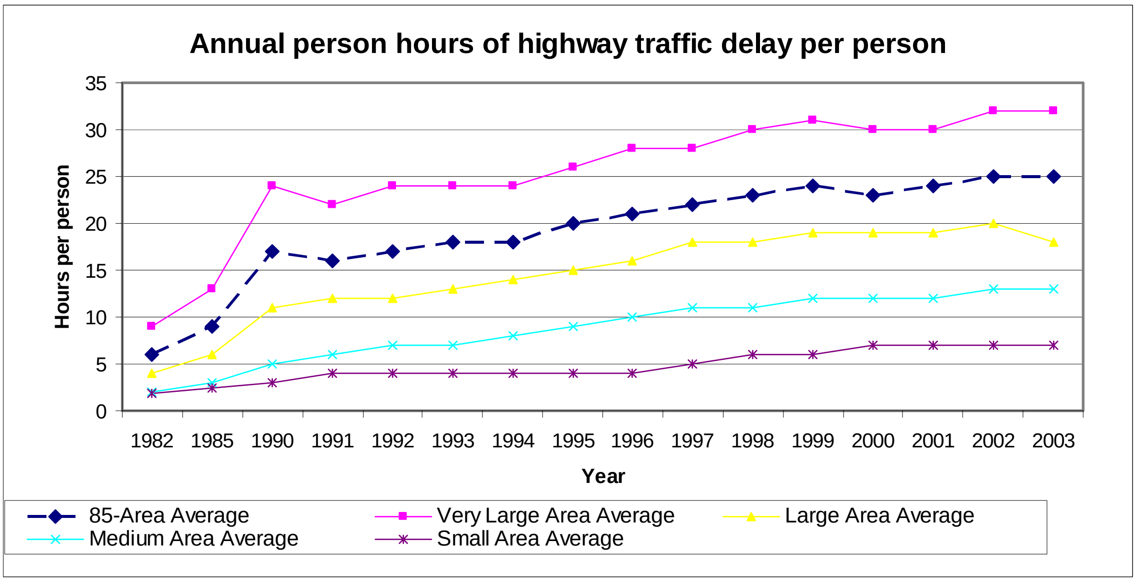


Figure 2-3: Long-term development of the travel time index by types of urban areas

2.4 Rail Freight

2.4.1 Current situation

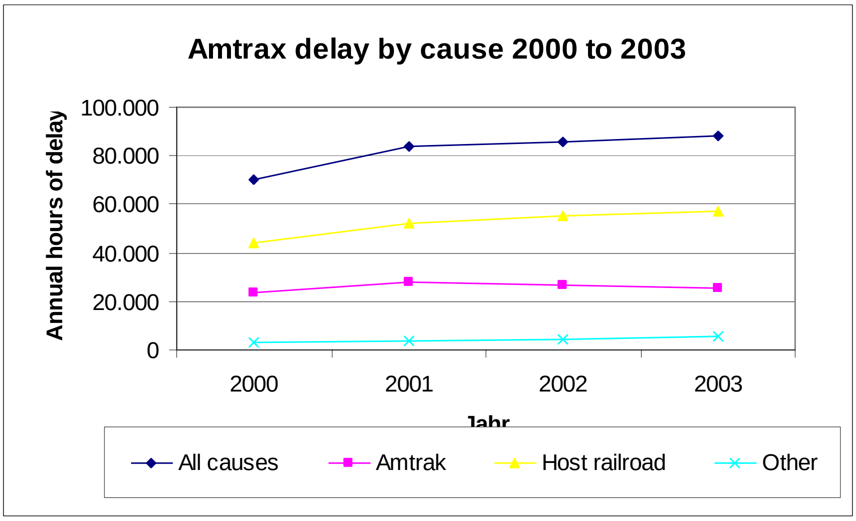
As with the highway system, congestion on American railroads usually comes in the form of chokepoints and bottlenecks. Overpasses and bridges with single tracks, sidings too short to accommodate the fuel- and labor-saving 7000-foot trains now in common use, and at-grade road crossings without proper warning devices all slow down rail traffic and reduce system capacity. The site to the east of Los Angeles where Burlington Northern Santa Fe's and Union Pacific's primary transcontinental trunk lines cross at grade is one of the biggest rail bottlenecks in the US, creating ripple effects as far east as Chicago and New Orleans. The $2.4 billion Alameda Corridor project, a public-private partnership that consolidated four rail subdivisions into a completely grade-separated, triple-tracked "rail expressway" between the ports of Los Angeles and Long Beach, is an example—if an exceptionally large one—of a project that can reduce rail congestion, and also eliminate a great deal of road congestion as well. SAFETEA-LU contains significant funding for grade separation projects, albeit of a less ambitious nature. On some major routes trunk line capacity is a problem, because some parts of even the major routes are single track.

At intermodal facilities, congested access routes also create delays on top of those arising within the facilities themselves. Chicago, the nation's primary intermodal rail hub and switch point, is notorious for this: for years, a common complaint among shippers was that rail-borne freight took more time to make the 10- or 20-mile trip between western and eastern classification yards in the Chicago area than it did to go from Los Angeles to Chicago. This "Black Hole of Chicago" has shrunk in recent years as railroad consolidation and improved operations have enabled high-priority container traffic to transfer from the western to the eastern railroads in only a few hours' time, but access road congestion remains a significant problem whenever trucks need to access truck/rail interchange facilities. Accessibility improvements are a key component of SAFETEA-LU and many states' transportation programs.

In regions with commuter rail service, conflicts invariably arise when transit agencies operate on right-of-way leased from freight railroads. Lease agreements generally force railroads to minimize or divert traffic during periods of commuter rail operation, squeezing more freight trains into the short windows of time during which they can operate. Both commuter and freight traffic can experience considerable delays on especially busy routes, a particular problem in Los Angeles and Chicago. Resolving such conflicts would require investment in double- and triple-tracking and longer sidings, and the rebuilt bridges and grade separations to accompany them. The US railroad industry has not made sufficient profits to make such capital investments, and there is no precedent for public subsidies to private railroad firms. The freight railways in the US resist sharing agreements with commuter rail. For example, a recent request by the Los Angeles region's commuter rail authority to expand service on the east-west route out of downtown was rejected. Such actions are controversial, because commuter rail is seen by many planners and elected officials as a way to reduce private vehicle use.

2.4.2 Statistical information

The Buerau for Transportation Stistics (BTS) annaually collects punctuality fitrues of Amtrax by type of service (long and short distance) and by cause (responsibility of Amtrax, of the host railroad operator or of external factors). The available information dates back to 1980. As the method of recording was changed in 2000 by Amtrax Figure 2-4 only presents the time series from 2000 on. The figure reveals that railroad related delays have slightly increase during the reporing period, which indicates growing congestion and / or track quality problems.



Source: Data from BTS (2006)

Figure 2-4: Amtrax performance 2000 to 2003

2.5 Ocean shipping

Congestion at and around the nation's seaports is a problem primarily because of the concentration of maritime traffic at a small number of locations—largely found in parts of urban areas developed prior to, or very early in, the automobile era. On the Pacific coast, all three major port complexes—Los Angeles/Long Beach, Oakland, and Seattle/Tacoma—are located in urban areas that already suffer from severely congested freeways. Alternatives to these ports, especially to heavily populated, well-located, extensively rail-connected Los Angeles/Long Beach, are few and far between. If trans-Pacific container flows even remotely approach the levels projected for them by 2020, all three ports will require major operational improvements in order to handle the additional volume, since their ability to use landfill to build additional terminal space is severely constrained. At present, there are proposals to build major new ports in British Columbia[4] and Baja California, but both areas would require extensive investment in rail and highway connections to be feasible, and would take decades to build. Expansion of the Panama Canal has been under discussion for many years.[5] This could significantly ease congestion at Los Angeles/Long Beach by reducing the need for land-bridge movements of intermodal cargo to locations in the South and Midwest, but the current proposal has not yet been approved by the Panamanian electorate, and construction would take several years. For now, projects such as the Alameda Corridor and Alameda Corridor East in Los Angeles and the FAST program in Seattle have served to alleviate congestion outside of the nation's Pacific ports, but much more work is necessary to accommodate *current* levels of freight flows—let alone predicted levels of growth.

At ports on the Gulf of Mexico and the Atlantic Ocean, congestion is somewhat less problematic than on the Pacific. Up and down these shorelines, there are many underutilized ports, most of which offer good access to major population centers. However, the central location of the Port of New York and New Jersey in the Washington, D.C. – Boston "megalopolis"—a corridor containing over 25% of the nation's population—means that it receives the bulk of East Coast traffic. Since the New York area is poorly served by freight rail, most of the distribution of this cargo—even to points far inland—occurs by truck. The huge volumes of vehicle traffic on greater New York's arterials and freeways make this a serious problem. The Port Authority of New York and New Jersey has responded with the Port Inland Distribution Network (PIDN), a system that would use rail land bridges to inland cities like Albany (New York) and Reading (Pennsylvania), and barges to nearby, underutilized seaports such as Boston and Philadelphia. Most or all of the rail components of PIDN are underway at this writing, but the waterborne routes are not yet operational. Smaller-scale road, bridge, and grade-separation projects have also taken place, and the pace of such improvements will doubtlessly increase under SAFETEA-LU.

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4 There is already a major port in Vancouver, but it faces the same capacity constraints as Seattle/Tacoma and Los Angeles/Long Beach. Canadian National Railways has responded by initiating the development of its western terminus at Prince Rupert, BC, located several hundred kilometers to the northwest of Vancouver, as a container port. (http://www.rupertport.com/)

5 The Panama Canal's locks cannot handle today's largest container ships.

2.6 Transit

American transit suffers from congestion largely as a byproduct of roadway congestion. While expensive fuel and high vehicle purchase taxes in Europe account for much of the difference in automobile utilization rates between the EU and the US, disparities in transit service quality also significantly impact this difference. Despite decades of investment in exclusive-right-of-way transit systems (rail and busway) amounting to tens of billions of dollars, the bulk of American transit ridership is on buses in mixed traffic, just like in Europe. Most US transit operators have only just begun to implement operational improvements such as reduced stop frequency (which simultaneously reduces congestion caused by buses pulling into traffic and increases average bus speeds), traffic signal priority systems (which allow higher average bus speeds), and peak-period bus-only lanes (which remove congestion as a problem for buses on major arterials during peak hours), to name three measures in common use in cities throughout the EU. As a result, most Americans—even those who live in central cities with extensive transit networks—purchase automobiles at the earliest opportunity, creating even more roadway congestion that further disadvantages those traveling on buses.

2.7 Aviation

In the US aviation delays are collected by the Bureau for Transportation Statistics by airport, airline and cause. The development of total flights delayed since 1987 is presented by the following figure.

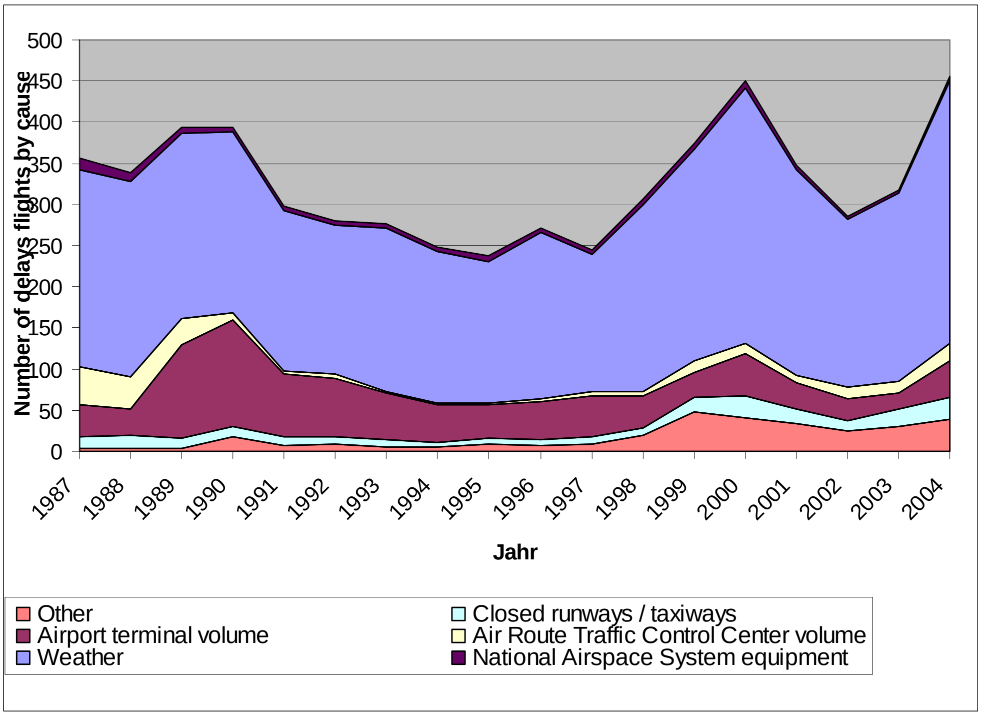

Figure 2-5: Delayed flights in the US since 1987

2.8 References

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3 Germany

3.1 Inter-Urban Road

The following institutions specific to inter-urban road transport have been contacted:

- The Federal Highway Research Institute (BASt)
- The Traffic Control Centre Hessen (VZH)
- The Planning Transport and Traffic consultants (PTV)

3.1.1 Methodology

BASt: The Federal Highway Research Institute (BASt) operates and evaluates automatic counting posts (600 on motorways, 700 on trunk roads), measuring network loads (ADT) continuously over the whole year. The counting posts are specifically located at highly frequented / congested network parts. The results are provided by single counting post. Outputs are ADT, typical traffic pattern, share of HGVs and LGVs (for most of the counting posts) for usual working days as well as factors to estimate holidays. Traffic count results are publisched annually in print version "Verkehrsentwicklung auf Bundesfernstraßen", Lat-est issue 2003, 2004 in preparation. Data available on CD-ROM.

VZH: Measurement of traffic volumes by around 700 counting posts in Hessen. The Information consists of actual traffic loads, which are directly submitted to the Traffic Control Centre. The new standard for detection loops (TLS 2002) allows the differentiation of 8 vehicle classes and the detection of average speeds in 1-munute intervals. The induction loops are supported by overhead devices for ultra sonic speed measurement. Congestion is defined when vehicles on a minimum length of 1000 m travel at below 35 kph for a minimum of 5 minutes. To exclude the non-capacity effects traffic loads are consulted.

Detecting the length (km) of traffic jams is supported by the ASDA-Photo-Tool by Daimler-Chrysler. This makes use of known characteristics of traffic jams. Further, since January 2005 the Project DIANA delivering Floating Car Data (FCD) to support the system in particular on state and county roads, where the installation of detecting loops is too expensive, has started with a test phase. FCD shall deliver the speed and position of those vehicles (usually taxis) equipped with FCD technology. However, the vehicle fleet is still small. The technology is currently tested by the German Air and Space Research Society (DLR) in Berlin, Hanover, Nürnberg and Vienna. Further FCD tests making use of mobile phones to locate vehicles is tested in Hanover and the Rhine-Mail agglomeration.

PTV: Collection and matching of several data sources on traffic conditions: Detection loops, FCD, MFD (= mobile Floating Data = positioning of individuals via mobile phones; advantage: huge mass of observations) and police reports (via traffic message channel TMC); European standard format LCL = Location Code List (BASt) + ca. 1500 event codes). All data sources are compiled within the German national traffic model Validate/Realtimes (PTV 2006).

DLR: The German aeronautics and space agency currently develops a satellite-based traffic observation system (Terrasar-X), which shall be able to detect traffic situations on roads by radar measurement from the orbit. With this system any kind of ground-based facilities would become obsolete. A pilot demonstrator shall be ready for the soccer world cup in July 2006.

3.1.2 Results and forecasts

Counting post information and detailed network descriptions have been used by IVV and IfV (2004) to perform a bottleneck-analysis for the German motorway network including forecasts to 2015 on behalf of the Federal Ministry for Transport, building and Urban Development (BMVBS). According to the Handbook on the Dimensioning of Roads (HBS) congestion was defined when the level of service decreases from E (bound traffic) to F (stop and go). This corresponds to a reference travel speed of 75 kph on motorways. The analysis was made on an hourly basis using location-specific and weather-dependent speed-flow functions. The following results were found for capacity-related congestion:

- in 1997 30% of the motorway network face 30 or more congestion-hours per year. This share increases to 31% in 2000 and is predicted to be 42% in 2015
- Total annual waiting time 1997 ranges around 900 million vehicle-hours
- Most affected are the urban states (Hamburg, Berlin, Bremen) and the states of Hessen, North-Rhine Westphalia and Lower Saxony.

Table 3-1 presents the details by federal state.

Table 3-1: Motorway sections affected by speeds below 75 kph at more than 30 hours per year 2000 and 2015 by federal state

Federal state	**Motorway network 2000**		**Motorway network 2015**	
	Length (km) per direction	Share (%) of congested sections	Length (km) per direction	Share (%) of congested sections
Bremen	96	80	79	96
Hamburg	162	65	144	80
Hessen	1,912	53	2,016	68
Berlin	132	49	145	83
Baden-Wuerttemberg	2,050	48	2,089	67
North Rhine-Westphalia	4,356	45	4,338	52
Lower Saxony	2,694	38	2,823	49
Bavaria	4,482	26	4,867	36
Rheinland-Palatinate	1,678	23	1,695	39
Schleswig-Holstein	962	19	1,019	33
Thuringa	574	19	1,002	14
Saarland	472	8	457	18
Brandenburg	1,532	7	1,538	17
Saxony	884	6	923	17
Saxony-Anhalt	520	4	743	22
Mecklenburg-Vorpommern	524	2	1,101	17
TOTAL	23,030	31	25,078	42

Source: BMVBW 2004

The actual number of congested hours (speed below 75 kph) per motorway segment is presented 2015 by Figure 3-1.

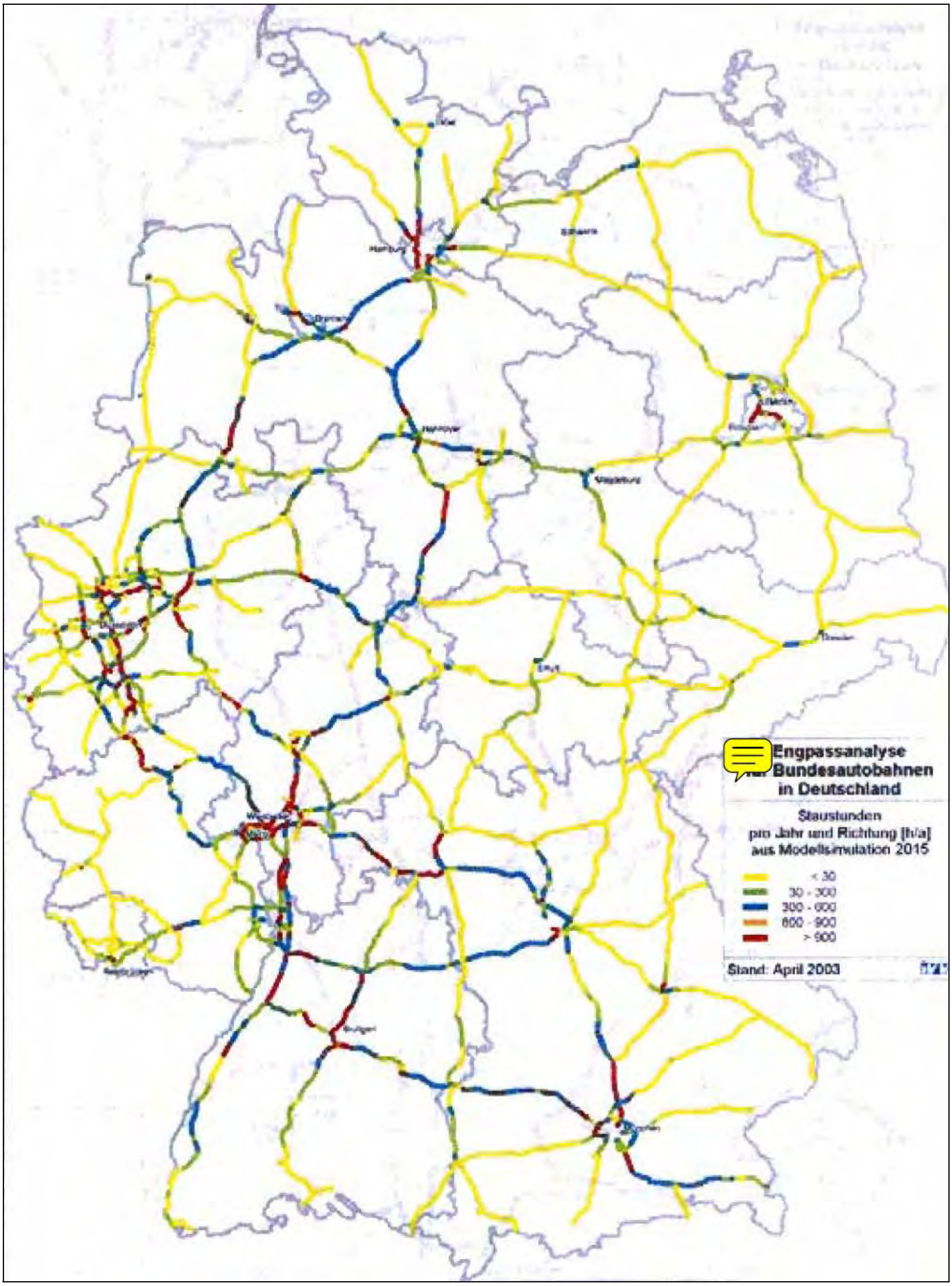


Figure 3-1: Congested hours per segment and direction

The analysis has not considered additional congestion due to construction sites and accidents. A sensitivity test has revealed that a 1% variation in traffic demand 2015 leads to a 2.5% change of congestion lengths.

The traffic model TREMOD developed by IVT (Heilbronn) for the German Environmental Agency (UBA) estimates vehicle kilometres by road classes and traffic conditions based on sample traffic counts and fuel consumption and sales statistics (ECMT 1998). The results for 1998 have been used by the UNITE project to estimate German road congestion costs (Link et al. 2002). The model outputs also report travel speeds, which allows the computation of a travel Time Index similar to the US Urban Mobility Study. The results are presented by Table 3-2.

Table 3-2: Vehicle kilometres by road class and traffic condition 1998

	Free Flow		Bound		Stop & Go		Travel
MW	Volume	Speed	Volume	Speed	Volume	Speed	Time
MW	mill. vkm	kph	mill. vkm	kph	mill. vkm	kph	Index
Motorways							
2-Wheels	1.620,2	105,1	186,9	80,2	28,9	19	1,10
Cars	125.390,5	110,7	145.718,0	84,9	2.360,5	9,5	1,25
Light Trucks	10.683,9	108,8	1.243,0	84,9	199,6	9,5	1,20
Trucks	21.039,0	85	668,4	77,7	353,1	5,8	1,22
Busses	939,5	83,6	29,9	70,5	15,7	5,8	1,22
Local Arterial Streets							
2-Wheels	52,2	39,9	2.328,0	31,5	46,1	19,5	1,28
Cars	2.933,9	58,4	138.408,0	35,2	2.733,6	5,3	1,82
Light Trucks	224,8	58,4	10.493,5	35,2	205,6	5,3	1,82
Trucks	195,0	52,2	8.390,5	28,9	152,3	5,8	1,91
Busses	26,8	42,4	1.276,5	22,7	25,2	5,8	1,95

Source: ECMT (1998): Road Traffic Congestion in Europe. Round Table 110. Paris.

BASt: The Federal Highway Research Institute currently works at a procedure to steadily monitor congestion levels on the German federal road network based steady counting post information.

PTV: The steady evaluation of various data sources (counting posts, police reports, FCD) is used to serve dynamic route search algorithms. Congestion statistics are not generated and not published, although the data would be ready.

3.1.3 Policy plans

With the Federal Governments Anti Congestion Programme (2000) reduction of bottlenecks in road, rail and waterborne transport is envisaged. Further capacity-related investment measures are carried out vial the Federal Investment Plan. Figure 3-2 presents the urgent investments in the federal road network resulting from the Federal Investment Plan 2003 to 2015. Neither the differentiation of the HGV motorway toll according to congestion levels nor the introduction of a respective passenger car toll to manage traffic demand are envisaged at the moment.

VZH: For the state of Hessen the following share of road congestion causes is estimated: Shortage of capacity: 30%, accidents: 30%, construction sites: 30%, other: 10%.

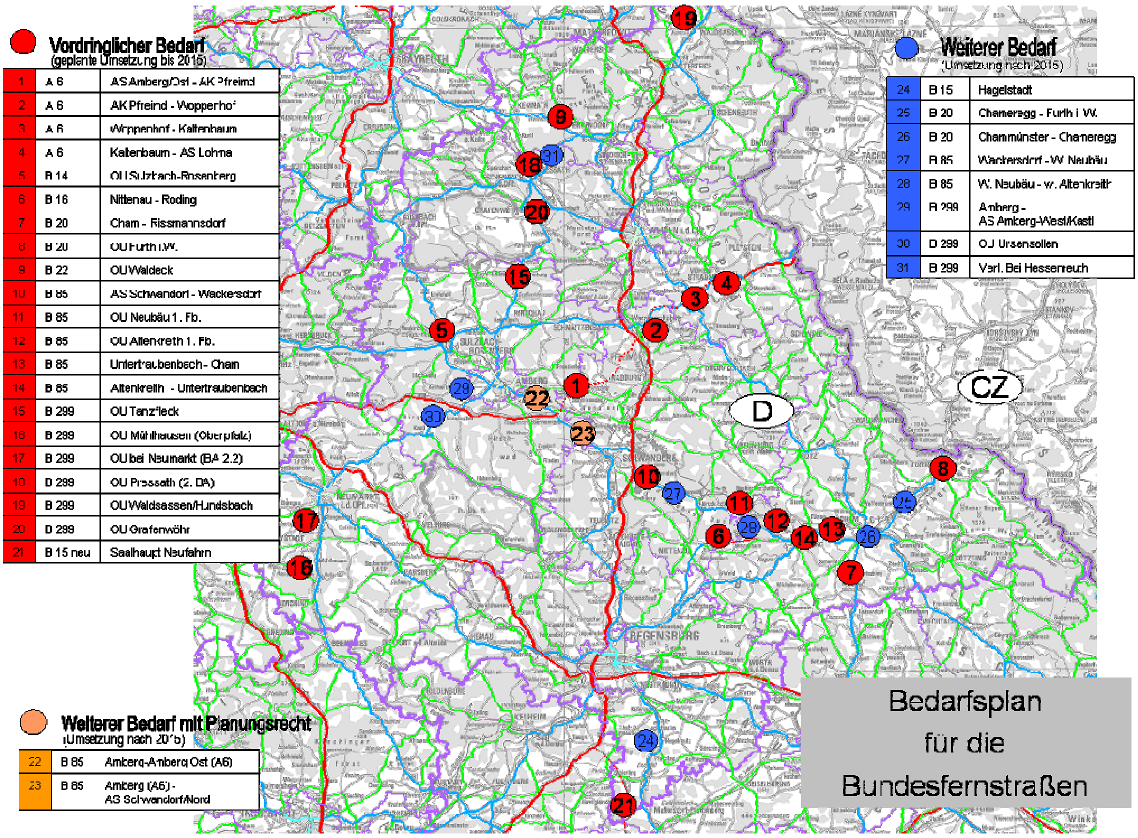


Figure 3-2: Investment requirement plan for German federal roads according to the federal investment plan 2003 to 2015.

3.2 Inter-Urban Rail

The following institutions have been contacted:

- DB: The German Rail Carrier Deutsche Bahn AG
- Pro Bahn: The travellers' consumer organisation Pro Bahn
- Warentest: The independent organisation for product testing Stiftung Warengest.

3.2.1 Methodology

The network-wide measurement and evaluation of delays is carried out by the infrastructure operator (DB Netz AG). The service operators assess delays of their own products (trains) and therefore are direct partners in fighting congestion. This also holds in local rain transport for the institutions ordering transport services (federal states, state transport societies, transport unions). In case investments are required to improve punctuality, the financing partners (usually federal and state governments) participate under the leadership of the Federal Railway Office (EBA).

DB: Actual arrival and departure times of all trains (passenger and freight) are monitored in real-time by the 7 control centres (Betriebsleitzentralen) Berlin, Frankfurt/M, Duisburg, Hanover, Karlsruhe, Leipzig, Munich, which control the traffic on the vast majority of the German rail network. Delays are attributed by their decisive cause and are documented in standardised form. Data is measured and evaluated continuously and for all network parts for the purpose of possible time-table adjustments. The measured delays are evaluated according to the following criteria:

- Type of product (train classes)
- Time periods (Days of the week / weeks / months)
- Regions (the 7 traffic control districts of DB Netz AG) and
- Causes (traffic-related, technical, personnel, construction-related, e. g. signals, superstructures, wires, etc..

Besides the operative use the data is stored for statistical analyses and evaluated annually. Due to the mainly automatic measurement and evaluation the additional labour costs are low. The development and maintenance of the technical system is part of the overall costs of the traffic control centre.

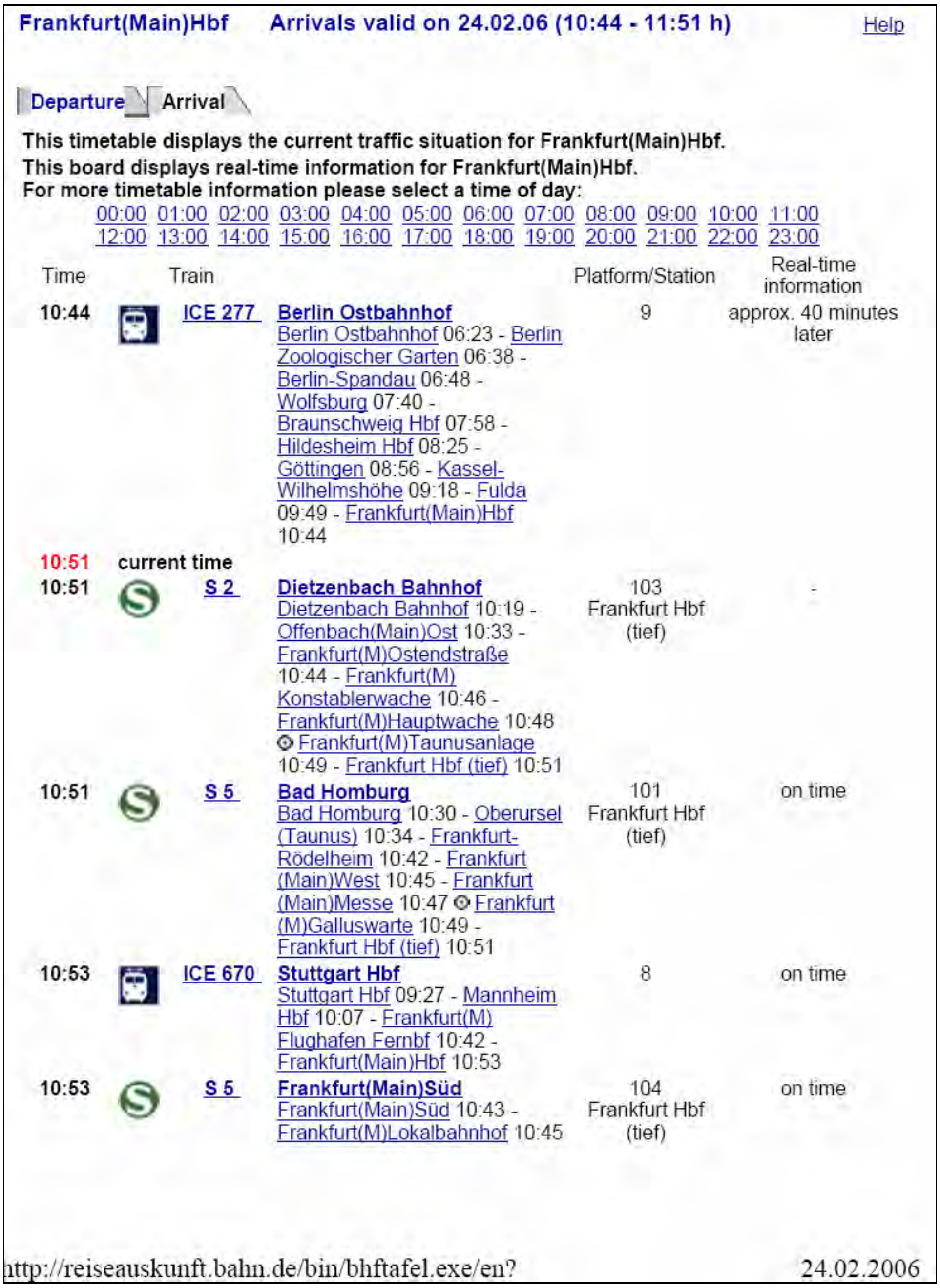
Pro Bahn: The state companies ordering public transport usually consists of good statistics on delays due to the passenger rights agreements. However, they are in most cases not publicly available. In Germany 32 of these public-private companies exist. The transport service operators have the duty to report delays to the companies having ordered services. Problem: Missed connections when passenger change the transport means are not considered. But the ordering companies know the number of passenger changing, which allows to estimate the time lost in this case. Pro Bahn Bavaria has started with a delay monitor on the internet in 2001 (www.pro-bahn.de/quak). However, the reliability has dropped after the first year in operation and thus current results are not significant

Warentest: Since 1997 the independent consumer organisation Stiftung Warentest (www.warentest.de) takes samples of the punctuality of various train classes by comparing the actual to the planned arrival time. At a representative number of stations between 12:000 and 14:000 arrivals are considered over a sample period of two weeks. The results are published in the orgainsation's journal by train station, train class and severity of delays.

3.2.2 Results and forecasts

DB: Delay classes in passenger transport: 1-5 min. (punctual), 6-15 min. and >15 min.
Freight transport quality trains: 1-15 min. (punctual), 16-30 min., 30-60 min. and >60 min. Delays are shown as origin and destination delays as well as average values using measurement points during the train run. Further, "transfers" of delays due to missed connections are considered. But the analyses are not published.

According to the DB-Netz AG annual report 2003 and 2004 the punctuality in passenger transport 2004 was 95%-96%, while it was only around 83% in 2003. A punctuality of 95% constitutes DB's long term target. Although punctuality analyses are not reported in a more detailled form, DB Reise&Touristik provides arrival and departure tables for all stations, including current punctuality information for long-distance trains. Regional light rail, which is operated by DB Region AG, are not included. The service can be accessed via the Internet under the URL http://reiseauskunft.bahn.de/bin/bhftafel.exe/en in several languages. An example for Frankfurt main station is provided by Figure 3-3.



Frankfurt(Main)Hbf Arrivals valid on 24.02.06 (10:44 - 11:51 h) Help

Departure Arrival

This timetable displays the current traffic situation for Frankfurt(Main)Hbf.
This board displays real-time information for Frankfurt(Main)Hbf.
For more timetable information please select a time of day:
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00
12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00

Time	Train		Platform/Station	Real-time information
10:44	ICE 277	**Berlin Ostbahnhof** Berlin Ostbahnhof 06:23 - Berlin Zoologischer Garten 06:38 - Berlin-Spandau 06:48 - Wolfsburg 07:40 - Braunschweig Hbf 07:58 - Hildesheim Hbf 08:25 - Göttingen 08:56 - Kassel-Wilhelmshöhe 09:18 - Fulda 09:49 - Frankfurt(Main)Hbf 10:44	9	approx. 40 minutes later
10:51	current time			
10:51	S 2	**Dietzenbach Bahnhof** Dietzenbach Bahnhof 10:19 - Offenbach(Main)Ost 10:33 - Frankfurt(M)Ostendstraße 10:44 - Frankfurt(M) Konstablerwache 10:46 - Frankfurt(M)Hauptwache 10:48 Frankfurt(M)Taunusanlage 10:49 - Frankfurt Hbf (tief) 10:51	103 Frankfurt Hbf (tief)	-
10:51	S 5	**Bad Homburg** Bad Homburg 10:30 - Oberursel (Taunus) 10:34 - Frankfurt-Rödelheim 10:42 - Frankfurt (Main)West 10:45 - Frankfurt (Main)Messe 10:47 Frankfurt (M)Galluswarte 10:49 - Frankfurt Hbf (tief) 10:51	101 Frankfurt Hbf (tief)	on time
10:53	ICE 670	**Stuttgart Hbf** Stuttgart Hbf 09:27 - Mannheim Hbf 10:07 - Frankfurt(M) Flughafen Fernbf 10:42 - Frankfurt(Main)Hbf 10:53	8	on time
10:53	S 5	**Frankfurt(Main)Süd** Frankfurt(Main)Süd 10:43 - Frankfurt(M)Lokalbahnhof 10:45	104 Frankfurt Hbf (tief)	on time

http://reiseauskunft.bahn.de/bin/bhftafel.exe/en? 24.02.2006

Figure 3-3: Example for online timetable information of the Deutsche Bahn AG for Frankfurt/Main main station, 24.2.2006, 10:40

Following from the legislation on passenger rights a study on the payments from transport service operators to delayed passengers exists, but is strictly confidential.

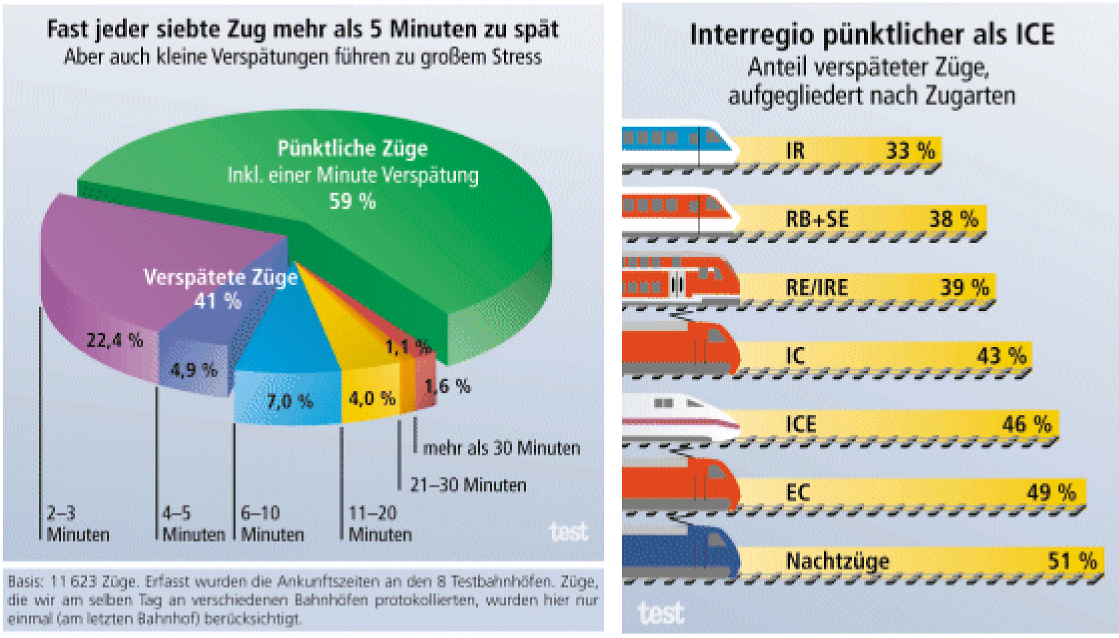
Pro Bahn: DB punctuality values report only the delay at the train arrival at its final destination. At intermediate stops delays can be much higher and here the highest share of passengers changes (Cologne, Mannheim, Frankfurt). Accordingly, delay figures weighted by the number of passengers affected would appear less positive. The delay situation in regional and urban transport, in contrast, is to be considered as much more positive because of less changing passengers and more frequent departures.

Warentest: In contrast to the official definition of DB (>5 minutes) Stiftung Warentest (2001) defines congestion for arrivals later than 2 minutes. Further, the 2001-Study investigates the probability of loosing connections due to delays between the various train classes. Source: Stiftung Warentest 2001Source: Stiftung Warentest (2001)

Figure 3-4 presents the results for 2001 for total delays (left) and by train classes (right). Key results:

- A total punctuality according to the DB-definition (+5 min.) = 86%
- Long-distance trains are most unpunctual.

A regional differentiation is not available.



Source: Stiftung Warentest (2001)

Figure 3-4: DB punctuality results 2001 by delay severity and train class

According to DB , bottlenecks which are particularly sensitive to delays are some specific passenger stations (e. g. Mannheim) and some segments of heavily loaded mixed traffic lines (e. g. Bremen/Hamburg – Hanover or Fulda – Frankfurt – Mannheim). Here, constrictive capacity extension measures are planned, which, however, advance only slowly due to permission-related -, financing – and constructive reasons. .

Freight transport: For domestic freight services the DB-owned company RILION provides some global figures on arrival and departure punctuality. These are based on a one-hour delay margin. It should be considered that this delay margin is much more (see Table 3-3).

Table 3-3: Railion punctuality figures for Germany 2003/04

Railion market segment: "Quality" (Domestic trains)		2003	2004	% change
	Nr Trains	(110,231)	(116,598)	
Punctuality at departure	< 60 min	96.0%	97.0%	+1.0%
Punctuality at arrival	< 60 min	89.0%	90.6%	+1.6%

Source: CER (2005)

Pro Bahn Bavaria has started with a delay monitor on the internet in 2001 (www.pro-bahn.de/quak). However, the reliability has dropped after the first year in operation.

As concerns bottenecks in rail infrastructure Baum et al. (2001) have presented a list of corridors where in 2ß15 considerable capacity restraints can be expected (Table 3-4).

Table 3-4: Bottlenecks on the main lines of the German railway network 2015

Main corridor	Main corridor section	Bottlenecks
Hamburg-Berlin	Hamburg-Büchen-Berlin	
Hamburg-Hannover	Hamburg-Lüneburg-Hannover	Stelle-Lüneburg
Hamburg-Rhein/Ruhr	Hamburg-Bremen-Osnabrück-Dortmund-Köln	Kirchweyhe-Diepholz Dortmund-Selmig
Rhein/Main-Stuttgart	Frankfurt-Mannheim-Stuttgart	Darmstadt-Mannheim
Rhein/Main-Basel	Frankfurt-Mannheim-Karlsruhe-Freiburg-Basel	Darmstadt-Mannheim
Rhein/Main-Würzburg	Frankfurt- Würzburg	Aschaffenburg-Gemünden
Dresden/Leipzig-Kassel	Dresden-Leipzig-Erfurt-Kassel	
Hannover-Rhein/Ruhr	Hannover-Hamm-Wuppertal-Köln Hannover-Dortmund-Köln	Minden-Wunstorf
Hannover-Rhein/Main	Hannover-Göttingen-Fulda-Frankfurt	
Hannover-Berlin	Hannover-Magdeburg-Berlin Hannover-Stendal-Berlin	
Nürnberg-Würzburg	Nürnberg-Würzburg	
Nürnberg-München	Nürnberg-Treuchtlingen-München	Nürnberg-Treuchtlingen
Rhein/Ruhr-Rhein/Main	Köln-Koblenz-Mainz-Frankfurt	Bonn-Koblenz
Stuttgart-München	Stuttgart-Ulm-München	Plochingen-Geißlinen Mering-München
Berlin-Nürnberg	Berlin-Dessau-Halle-Jena-Nürnberg Berlin-Wittenberg-Leipzig-Nürnberg	Fiirth-Bamberg
Fulda-Würzburg	Fulda-Würzburg	Fulda-Mottgers

Souorce: Baum et al. 2001

Baum et al. (2001) list a number of reasons for increasing capacity problems in Germany: closure of lines and nodal facilities, too little maintenance activities leading to roughly 600 speed restrictions, mixed operation (high speed and local transport plus freight services) on 80% of the network and the high share of international and private local services.

3.2.3 Policy plans

In the course of the federal investment plan (BVWP 2003) the above mentioned influencing factors have been considered in terms of a general transport forecast 2015. From this the "railway requirement plan" derives, which sets the most important plans for infrastructure ex-tension and new construction. The DB AG has adopted its enterprise objectives, the "Strategy Net-21" to this plan. The strategy describes asset maintenance, replacement, technical modernisation and rationalisation measures as well as extension and new construction measures for the entire track network. This strategy forms the base line for current investment decisions.

The priority extension and new construction measures are agreed between DB AG and the transport ministry (BMVBS) and are realised according to the available financing sources. According to the political goal to shift more traffic from road to rail these measures consider a respective traffic growth. Reducing delays by shifting traffic back from rail to road has never part of a serious debate in transport policy.

EU activities concentrate on the provision of barrier-free intermodal corridors for rail freight transport and for high-speed rail passenger transport. Thereby, qualitative and capacity improvements and technical conversions to ensure interoperability are facilitated. Due to limited budgets, the relatively low funding share per project and due to the high number of projects to be financed, the success of the funding programme in total is limited and the goals can be reached in the long-term only.

3.3 Aviation

Institutions contacted:

- Arbeitsgemeinschaft Deutscehr Verkehrsflughäfen (ADV)
- Deutsche Lufthansa AG (DLH)
- Frankfurt Airport AG (FRAPORT)

FRAPORT: Delay data is recorded, assessed and stored for internal statistical and controlling reasons by all major airports. Delay causes are discussed with the airlines and the air traffic management and then the information is passed to EUROCONTROL for further consolidation. FRAPORT does not publish punctuality data itself.

3.4 Waterborne transport

The following institutions have been contacted:

- Bundesverband der deutschen Binnenschifffhart (BDB)
- Several port authorities
- Ports of Duisburg and Hamburg
- The Short Sea Shipping Promotion Centre (SPC)

3.4.1 Methodology

BDB: Delay statistics are not recorded as this is not an issue in inland navigation. Recorded are the passing times of ships at locks, but not their arrivals. At locks with high traffic volumes waiting times occur, but they are not documented. Different ships have varying priorities (e. g. passenger and police high). A navigation system with announcement exists for communication between vessel and lock in order to avoid waiting times. Data of delays are – if anyway – only kept by shipping companies.

Publications are made of the number of ships per waterway according to commodity loaded and type of ship (traffic load data only).

3.4.2 Results and forecasts

BDB: Congestion is not relevant for inland navigation. Delays in inland navigation are only caused by special events (damaged ships, technical problems at locks, etc.). No specific critical location in the network. In the future delays in inland navigation will further decrease as ships get bigger.

SPC: Congestion does not occur. However, often there are waiting times when entering a harbour because of lags of cranes to unship the vessels. The priority of ships varies according to the ship size: Small inland barques usually have to wait for free slot in case of unloading capacity problems. While big Ships have a higher priority. **Port of Duisburg**: Duisburg constitutes Europe's biggest inland port. Congestion or excessive traffic volumes on the waterways are not occurring. Also there is no waiting time for ships to enter this harbour. However, during July and September a long waiting time up to 60 hours in the western European sea ports (Rotterdam und Antwerp) occur due to reduced staff (holidays.

Bremen port consulting: No Congestions, sometimes ships must wait to get a free slot to get unloaded. Around 10.000 Ships per year. Often a high delay time, due to weather condition or technical problems, but not because of a high volume of traffic.

Port of Hamburg: The port of Hamburg constitutes a special case because all ships must enter the port through the river Elbe. Congestion can occur in front of the Elbe so ships have to wait, but there are no figures available.

3.5 Urban road transport

3.5.1 Measurement and definition of congestion

Berlin: In total 600 detector loops are located in Berlin: 300 at motorways and 300 within the city area. All detectors continuously collect data, but the transmission to the traffic control centre differs. Motorway data are transmitted every 5 minutes in aggregated form, while the detectors within the city area transmit only in case a change in traffic conditions is recognised.

The Traffic management Centre (VMZ) Berlin combines these measurements with police reorts, state traffic centres, the public transport service providers, etc. To provide the customer with an all-round mobility service information on construction sites, parking space, P.T. time tebles and connections and events are combined and presented online.

Frankfurt/Main City: In the framework of developing the "integrated Common Transport Controle Centre" currently a software is developed and tested, which determines common trafic conditions for the urban main road network on the basis of detectors (induction loops, infra red detection). In particular the traffic quality will be presented in by six service levels for controle purposes and four levels for online publication. The data will be ready for the world championship 2006 for a demonstation route; the remaining urban network will then step by step be equipped with detection facilities.

3.5.2 Current situation

Berlin: As a large city Berlin suffers considerably from commuting traffic. Moreover, bottlenecks exist at the motorway junction "Funkturm" and on the A100 between the motorway junction "Funkturm" and the triangle "Charlottenburg". These routes belong to the most dense road segments in Europe.

Based on transport model data city traffic of Berlin can be viewed at current time and as forecast information online at www.vmzberlin.de. In addition to the graphical presentation a list of current traffic messages is available. An example for morning peak traffic in the city centre is given by

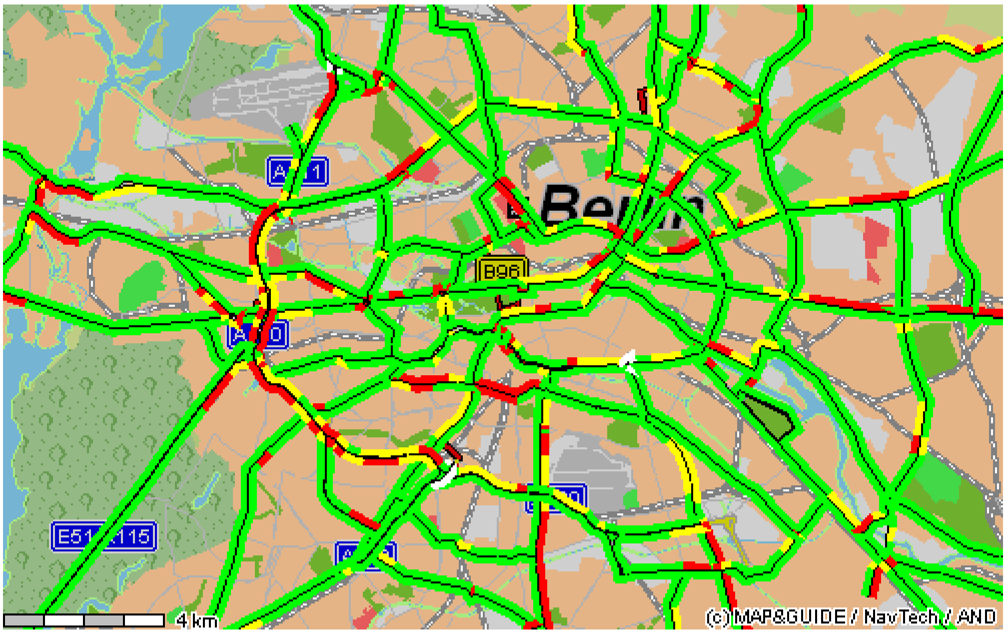


Figure 3-5: Berlin road network traffic conditions at morning peak.

Source: www.vmzberlin.de

The city of Frankfurt claims weather conditions and the parking in second row for loading and unloading purposes an important cause of congestion. Overall, the situation is typical for medium sized cities experiencing morning and afternoon peak traffic due to the strong commuting flows into and out of the city's central business and banking district.

3.5.2.1 Forecasts

Traffic forecasts are within the responsibility of the federal state of Berlin (not the city).

3.5.2.2 Measures to reduce congestion

Alongside the main city roads 20 information plates are distributed across the city, informing on congestion and other traffic disturbances.

3.6 Urban Public Transport

3.6.1 Measurement of delays

Berlin light rail: Delays in the light rail system are determined by so-called train run tracing systems. At various signals in the systems time table telegrams are stored. Deviations of current arrival times are submitted to the traffic control centre for internal use. However, an interface to the multi-modal Traffic Management Centre (VZM) exists and is used.

3.6.2 Current situation

Berlin: The Berlin light rail network, which is most intensively occupied in the city area, can be subdivided into three parts:

1. North-South: Here the tunnel under the city constitutes a bottleneck

2. East-West: The bottleneck here is the stretch between Ostbahnhof and Westkreuz

3. Ring: Main botteneck is the eastern and southern ring

3.6.2.1 Forecasts

No forecasts have been made so far.

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4 France

4.1 Inter-urban road transport

4.1.1 Introduction

In order to increase the benefit of the private-public French motorway concessionaires congestion analyses play an increasing role in the companies' activities. In particular the real-time estimation of travel times in the case of congestion or as a consequence of accidents is increasingly acknowledged. To improve technologies at the motorway access of Marseille research to compare video-based traffic observation to the conventional induction loop technology is carried out. The advantage is seen in the more precise analyses of conflict situations, in particular at or around intersections.

Research is currently conducted to adopt the U.S. system CLAIRE by the research centre Turner Fairbanks applied by the Federal Highway Administration (FHWA) for observing congestion levels on the interstate highway system

In the report "Financement des infrastructures de transport" the Senate analyses the past public financing of transport infrastructures. Globally the amount of public investments has decreased and this reduction has had many consequences on the different infrastructures of every mode of transport, e.g. congestion. However, an increase of the public investments is necessary to deal with the projected increase of traffic on all transport networks. For that, the Senate describes at the end of the document its priorities for the next investment plan.

4.1.2 National systems for measuring traffic conditions

The French trunk road network is characterised by mainly privately operated and tolled motorways, toll-free national roads operated by the central government and secondary trunk roads operated by local authorities. On the motorways the operation and tolling process naturally generates highly differentiated traffic volume data. For example data from the motorways network of ESCOTA (data produced by the toll service) is provided in (7);

In addition the following means to collect traffic volume data exist:

- Automatic counting posts (1), (7) : SIREDO (automatic counting posts on the motorway network, the national road network and the secondary road network). The SIREDO detector system delivers continuous information. SIREDO is a country-wide system of magnetic loops. These automatic stations are located on the motorway network, the national roads and the secondary road network. In addition to these SIREDO station each province or road concessionaire can collect data in an independent way.
- SIREDO (Système Informatisé de REcueil de DOnnées) is a national information system of the road traffic. In 2002, there were about 1 800 SIREDO station on the national road network. The SIREDO stations can provide much information about road traffic and in an instantaneous way: for each vehicle, it gives presence time, travel-speed, type of vehicle. It can also provide average measures such as vehicle flow, occupation

rate of the road, average travel speed…These data allow evaluating the degree of utilization of the road and eventually organizing an alternative route. In addition to that, the whole data are stored in a data basis.

- Video camera (1) Video camera systems are country-wide installed, depending on the needs of each province and road concessionaire.
- Household surveys, inquiries; Some cities (such as Lyon, Grenoble, Paris…) regularly carry out **household surveys**. Generally this type of surveys are realised every 10 years (for example in Lyon, the last household survey has been realised in 1995. A new survey is now being realised (2005-2006)). Others inquiries are also realised. They can be punctual for little traffic studies (origin-destination surveys) or more global at the level of the city or at regional or national level.

Traffic conditions:

- Automatic counting posts : Magnetic loops (for example travel time can be estimated from measures provided by loop detectors) or pneumatic tubes (3); These data can be collected by the SIREDO station but also by ordinary magnetic loops or temporary pneumatic tubes…
- Video camera can also be used to evaluate travel time: an experiment is currently engaged on a motorway section (A7, North of Marseille) (3);
- Specific vehicles in the traffic flow can measure travel speeds and travel times on chosen routes (static data) (1); These vehicles are floating car data. They "measure" congestion with a specific system called "MiTemps" which determine travel speed and travel time on chosen routes.
- Vehicles on patrol on the road network can provide with information about traffic fluid-ity…(1);
- National police force (1);
- Video surveillance allows visualizing traffic fluidity in real time (1). Besides illustrative web camera pictures video recordings are transferred into traffic flow data measurements. This system is called the Automated Incident Detection (The DAI: Détection Automatisée d'Incidents). It provides information such as traffic flow, travel speed, vehicle types, distance between vehicles, occupation rate… It can also detect incidents such as the presence of a pedestrian, traffic congestion…
- Information about events (congestion, accidents) can also be obtained by road users with emergency call posts (1);

By these measures the following indicators are collected, differentiated by time (peak/off-peak, hour, day, week, month) and by vehicle category (light vehicles, heavy vehicles and motorcycles (7); on motorways, 5 categories of vehicles are distinguished):

- Travel times (2); Travel times are estimated on specified routes depending on the cities, depending on the congestion problems… These measures occur on urban expressways, inter-urban freeways, on national road network, on motorway network, on beltways (for example Paris) and on some urban roads.

- Average daily traffic (7);
- Average annual daily traffic (7);
- Average daily traffic on summer (7);
- Heavy trucks rate (7);

The SETRA (Service d'Etudes Techniques des Routes et Autoroutes) and the DRE (Direction Regional de l'Equipement) regularly publish traffic maps These maps present the average annual daily traffic volumes for light and heavy vehicles. They have to be ordered at SETRA or to any DRE. They are generally updated each year.

Congestion situations appear when the instant demand exceeds the road capacity. It causes the apparition of a queue and the decrease of vehicles speed. Congestion can be defined with (7):

- frequency or number of hours when the level of service is significantly worse than the normal level of service,
- threshold of significant discomfort: vehicles speed begin to be conditioned by traffic volumes,
- threshold of high density traffic: vehicles speed depends on traffic volumes and the overtaking possibilities are reduced,
- threshold of congestion risk: vehicles speed is highly strained and each acci-dent will lead to congestion.

These thresholds can be used for different periods:

- Hourly: a saturation hourly flow is defined. It constitutes the threshold from which traffic conditions are significantly perturbed. For this indicator, it is more interessant to work in both direction;
- Daily: the threshold is based on the daily traffic.

For example, in the analysis of the traffic congestion in the PACA region (Provence – Alpes – Côte d'Azur), the congestion level on a road section is defined by the number of congestion hours or the number of hours when the hourly traffic is superior to the saturation hourly flow, a number of days with a congestion period that means the number of days with at least one hour of congestion and finally the number of days with a daily traffic superior to the discomfort threshold. From the results of this analysis, the hourly flows of saturation vary from 5200 to 6800 vehicles/hour for a road with two lanes per direction and from 7800 to 8000 vehicles/hour for a road with 3 lanes per direction (7).

The observation data is transferred into quality of service indicators by methods of travel time estimate (methodology described in document 2). The methodology used in "Les temps de parcours" (2) can be summarised as follows: Different methodologies are used to estimate travel time, which can be evaluated from the average travel speed. It can also be evaluated with the method of mobile phone tracking. (The document "Les temps de parcours" is not available on the web).

The system "MiTemps" (which is a software performed by the CERTU) is also used to evaluate travel times. In fact, "travel time" is a good criterion to evaluate the level of service of a road. Moreover, this criterion is also necessary in road safety studies and to evaluate the regulation strategies. The results obtained by the software "MiTemps" allow quantifying the evolution of the traffic conditions, to measure the speed of the traffic flow, to compare with the traffic conditions of the alternative routes and to precise queue time and queue length.

The results are used to trigger variable-legend traffic signs for traffic demand management purposes and to serve the growing demand of users towards intelligent traffic information systems.

The road operators are obliged to monitor traffic quality according to level of service as perceived by the users. The analysis of travel times on specific routes is a very relevant means to achieve this objective. This measure particularly helps assessing the impacts of various road safety and regulation measures. The results of the MiTemps software make it possible to quantify the evolution of traffic conditions over time, to measure travel speeds as a basis for incident management, or to evaluate the effect of investment measures, to compare traffic conditions among competing routes and to specify the duration and the lengths of traffic jams.

4.1.3 Current situation

4.1.3.1 General development

Many motorways are currently on the way of saturation (23). They carry the main share of the international transit traffic (that means about 50 % of the freight road traffic in France). This statement is valid for the motorways listed below.

- A1 : Paris-Lille,
- A10 : Paris-Poitiers,
- A6 : Paris-Lyon,
- A36 : Mulhouse-Beaune.

Further affected are the Valley of Rhône and the corridor of Languedoc (A7 and A9) (32), the seven crossing points through the "Alpes" and the two means of access through the Pyrenees: 4.5 millions of heavy trucks cross every year the massif of the Pyrenees.

The toll-free national road network is not more occupied than the motorway network. Although they have to pay tolls, usually transit traffic prefers to drive on motorways than on the national roads because speed is more limited and then the journey is longer on national roads. National roads are more occupied by local traffic and short distances traffic.

According to the analysis on traffic congestion in the region of PACA (Provence-Alpes-Côtes d'Azur) (in 2002), the most congested time periods depends on the type of roads. The determination of these most congested time periods have been defined through an analysis of the 100 hours the most loaded on 1 year (7).

- On motorway sections, far from the cities, the 100 hours the most loaded are concentrated in July and August and also on April, May and June (during the long week and Easter holidays). Five sections are particularly concerned: Lançon, East of Aix en Provence, St Maximin, Antibes and Menton.
- Around Marseille: the most loaded hours are equally distributed on each month of the year except on August.
- Around Toulon: on the east side of Toulon, the most loaded hours are in the beginning of the year whereas on the west side of Toulon, they are at the end of the year.
- Finally, around Nice: the most loaded hours appear before and after the two months following the summer holidays (June and September). At the north of Nice, the most loaded hours happen all the year except in January.

The analysis of the present saturation levels (based on traffic volumes of 2002) and the analysis of the predictions for 2020 bring a pessimistic vision of the traffic conditions more particularly near conurbations. The situation in 2002 already shows many saturation points and the predictions for 2020 indicate that the situation will get worse.

Consequently, the impact of road developments will not absorb the increase of road traffic predicted for 2020. Moreover, in the horizon 2020, travel times between the main urban poles will significantly increase. Finally, the road congestion problems would not be solved only by new road developments. That is why, it seems important to combine these road developments with other measures in other domains:

- To change the behaviour of road users: road safety, speed limitation in congestion situations…;
- To study solutions to limit journeys;
- To develop the solutions of alternative modes of transport.

The most affected user groups are the commuting passengers.

4.1.3.2 Results of the PACA congestion study

To prepare the public debate on the LGV (Ligne à Grande Vitesse: high speed line) in PACA (Provence – Alpes – Côtes d'Azur), RFF (Réseau Ferré de France) aimed at receiving a panorama on traffic conditions and road network congestion in the region of PACA, and more particularly on the roads, that permit the same access as the LGV. The study (7), realised by the CETE Méditerranée, first gives a diagnosis of the present situation. Then it gives some predictions for the 2020 horizon.

The synthesis gives the following results:

- Roads accessing to agglomerations are congested in different proportions: from 54 days of important discomfort on the A8 in Aix-en-Provence to more than 340 days in St Laurent du Var.
- More than 70% of the days are superior to the discomfort threshold and more than 45 % of the days present at least one hour of high congestion: on the A8 at the en-

trance of Nice (in St Laurent du Var), at the north of Nice, on the A50 at the entrance of Marseille and on the A51 at the entrance of Aix-en-Provence (Luynes).

- At the entrance of Toulon and between Aix-en-Provence and Marseille (Cabriès), there are between 40% and 60% of the days superior to the dis-comfort threshold. On these sections, days with more than one hour of con-gestion are not so important (between 4% and 7%).
- Significant disturbed conditions are also observed near Lançon (A7), Antibes and at the east of Aix-en-Provence (A8). On these sections, there are between 15 and 30% of the days superior to the discomfort threshold.
- The other sections of the motorway network still benefit from a relative fluidity, without major congestions.
- The volumes of traffic are important on the main road RN98: more than 95% of the days present one hour of congestion. The main roads accessing to Aix-en-Provence are also congested: 77% of the days present at least one hour of congestion on the RN96 in Mayrargues and 63% on the RN7 in St Cannat.

In short, the Mediterranean Corridor, in spite of a very powerful and highly developed infrastructure network, does not escape from a very alarming traffic situation. Figure 4-1 summarises the most important current traffic conditions: the total of all "zones" of saturation and of the "zones" of significant accident risks, represents nearly 40 % of total national roads and motorways.

Source: RFF (2004) (7)

Figure 4-1: Development of travel times in the PACA region 2002 to 2020

These traffic conditions highly disturb the travel times between the main cities, and more particularly at the end of the travel that means downtown: the average travel speed in peak period in the centre of Toulon is about 15 kph, around Marseille it is about 36 kph (and only 16 kph in the centre).

4.1.4 Forecasts

4.1.4.1 National traffic forecasts (all modes)

As the main drivers of traffic congestion the general Increase of the road traffic (7) and in particular the growth of transit traffic (24) are considered.

The analysis realised by the government presents the transport demand projections for the time horizon 2025 (30). As far as passenger transport is concerned, the main assumptions used for this projection are:

- a GDP average growth of +1.9% per year between 2002 and 2005,
- an increase in fuel prices,
- stable prices in railway transport and air transport,
- and the implementation of new road infrastructures.

The results for passenger transport are:

- + 1.8% per year for the horizon 2025 on national road network. This growth is quite low in comparison to the growth rate observed between 1980 and 2002: +3.1%. This difference can notably be explained by saturation phenomenon,
- +1.8% per year for the horizon 2025 on national rail network (without Ile de France) and more particularly 2.6 % for very high speed lines,
- + 1.8% per year for the horizon 2025 for internal air traffic.
- The analysis realised by the government presents the transport demand projections for the time horizon 2025 (30). As far as freight transport is concerned, the main assumptions used for this projection are:
- + 0.36% in road prices (increase in petroleum price included),
- The increase in road infrastructure length (+ 4792 kilometres of new motor-ways between 2002 and 2005),
- The opening (before 2025) of the new railway line: Perpignan – Figueras and Lyon – Turin,
- The opening (before 2025) of the new river infrastructure: the channel of Seine – Nord Europe.

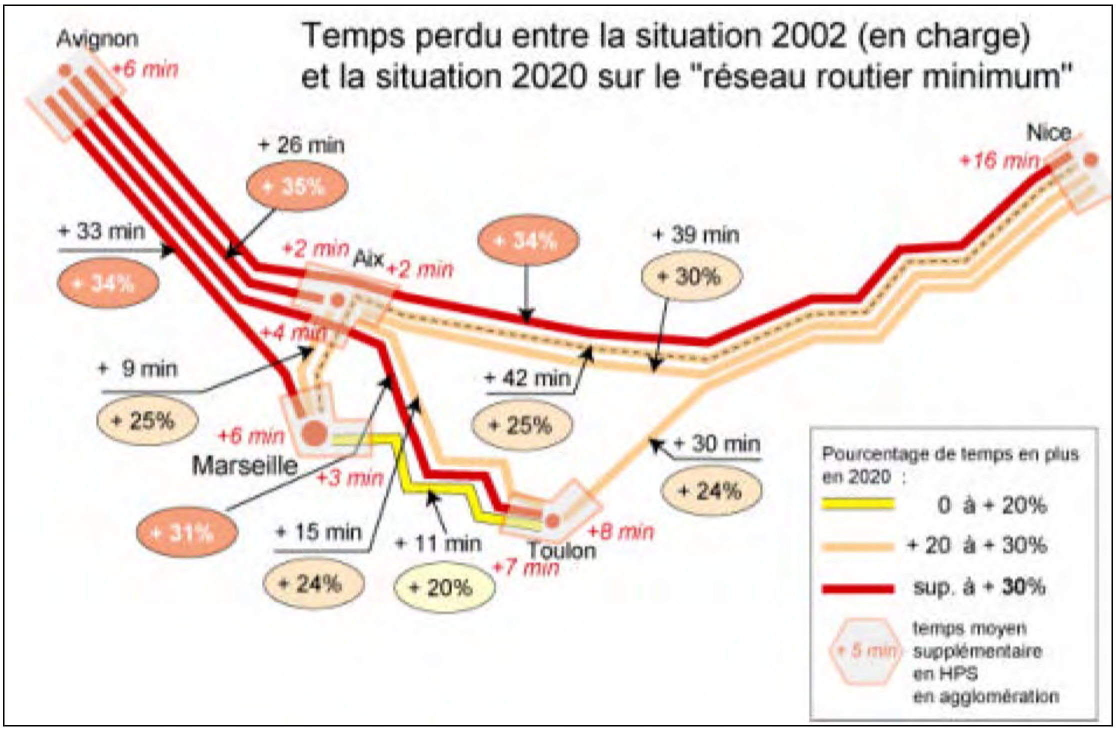
The results for freight transport are:

- + 1.5 % per year of road traffic demand for the horizon 2025,
- + 1.2 % per year of rail traffic demand,
- + 0.5 % per year of river traffic

4.1.4.2 Forecast of the PACA congestion study

The analysis of the PACA congestion proposes a prediction for 2020 horizon based on the following assumptions : GDP average growth of 2.3% per year, coal duty, de-crease by 10 % of the railway price (for passengers), low decrease of the air passen-ger transport…The results of this prediction indicate that the situation will getting worse and very quickly. The impact of road development is low compared to the in-crease of road traffic. Travel times increase dramatically on all the studied sections (7);

Figure 4-2 gives an estimate of the average wastes of time, between the situation 2002 and the situation 2020 under the assumption of a constant network. The worsening of travel times is very sensitive to the principal agglomerations within the PACA region, driven by the urban peak hour conditions.



Source: RFF (2004) (7)

Figure 4-2: Development of travel times in the PACA region 2002 to 2020

The analysis of the evolution perspectives in the valley of the Rhône and in the corridor of the Languedoc indicates that the traffic conditions will get worse on the A7 and the A9 within the coming 20 years. These predictions are based on the following assumptions: a GDP average growth between 1.9% and 2.3%, a barrel price between 60 $ and 100 $ and different infrastructures developments (32);

4.1.5 Policy plans

Policy plans to fight congestion in the future envisaged are:

- Change of the road-users behaviour: road safety, speed limitations in disturbed conditions…(7);

- Study on solutions to limit journeys: land-use planning and development (7);
- Development of alternative transport solutions: urban and inter-urban public transport (7);
- Development of a inter-urban traffic management plan: the aims of this plan is to limit the effects of unpredictable and predictable disruptions on a corridor, a network or a specific zone. It must also contribute to the road-users safety (9);
- Implementation of congestion pricing (10);
- Develop freight river transport to reduce freight road transport (24);

4.1.6 Use of the congestion information

In the case of the analysis of the PACA congestion, the information on traffic conges-tion is used to justify the setting up of the rail high speed line in the region of PACA.(7)

Information on traffic congestion is used to calculate congestion costs from time lost and depending on the type of roads and vehicles (light or heavy) (33). As far as this study is concerned, the main objectives are to make road users aware of the infrastructure costs and to evaluate properly the road occupancy rate. These indicators are congestion marginal cost, external cost of insecurity, environmental costs (noise effect, air pollution and greenhouse effect)

4.2 Urban road transport

4.2.1 Measuring congestion

4.2.1.1 General methods of congestion detection

In French urban areas traffic volumes and traffic conditions are measured by:

- Automatic counting posts;
- Manual traffic counts and observation of the urban saturations;
- Origin-Destination surveys; Each city can organize its own Origin-Destination surveys. Consequently, there are many O-D surveys in Paris: they can be O-D surveys led by public transport, O-D surveys led for traffic studies in a particular zone…There were households transport surveys in Paris in 1994, 1997, 2002, and a new one will be launched soon.

The system CLAIRE is also used to "measure" traffic conditions. This system has been performed by the INRETS (Institut National de REcherche sur les Transports et leur Sécurité). It can be used with different systems of regulation. CLAIRE is used to detect road saturation, to determine the causes of this saturation, to store these data and to propose actions to reduce congestion such as solutions in regulation at light controlled crossroads…(1), (3);

A new tool is being developed by the INRETS (Institut National de REcherche sur les Transports et leur Sécurité): a congestion observatory. This system classifies the dif-ferent congestion patterns observed on a day, a month or a year. Many congestion indicators are stored: km*h, frequencies, length…(3);

The measures collect the following data differentiated by time segments (peak and off-peak periods, hourly, daily, weekly, monthly and annually) and by vehicle categories (light vehicles, heavy vehicles and motorcycles (7)):

- Traffic loads (daily and hourly) (1);
- Travel speed (1);
- Travel time (1),(2);
- Estimation of transit traffic, exchange traffic and internal traffic;
- Length of saturation queues, measures of the waiting times;

Measures are regularly performed: it can be monthly, quarterly, annually…It depends on the importance of the town and on the importance of roads studied. For example, in Toulouse and its suburbs, the 60 automatic counting posts on urban expressways provides with measures every 6 minutes. On urban roads, measures are provided every 3 minutes by 400 counting posts (1);

In big cities, some automatic counting posts are permanent. They are often located on main urban roads or secondary urban roads; Towns also have databases formed by automatic counting or manual traffic counts realised for urban studies or traffic studies and some towns publish each year a collection of road count. In Lyon, each year the commune of Lyon collects traffic volumes with permanent counting posts on the main roads. The map below indicates daily traffic volumes in the 1st arrondissement of Lyon in 2004.

Figure 4-3: daily traffic volumes in the 1st arrondissement of Lyon in 2004.

The main goal of the study "Traitements des données de trafic – Besoins, Etat de l'art, Exemples de mise en œuvre" financed by the French government 2000 was to create a tool of traffic data processing for the city of Toulouse and its suburbs. However, the results are easily adaptable to other local contexts. The study presents different methods to measure and evaluate traffic data. It also details the technical characteristics of a data processing system according to the three following steps: the data qualification, filtering and calculation of the data and finally prediction of traffic conditions. As far as "congestion" is concerned, the report deals with the different ways to determine congestion both on expressways and urban roads. It also presents information on congestion measurements, processing of congestion data and the implementation of European projects such as ANTARES, QUARTET+ and CLEOPATRA.

Time series of travel speeds and the extent of traffic jams in Paris are recorded by the prefecture of the district Ile-de-France. The results of the measurements are provided at the web site www.sytadin.equipement.gouv.fr. Usually traffic data are free and can be ordered at the communities. The website also provides the road users with real-time information about traffic conditions on the urban freeways of the network of Ile de France. Other useful information are also available on this website: indicators used to define congestion, methodology to collect and process data....

Each four-month period, the website product statistics such as general data about mobility in "Ile-de-France", tools used to "know" traffic and global analyses on each part of the network monitored (traffic evolution, traffic volumes, time spent in traffic, travel speeds, traffic congestion...) gives an illustration of the situation at 2.3.2006, 14:22 h.

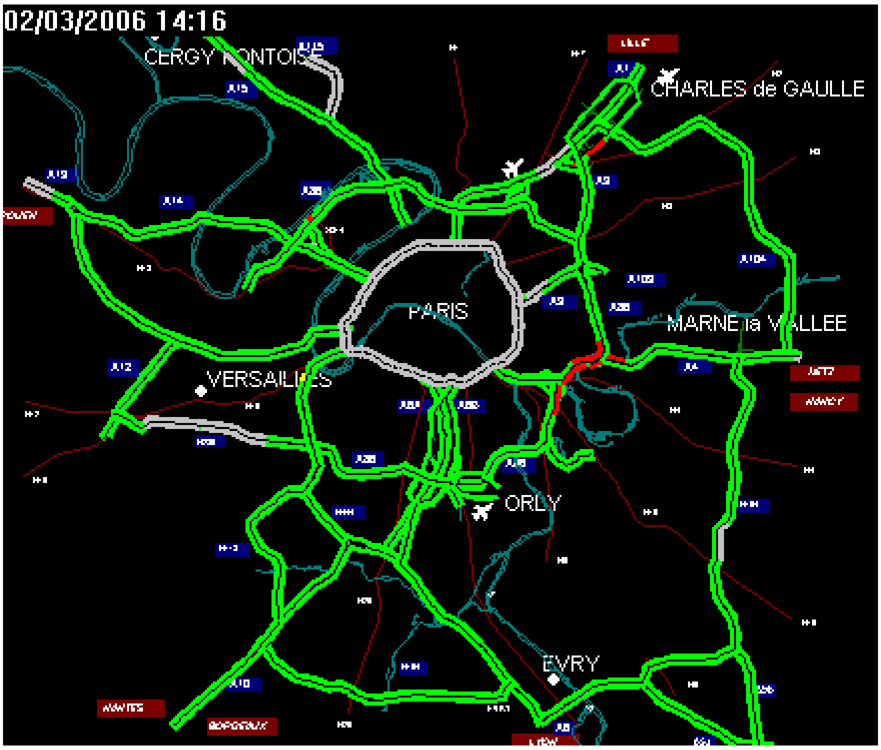


Figure 4-4: Traffic condition on Il de France

Sources:

http://www.sytadin.equipement.gouv.fr/ensavoirplus/stats/pdf/stats_reseau_sirius_2003.pdf

http://www.sytadin.equipement.gouv.fr/ensavoirplus/stats/pdf/Deplacements_VRU_3Q_2004.pdf

4.2.1.2 The congestion control system CLAIRE

The software CLAIRE was developed by the French ministry of transportation as an expert decision making system for real time traffic management between 1984 and 1990. CLAIRE can detect the onset of traffic congestion, determine its cause, and predict how it might develop. Using historical data and real time data, CLAIRE recommends solutions to relieve congestion. Traffic engineers throughout its development have validated the methodology used by CLAIRE. A simulation assessment of CLAIRE has demonstrated clear reductions for drivers in travel time, number of stops, and fuel consumption. CLAIRE has been operating as an automatic system in Paris since 1990.

CLAIRE uses symbolic calculus and deductive methods to process quantitative and/or qualitative information. CLAIRE can be divided into two subsystems. The first subsystem runs online and puts into effect procedures to remedy the current traffic conditions. The second subsystem runs off-line and consists of a congestion recognition function and a learning function.

CLAIRE helps the basic control system adapt to the congested traffic conditions. When the congestion is diminished, CLAIRE returns the control to its initial state. CLAIRE manages a longterm memory of previously recorded congestion and gridlock scenarios and is capable of recognizing previously recorded traffic situations. A history of the congestion problem can be generated off-line and the learning function can broaden the solution database with newly developed congestion management strategies.

4.2.2 Congestion indicators

In the analysis of the traffic congestion in the PACA region (Provence-Alpes-Côte d'Azur), the following indicators are used to define urban congestion (7):

- Vehicles * travelled kilometres : this indicator characterizes the network load proportionately to the length of the route,
- Vehicles * time spent on the road section: this indicator characterizes the occupation time by road users on a particular section.
- Annual average speed in comparison to the speed limitation

Methods of travel time estimate (methodology described in document 2). This book deals with the estimation of travel time: what is the travel time? How it is measured? Which means are used to give the information to road-users? The content of the book is: the utilization of travel time, the presentation of the different methodologies used to estimate travel time in real time, the presentation of the methodology used to evaluate the travel time on urban express ways, on inter-urban motorways, the presentation of the methodology used to evaluate the travel time with the mobile phone tracking, the presentation of the estimation and the diffusion of travel time on urban express ways in the Parisian region, on the Parisian beltway, on the urban ways in Paris, on the motorways, on the national network and in the other countries.

In (5) a global and a local congestion indicator for urban areas is proposed and demonstrated for the cities of Montpellier, Nice and Lille. These two indicators evaluate congestion from two observations: real travel speed (speed evaluated from the speed-flow function) and free travel speed (maximum speed allowed by road geome-try) . The global congestion indicator provides with a global view of congestion on the road network. And the second indicator gives information about local congestion. The results vary between 0 and 1. 0 indicates a completely congested network whereas 1 indicates a perfect fluidity.

This methodology of the congestion indicator is based on the following assumptions:

- modelling of road networks and traffic;
- Congestion function with traffic flow curves;
- Definition of the shortest paths;
- Definition/ computing of congestion indicators

Two indicators are calculated: one general and one local.

- General congestion indicator: ratio between the sum of observed (computed) speeds on the charged network, on all roads segments at a given time and speeds of the network free of charge. If the indicator = 1, the network is fluid, if it is =0 there is saturation.
- Local congestion indicator: similar to the general congestion indicator but computed by road segment.

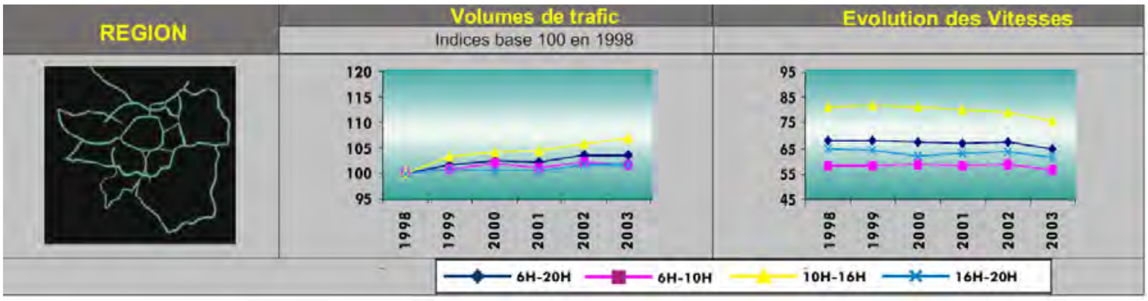
4.2.3 Current situation

4.2.3.1 Paris

On the basis of traffic observations the prefecture of the region Ile-de-France publishes annual statistics on travel speeds by time of day and the share of congested road space. The data reported is differentiated by:

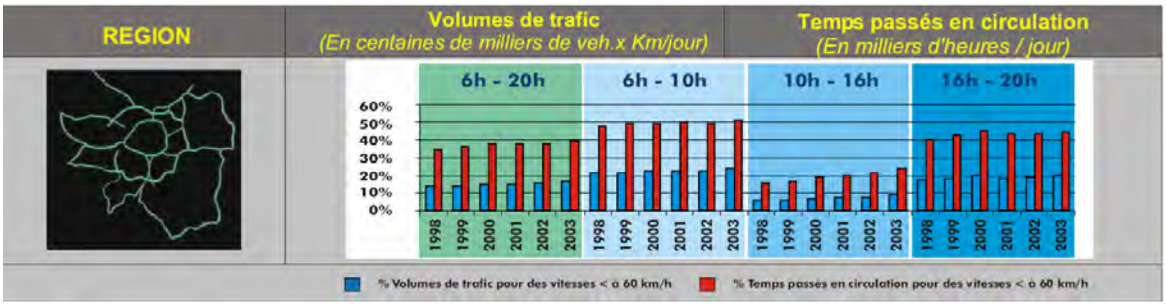
- Time of day (6:00 – 10:00, 10:00 – 16:00, 16:00 – 20:00), by
- Type of networks (two groups of radial roads and two ring roads) and by
- reason (recurring congestion, incidents and blockades / road works)

Some results are presented in Figure 4-5 to Figure 4-7 below for the period 1998 to 2003.



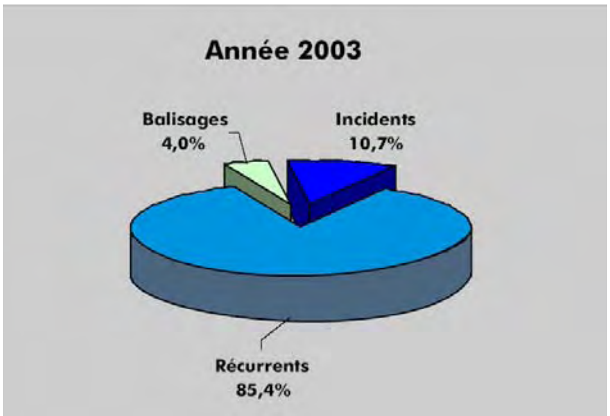
Source: (34) - Prefecture de la région d'Ile-de-France (2005)

Figure 4-5: Average speeds in Ile-de-France 1998 to 2003



Source: (34) - Prefecture de la région d'Ile-de-France (2005)

Figure 4-6: Vehicle kilometres at a speed < 60 kph in Ile-de-Freance 1998 to 2003



Source: (34) - Prefecture de la région d'Ile-de-France (2005)

Figure 4-7: Congestion reasons, Ile-de-Freance 2003

4.2.3.2 Other urban areas

Today, many urban bottlenecks have been identified such as (23):

- The region of Paris,
- The region of Lyon,
- The region of Bordeaux.

For passenger transport, the most congested time periods are week peak periods, holidays and above all the Friday evenings, where the most affected user groups are the commuting passengers.

Under the assumption of 100 vehicles per lane and km in congested conditions and a value of time of 13.3 Euro/vehicle-hour, the volume of congestion on urban freeways is about (24) (the main topic of the document is the development of waterborne traffic but the first part of the document deals with the problematic of road congestion).

Table 4-1: Congestion values of French urban freeways

Agglomeration	**Length (lane-km) * duration (hours) of traffic congestion**	**Monetary costs (million €)**
Ile de France	644.000	857
Lyon	56.000	74
Lille	50.000	67
Others	1.880	3
National	751.880	1.000

Source: (24) : "Développement des trafics fluviaux"

The evaluations provided in Table 4-1 are to be considered with much care as the underlying figures from (24) are not detailed enough. Consequently, it seems delicate to evaluate congestion in hours*kilometres and in monetary cost for the other freeways and for the national urban freeway network.

The local congestion or "fluidity" indicators proposed by (5) are presented by Figure 4-8 for Montpellier and Figure 4-9 for Lille. The results of global congestion indicators are 0.68 for the city of Montpellier and 0.72 for the city of Lille. The results of local congestion indicators show an intensive congestion on the road network in Montpellier and an extended congestion on the road network in Lille (5).

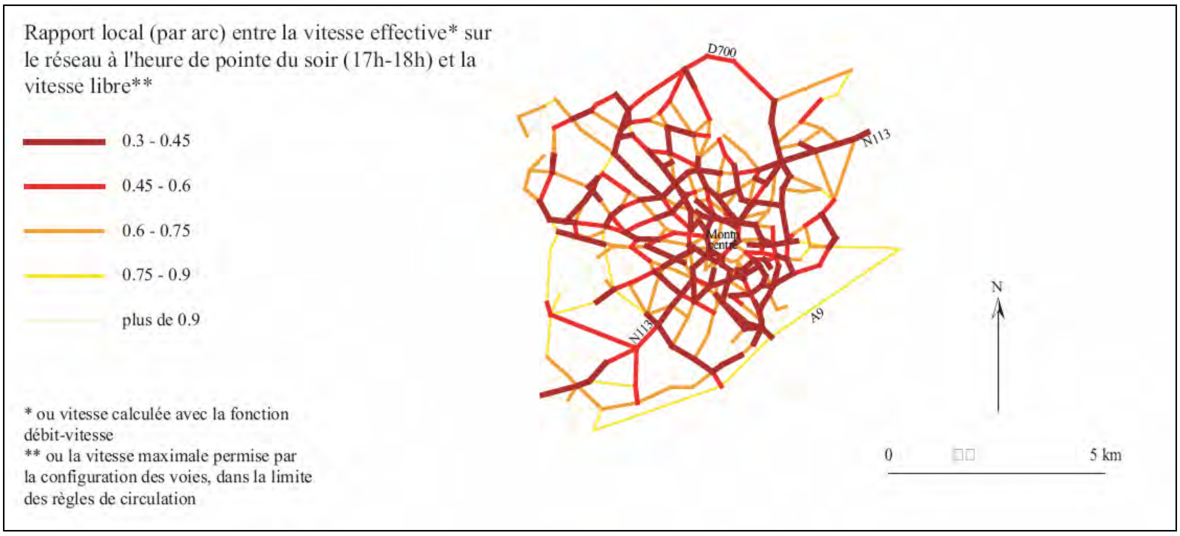


Figure 4-8: Local congestion indicator for Montpellier

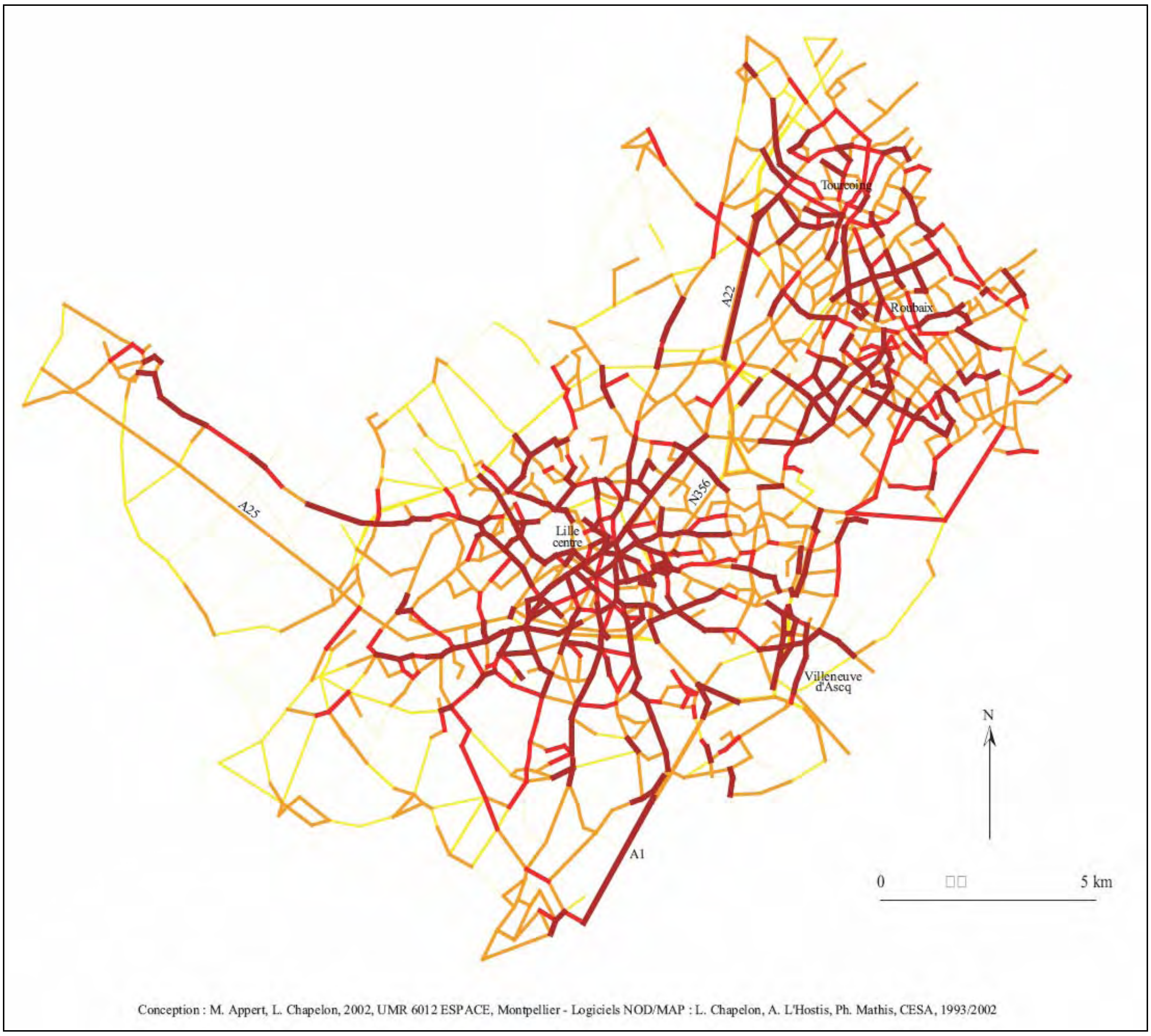


Figure 4-9: Local congestion indicator for Lille-Roubaix-Tourcoing

According to (24 the main drivers of traffic congestion are the quality of infrastructures and transit traffic.

4.2.4 Forecasts

The analysis of the PACA congestion study (7) predicts that the situation on urban and inter-urban roads will get worse very quickly. The impact of road development is low compared to the increase of road traffic. Travel times increase dramatically on all the studied sections (7);

4.2.5 Policy plans

Congestion pricing (8): Presentation of different methods of congestion cost evaluation:

- Method of the INRETS (Institut National de REcherche sur les Transports et leur Sécurité): this method evaluates the costs of congestion for road-users who do not directly participate to the traffic congestion. For that, three costs are calculated: additional annual expenses required for public network be-cause of the intensive traffic congestion, evaluation of time lost for the road-users on the basis of hourly income, evaluation of time lost for pedestrians and cyclists by applying an increase by 10% to 20% for the travel time due to traffic congestion and also evaluated on the basis of hourly income. The global amount evaluated by this method varies between 2.3 billion of euros to 4.4 billion of euros.

- Method of the CGPC (Conseil Général des Ponts et Chaussées): the mar-ginal cost of congestion corresponds to the cost of lost time imposed by road-users to the other users. This approach consists of determining the time losses due to the introduction of an additional vehicle in the traffic on a one-kilometre section. It finally corresponds to the lengthening of travel times. The evaluation of this lost time is made on the basis of the value users implicitly attribute to their time. The global cost can be evaluated by the multiplication of this time value by the amount of lost time and the volume of traffic.
- According to an article published in the CCFA (Comité des Constructeurs Français d'Automobiles), congestion cost is not considered as an external cost linked to car. Indeed, according to the author (Christian Mory), motorists are the first users penalized by congestion. Consequently, the cost corre-sponds to an internal cost.
- The study led by D. Oica does not take into account congestion costs. Indeed, cost evaluation is difficult and there are many different evaluation methodologies. Moreover, some references show that congestion costs are al-ready highly internalised (Traffic jams mainly penalize motorists, who then suffer from lost time). In this study, the quality of the infrastructures is also considered as an important driver of traffic congestion. Consequently, con-gestion costs are not considered as external costs.
- Consequently, congestion costs are already highly internalised. Indeed, according to this study, congestion cost does not constitute social costs.
- The method INFRAS/IWW is based on a comfort theory that defines lost time as a misuse of existing infrastructure. The congestion cost is defined from a traffic function and so, only applied on road transport. The global congestion cost is defined as the difference between marginal social cost and the aptitude of users to pay for an optimum infrastructure level of service. Two mod-els are used for urban and inter-urban travels. These models are based on data basis on traffic characteristics and variables such as time value for each transport mode, average number of passengers per car…Example: time value is deduced from a model called ETS (1998). One hour of professional travel is worth 21.44 €. According to the model FISCUS (1999), a private travel is worth only 25% of this amount. Finally, lost time in traffic congestions in France is about 5.2 billions euros. The users aptitude to pay would correspond to incomes of 37.8 billion euros in France;

Urban pricing: In urban context, congestion pricing will not lead to fluidity. Indeed im-proving traffic conditions in an urban context will inevitably lead to an increase in the demand. So, the way of pricing in urban context have to change. Both cost and duration of travel have to be treated. Increasing prices and reducing speed are efficient solutions. The method of speed reduction is currently widespread in different Euro-pean cities. The first solution (increasing prices) can be implemented through the parking pricing but also through an urban toll (10);

- Toll (10), (11);

- Parking pricing (10), (11), (30)
- Fuel charging (11);
- Vehicles charging (11);
- Pricing per kilometre (11);
- Public transport subsidies (11);
- Implementation of "High Occupancy Toll lanes" (11);
- Implementation of "High Occupancy Vehicles lanes" (11);
- Negotiable licence (11): public authorities create a certain number of licences to authorize a certain traffic volume. The quantity of licence produced depends on the objectives in term of traffic volume (pollution…). Then licences can be sold between the different road-users.
- Develop freight river transport to reduce freight road transport (24);

In the analysis of traffic demand projections realised by the government (30), policies envisaged to fight congestion are:

- -Control of local mobility : For short travels (inferior to 3 kilometres), modal shift to bike or walking would allow a decrease of 4 billions vehicles-kilometres; For longer travels, a supply growth in urban public transport would allow a modal shift of 4.3 billions vehicles-kilometres for urban travels,
- -Parking policies and space sharing are powerful tools to regulate the use of car in the centres of towns. These tools would allow a decrease of 9 billions vehicles-kilometres.
- -Control of peri-urbanisation phenomenon could concern between 5% and 10 % of the local traffic, that means about 20 billions vehicles-kilometres,

These different policies are not independent, they complement each other. So, globally, stakes can be evaluated at about 10 billions vehicles-kilometres with transport and parking policies and at about 20 billions vehicles-kilometres with urban management policies.

Information on traffic congestion is used to provide real time information for the road users thanks to the variable-legend traffic signs

4.3 Rail transport

4.3.1 Measuring congestion

Measurement of traffic volume and delay data:

- Transport plan: each year, RFF (Réseau Ferré de France) realises a transport plan, that means a database which predicts time table for each train;
- Retroactive base: this base records the real traffic flow in comparison to the predicted time table. Measures collected are not performed;
- In some regions, there is also a database relating to delays.

Measuring travel times, delays and traffic volumes on the entire network differentiated by hours and by the following train classes in passenger transport according to lines:

- -railway traffic around the region of Paris (14),
- -radial lines without very high speed train (14),
- -radial lines with very high speed trains (14),

for passenger and freight transport data are differentiated by type of locomotive (that means the train speed): for example Very High Speed Line have a travel speed of 220 km/h, TER (Transport Express Régional) have a travel speed of 140-160 km/h, heavy trains have a travel speed of 80-100 km/h….

To charge the SNCF for using RFF's infrastructures, RFF uses some captors located on many sections of railway lines. These captors provide real time information. These data are only used for invoicing, but could be used for other purposes in the future. The data is published by the referent document of the Réseau Ferré National. This document can be found on www.rff.fr/pages/docref/autre/accueil.asp?lg=fr.

4.3.2 Definition of congestion

Normally, there is no "congestion" in the rail transport: Indeed time tables organize rail traffic flow in order to avoid congestion. But railway lines are considered as being saturated when a demand of regular slots cannot be accepted because of insufficient capacities.

Even if the theoretical capacity is respected (about 12 slots/hour/railway because of security conditions), "congestion" phenomenon can appear. Delays are an indicator of this rail traffic "congestion" (17). Delays superior to 5 minutes are considered as congestion.

Passengers' congestion can be defined by the comparison between the number of passengers observed and the maximum capacity of the train/coach. (16)

There are no studies specifically based on congestion problems. Generally, studies concerning congestion are more particularly focused on new infrastructures to solve congestion problems or bottlenecks. Speed-flow curves for rail transport are currently in the process of being realised.

4.3.3 Current situation

In passenger transport the "Paris-Lyon" high-speed line is the most heavily trafficked on the French network. In the medium term, it will experience saturation problems. Cur-rently, the capacity of the railway line is already completely used. Conse-quently, there are some problems of irregularity. In 2004, the percentage of train on time for the South-East high speed line is about 82,2% (the percent-age for the North high speed line is about 87.1% and 86.3% for the Atlantic high speed line). Today, the main possibility to gather capacity is to increase the volume of passengers transported. Actions on prices and on quota of re-duced rates are also practiced by the SNCF (15),

Other lines are also heavily trafficked such as the slot of Lorraine, the plain of Alsace and finally the line Paris-Le Havre, Further, main nodes of the rail networks are congested. They constitute bottlenecks and often amplify delays of trains. Apart form Paris, these bottlenecks are lo-cated in Lyon, Toulouse, Bordeaux and Lille (17),

In the valley of the Rhône and in the corridor of the Languedoc, the main saturation points are Lyon, Marseille, Nîmes, Montpellier, Sète and Nar-bonne. The main congested railway lines are Nîmes – Montpellier, Arles – Marseille, Aix-en-Provence – Marseille and Nice – Cannes.

In freight: the most loaded railway lines or nodes are:

- The “Magistrale Ecofret”: it is constituted by a main branch between Metz and Marseille and some axis at the North: Great-Britain/Benelux/Germany and Lorraine then Le-Havre/Lorraine/Dijon and also Lyon-Italy and Nîmes-Spain,
- The Atlantic Ecofret,
- The slot of Lorraine (between Metz and Nancy),
- The node of Dijon,
- The node of Lyon,
- The node of Montpellier.

For passenger transport, the most congested time periods are week peak periods, holidays and above all the Friday evenings, where the most affected user groups are the commuting passengers.

4.3.4 Forecasts

Passengers transport: Projected development of traffic congestion for the high speed line “Paris-Lyon”: With an annual growth of the traffic of 1.8% per year (without new pro-ject), the traffic in 2012 will increase by 15% (without new project). It is as-sumed that half of this 15% could be absorbed by bigger or additional cars in trains. The other part of this additional traffic requires bigger capacities. To conclude, traffic predictions for 2012 indicate that saturation will grow and will appear on longer periods than currently (15).

As main drivers of congestion and delays the following items are identified:

- Limitation in equipment capacity (15), (16);
- Planning problems (17);
- Since the allocation of slots is organized by the transport plan, congestion problems should not exist. However, the differences of travel speed between trains can cause congestion problems, that means delays.

4.3.5 Policy plans

Project of a 13th slot for the high speed line “Paris-Lyon” (15).

Use of equipments with bigger capacities:

- High speed lines with 2 levels (16);

- Use of efficient control system (16);
- Optimising the use of the infrastructure more particularly during off-peak peri-ods. For that, it is necessary to raise prices when there are lacks in infrastruc-tures or equip-ments and to reduce prices to increase traffic volumes during off-peak periods (16);

Thanks to these measures, the capacity would reach 4 times the current traffic on the South-East high speed line (that means the most congested line today). Comparisons with interna-tional networks show that such a level of capacity is possible (16).

- Improve the quality of planning (17);
- The system of infrastructure fee is already applied in the rail transport. Prices depend on the period of the day: using railway lines during peak-periods is more ex-pensive than during off-peak periods (nights) or during normal periods. To reduce congestion, RFF could intensify the difference between prices.

The EU White Paper encourages projects that permit exchange between European countries. This can have an effect on the development of new infrastructures which could facilitate these exchanges. Projects of bottlenecks bypass belong to this type of projects since they bring fluidity on exchange lines: freight bypass of Lyon, bypass of Montpellier, bypass of Bor-deaux…

The ERTMS (European Rail Traffic Management Systems) project will contribute to reduce congestion problems. In fact, this system will coordinate the signals between the different European countries. This measure will help train drivers and so it will reduce delays and breakdowns.

4.4 Waterborne transport

4.4.1 Measuring congestion

For maritime shipping satellite pictures (19) and radar (19) is used to support the annual measurement of the following indicators:

- For maritime shipping: Traffic volumes (19),
- For waterways: traffic volumes by type of goods and type of traffic (20), tonnage shipped by type of boats (20), traffic densities (20) and tonnage by river port (20).
- For seaports: data on the activities of ports in France, European neighbour countries and overseas (21), traffic data by type of goods (21), traffic data by type of condition-ing (21), traffic data by countries (21)and passenger traffic data (21).

The data is differentiated according to vessel types as follows:

- For maritime shipping: cargos and bulk carriers (19), oil-chemical tankers and container ships (19) and roll-on roll-off, methan tanker (19),
- For inland navigation: powered craft (20), pushing by power craft (20), pushing by tug (20) and towed (20),

Data are also differentiated by type of traffic: expeditions (20), inbounds (20), inland traffic (20) and transit (20).

Data publication in the field of Inland navigation: each year the "Voies Navigables de France" (VNF) publish statis-tics about inland navigation (20); For seaports the French department of transport publishes each year a statistics book that presents the activity results of seaports (21);

4.4.2 Current situation

The most congested inland and maritime shipping network parts in France are:

- River terminals : terminals of the Rhineland, South-West terminals (24);
- Autonomous port of Marseille (24);

In western Mediterranean, the maritime traffic is more important during holiday peri-ods and more particularly in July (accumulation of activities: economy and tourism) (19).

4.5 Aviation

4.5.1 Measuring congestion

The DGAC regularly publishes statistics about passengers traffic;

Delay observatory: The CNCA (Conseil National des Clients Aériens) has imple-mented a delay observatory for the French aviation (28), (29);

The measures determine the following indicators on an annual basis for all flights at international airports:

- passengers traffic volumes: departing and arriving passengers (25);
- delays on departures and arrivals (25);
- percentage of flights on time and delayed (on departure or arrival) (25);
- average delay in comparison to the number of flight realised (25);
- average delay in comparison to the number of flight delayed (25);
- classification of delay causes (25);
- data provided by the delay observatory: causes of delays, punctuality of flights, average time of delays, evolution of the average time from 2000, distribution of the passenger traffic by airport (29);

Data are differentiated by the nature of flights:

- commercial aviation which represents about 88% of the global aviation traffic (26);
- general aviation (26) ;
- business aviation (26) ;

Data are also differentiated by type of flights:

- domestic flights (26);

- international flights (26);
- overflights (26)

In aviation, congestion is revealed by the importance of flight delays (26). The simultaneous presence of several aircrafts in a same airspace is also an indicator of air congestion (27)

4.5.2 Current situation

The key results of air traffic congestion are:

- Identification of the causes of congestion (delays) (26): the main causes of delays in aviation are due to a lack of capacity in the air control:
- the capacity of the infrastructure are limited,
- There are coordination problems between European countries: Many losses of time are due to heterogeneous administrations and systems of security.
- The behaviour of airlines companies: For competition, airline companies have more and more attractive prices which attract more and more passengers.
- The re-organization of air network in hubs have encouraged airline companies to use bigger aircrafts and so to increase their capacity and their traffic,
- Competition between airline companies has also implied the increase in frequencies.
- Evaluation of congestion costs (26): the cost of delays in air transport in Europe and due to air control was between 6.6 and 10.7 billions of equivalent euros in 1999.

The most congested time periods are:

- For a year: summer holidays (26);
- For a week: on Fridays (26);
- For a day: there are two peak-periods: in the morning and at the end of the afternoon but the traffic volume does not decrease between the two peak-periods (26);

The main drivers of congestion traffic and so the main drivers of flight delays are:

- Air navigation: it is responsible for 35% of flight delays (26);
- Air control: The lack of capacity of air control (in charge of the aircrafts supervising) is responsible for 68% of flight delays. This includes the limited capacities of the infrastructure (spacing standards, restrictions of civilian airspace for military flights) and the coordination problems between European countries (26), (28);
- Behaviour of airline companies: increase in flight frequencies and reduction of prices. These measures lead to a high level of air traffic and an important concentration of flights (26), (28);

4.5.3 Policy plans

Policies envisaged to fight congestion are:

- Use of aircrafts with bigger capacities (16);
- Use of efficient control system (16), (28);
- Optimisation of air traffic flow management (27), (28): Currently, the method of air traffic flow management is based on the following strategy: the first aircraft arrived is the first accepted. This method does not allow the optimisation of airspaces. To optimise capacity, a new method is proposed, it is based on stochastic optimisation method;
- Acting on the demand to compensate the current lack of capacity of the supply: applying user-fees depending on the capacity of the aircraft: the bigger the aircraft is, the cheaper the fees will be (26) and applying a price discrimination depending on the time and space peaks e.g. the priority pricing : the longer an aircraft waits, the cheaper the airline com-pany will pay (26);
- Coordination on the European level (28);

4.6 Paris urban public transport

4.6.1 Methodology

Traffic volume and delay information is generated from time tables and automatic operating systems by collecting real time localisation of bus, tram, metro, etc. and evaluating delays.

The periodicity depends on the network: it can be continuously if the urban public transport network is equipped with GPS. This is the case for Paris for the bus network, in Lyon for the bus and the tramway network, in Grenoble for the tramway network…

Globally, renewed public transport networks are often equipped with this GPS system.

Data are differentiated by type of transportation: bus, tramway, trolley and underground…

4.6.2 Key results – current situation

Public transport delay is a problem specific to urban agglomeration centres.

4.7 Literature review

In the course of the case study an extensive literature review has been carried out. The sources referred to in the text above including abstracts are listed in term, grouped by thematic areas. Further information, including the freely available PDF files, is available through the COMPETE congestion literature database, which is provided with this report.

4.7.1 Inter-urban and urban roads

4.7.1.1 Measurements and processing of traffic data

1. L.Bréheret, F.Schettini, E.Bernauer, M.Barbier 2000: "Traitements des données de trafic – Besoins, Etat de l'art, Exemples de mise en œuvre". Study within the framework of the « Programme national de REcherche et D'Innovation dans les Transports terrestres », PREDIT (1996-200). http://www1.certu.fr/catalogue/scripts/pur.asp?title_id=469&lg=0
   <u>Abstract</u>: *The main goal of this study is to create a tool of traffic data processing for the city of Toulouse and its suburbs. However, the results are easily adaptable to other local contexts.*
   The study presents different methods to measure and evaluate traffic data. It also details the technical character-istics of a data processing system according to the three following steps: the data qualification, filtering and calculation of the data and finally prediction of traffic conditions.
   As far as "congestion" is concerned, the report deals with the different ways to determine congestion both on expressways and urban roads. It also presents information on conges-tion measurements, processing of conges-tion data and the implementation of European projects such as ANTARES, QUARTET + and CLEOPATRA.

2. CERTU, CETE Sud-Ouest (2002): "Les temps de parcours". Report.
   http://www1.certu.fr/catalogue/scripts/pur.asp?title_id=663&lg=0
   <u>Abstract</u>: *This document deals with the indicator of travel time: How is travel time defined ? By which means is travel time measured ? Which means are used to inform road-users ?*

3. http://www.inrets.fr/ur/gretia/intelligentsdest.html
   <u>Abstract</u>: *On this web document, the INRETS (Institut National de Recherche sur le Trans-port et leur Sécurité) gives in-formation about the traffic indicators, the evaluation of transport network performance (capacity evaluation, congestion evaluation), traffic control and traffic management in disrupted conditions (accidents and conges-tion).*

4. http://www.sytadin.equipement.gouv.fr
   <u>Abstract</u>: *This website provides the road users with real-time information about traffic conditions on the urban freeways of the network of Ile de France. Other useful informa-tion are also available on this website: indicators used to define congestion, methodology to collect and process data….*
   Each four-month period, the website product statistics such as general data about mobility in "Ile-de-France", tools used to "know" traffic and global analyses on each part of the network monitored (traffic evolution, traffic volumes, time spent in traffic, travel speeds, traffic congestion…)
   http://www.sytadin.equipement.gouv.fr/ensavoirplus/stats/pdf/stats_reseau_sirius_2003.pdf
   http://www.sytadin.equipement.gouv.fr/ensavoirplus/stats/pdf/Deplacements_VRU_3Q_2004.pdf

5. M. Appert: "Dynamiques territoriales méditerranéenne : dynamiques urbaines méditerra-néenne – Evaluation de la congestion des réseaux routiers urbains : les cas de Montpellier, Nice et Lille". Report. http://www.umrespace.org/pages/Appert.pdf
   <u>Abstract</u>: *This report evaluates traffic congestion through the application of eight indica-tors on different urban road net-works such as the network of Montpellier, Nice and Lille.*

4.7.1.2 Traffic modelling

-P. Berthier (1998)"Congestion urbaine : un modèle de trafic de pointe à courbe débit-vitesse et demande élastique"
Abstract: Many studies have shown the importance of external costs of road congestion, especially when peak-periods appear. But the modelling of road congestion subject to peak-periods generally uses a bottleneck model, without the classical travel-time function used in models without peak-periods. This paper tries to synthetise these mod-els, which are in fact complementary and presents a peak-period model in which the relation is rein-troduced. This relation is here considered as a relation between speed and distance be-tween cars. The model also intro-duces cost-sensitive demand.

7. CETE Méditerranée (2004) : "Analyse de la saturation routière en PACA" (Provence – Alpes – Côte d'Azur). Report. http://www.debatpublic-lgvpaca.org/docs/pdf/etudes/saturation_routiere/LGV_PACA_synthese_RFF_saturation_routiere_nov_2004.pdf
Abstract: To prepare the public debate on the LGV (Ligne à Grande Vitesse: high speed line) in PACA (Provence – Alpes – Côtes d'Azur), RFF (Réseau Ferré de France) wanted to have a panorama on traffic conditions and road net-work congestion in the region of PACA, and more particularly on the roads, that permit the same access as the LGV.
This study, realised by the CETE Méditerranée, first gives a diagnosis of the present situa-tion. Then it gives some predictions for the 2020 horizon.

4.7.1.3 Congestion costs

8. Sénat (2001-2002): "Les nuisances environnementales de l'automobile ". nformation re-port of the Senate. http://www.senat.fr/rap/r01-113/r01-113.html
Abstract: This document describes the negative effects of the motor vehicle and the public policies to implement in order to reduce these pollutions. Based on four costs-benefits studies, the document also analyses the external costs of transport – accident, environ-mental and congestion costs of transport.

4.7.1.4 Policies to fight con-gestion

9. SETRA (2002): "Plan de gestion du trafic interurbain – Guide méthodologique" Guide of methodology. www.setra.fr
Abstract: This guide deals with the inter-urban traffic management plan. It presents the main objectives of the plan and then gives methods to write the document.
The main goal of this plan is to limit and manage the effects of congestion on a road, a network or a zone.

10. Y.Crozet, G. Marlot, Laboratoire d'Economie des Transports, Université Lumière Lyon 2, CNRS, ENTPE (2001): "Péage urbain et ville « soutenable » : figures de la tarification et avatars de la raison économique". "Les Cahiers Scientifiques du Transport". http://www.afitl.com/CST/Contenu%20des%20pr%C3%A9c%C3%A9dents%20num%C3%A9ros/N40/CROZET40.PDF
Abstract: To fight urban congestion, urban pricing seems to be an obvious solution. But implementing an urban road charge does not lead to traffic fluidity. To make road users aware of their non-sustainable behaviour, it is impor-tant to act both on cost and travel time by rising prices and reducing travel speed.

11. M.Raymond, Université Montpellier I, Faculté des Sciences Economiques (2005) : "La tarification de la congestion automobile : acceptabilité sociale et redistribution des recettes du péage". Doctoral thesis.
    http://www.sceco.univ-montp1.fr/creden/theses/theseMReymond.pdf
    Abstract: Over the past decades, urban automobile usage has reached its limits. In order to regulate inner-city automobile flow and to reduce its external effects, many economists have advocated the implementation of a traffic conges-tion toll.
    The introduction of congestion pricing of urban travel in Western cities is bound to be rejected by motorists. To increase the general acceptance level, it seems that public authorities should focus on redistribution of revenue generated by these tolls. Indeed, allocation of the resources in question to the transport sector would avoid pe-nalising those motorists for whom such a measure would prove prohibitive. However, a total and exclusive allo-cation to motorists would only aggravate the situation, whereas a full distribution to public transportation would result in a substantial cost increase. In this context, mathematic modelling allows to determine an optimal allo-cation of revenue accrued from congestion pricing, between the public transportation and motorway networks.
    A study carried out in Switzerland confirms that an appropriation of revenue to the transport
    *sector, and more specifically to the development of public transportation, would bolster toll acceptance.*http://www.sceco.univ-montp1.fr/creden/theses/theseMReymond.pdf

4.7.2 Rail

4.7.2.1 General data

12. SNCF (2005 – 2006) "Régularité des trains de pointe SNCF". Statistics.
    http://www.stif-idf.fr/amelio/qualite/sncf_trains/regul-chiffres.pdf,
    http://www.stp-paris.fr/amelio/qualite/sncf_trains/regul-graph.pdf
    Abstract: These documents are a data table and a graph indicating the reliability rate per week for trains in Ile-de-France from 2005 to the beginning of 2006.

4.7.2.2 Rail network capaci-ties

13. R. Lauterfing (1999) "Le projet de grand contournement ferroviaire du bassin parisien au départ du port du havre dans le cadre des corridors de fret européens". Thesis. http://memoireonline.free.fr/12/05/47/contournement-ferroviaire-bassin-parisien.html
    Abstract: This thesis studies the need for developing the processing capacities of the goods of the port of Le Havre in the framework of the maritime transport development and with European competition. Then it develops the impor-tance of the hinterland of a seaport and the role and the importance of the rail within this hinterland.
    Finally, the thesis studies the long distance railway project towards Eastern Europe and the likely contribution of this to the port of Le Havre.

14. A.Sauvant (2003, May-June): "L'évolution de la capacité utilisée dans les maillons critiques du réseau ferroviaire classique de 1980 à 2000". Notes de synthèse du SES. http://www.statistiques.equipement.gouv.fr/article.php3?id_article=355
Abstract:
This document analyses the evolution of rail traffic from 1980 to 2000. This analyse shows a global decrease : For example, rail traffic on the Parisian belt has decreased by 37 %. On conventional radial lines (non-high speed), traffics has decreased by 18 %. On the other hand, traffic has increased by 6 % on high speed radial lines.
After a brief explanation on the main causes of this decrease, the report tries to explain why despite the decrease of the rail traffic, we cannot conclude that capacity have increased on the rail network.

15. Conseil Général des Ponts et Chaussées (2005, January): "Augmentation de capacité de la ligne à grande vitesse Paris-Lyon". Report.
http://lesrapports.ladocumentationfrancaise.fr/BRP/054000559/0000.pdf
Abstract: *The "Paris-Lyon" high-speed line is the most heavily trafficked on the French network. In the medium term, it will experience saturation problems. Therefore, an increase in capacity is needed.*
After the presentation of the present situation and the traffic prediction for 2012, this report describes the differ-ent projects proposed to increase the capacity of the Paris-Lyon line.

4.7.2.3 Measures to fight congestion

16. A.Sauvant (2002, September-October) "Des réserves importantes de capacité à long terme dans les principales lignes ferroviaires à grande vitesse et les grands aéroports parisiens". Notes de Synthèse du SES.
http://www.statistiques.equipement.gouv.fr/IMG/pdf/NS_143-25-32_cle7b1b41.pdf
Abstract: *In Paris, the main railway lines and airports still have considerable spare capacity in certain conditions: using trains with larger capacities, using infrastructure during off-peak periods, etc.*
For railway lines, this increase in capacity would reach about four times the present flows of the "LGV Sud-Est"(Paris-Lyon high speed line) and four times the flows in Paris airports.

17. INRETS (2004): "Gestion optimisée du trafic ferroviaire : peut-on accroître l'offre et comment ?". Work sheet. http://www.inrets.fr/infos/fiches/aide/pdf/aide5.pdf
Abstract: *This document presents the two research themes of the INRETS dealing with "rail transport planning": the de-velopment of a rail traffic model and rail traffic management. This document also deals with the problems of delays due to bottlenecks in rail networks.*

4.7.3 Urban public transport

4.7.3.1 External costs

18. Syndicat des Transport d'Ile-de-France (STIF)"Les coûts externes du transport". Report.
http://www.stif-idf.fr/chiffres/compte_regio/chapitre3.pdf
Abstract: *This report analyses the pollution external costs due to urban public transport in Paris: costs of noise, air pollu-tion, greenhouse effect, congestion and accidents.*

4.7.4 Waterborne

4.7.4.1 General data

19. Services et Conception de Systèmes en Observation de la Terre (SCOT), Ministère de l'Equipement, du Transport, du Logement, du Tourisme et de la Mer – Direction des Affaires Maritimes et des Gens de Mer (2004): "Etude du trafic maritime en méditerranée occidentale ". Synthesis report.
    http://www.mer.equipement.gouv.fr/actualites2/03_rapports/rapports/trafic/rapport_final_damgm_annexe_1.pdf
    Abstract: After a global view of maritime traffic, this report describes the characteristics of maritime traffic in western Mediterranean. To conclude, the document proposes a prospective evaluation of the traffic in western Mediter-ranean.

20. Voies Navigables de France (VNF), Ministère de l'Equipement, du Transport, du Logement, du Tourisme et de la Mer (2001):"Statistique annuelle de la navigation intérieure". Statistics collection
    Abstract: This document presents the statistics by waterways sections, traffic flow currents and flows in main river ports.

21. Direction du Transport maritime des Ports et du Littoral (2002): "Résultats de l'exploitation des ports maritimes". Statistics collection
    Abstract: This document presents the results of the commercial seaports activity in 2002. It also presents some retrospective statistics and traffic flow by flag.

4.7.4.2 Traffic predictions

22. J-C. Méteyer, P. Normand (2000, September-October): "Nouvelle projection de transports fluviaux de marchandises en France". Notes de synthèse du SE.
    http://www.statistiques.equipement.gouv.fr/IMG/pdf/NS131-9-14_cle7bb141.pdf
    Abstract: This document presents a new type of forecasting for freight inland waterway transport for the 2020 horizon.

23. Senate (2001-2002): " Liaison fluviale à grand gabarit Saône-Rhin ". Information report.
    http://www.senat.fr/rap/r01-366/r01-366.html
    Abstract: This report criticises the fact that freight transport has never been a political priority in comparison to passenger transport. Given the congestion level on the national road network, it seems today necessary to develop rail freight transport and also waterborne freight transport.
    For that, it is indispensable to develop the French river network, which is today obsolete, and more particularly the connection to the European network.

24. P. Clément-Grandcourt (2004): " Développement des trafics fluviaux". Report.
    http://www.transports.equipement.gouv.fr/dttdocs2/rap_Clement-Grandcourt-06-04-voies-fluviales-II.pdf
    Abstract: The first part of the document deals with the problematic of road congestion and more particularly the prob-lematic of heavy trucks traffic. To reduce pollution due to heavy trucks, a solution could be to develop freight river transport. To develop containers transport by inland waterway, many conditions are necessary. These con-ditions are developed in the second part of the report and then applied to different French networks (Nord, Ile-de-France, Saône-Rhône). Finally, the last part of the report presents means to accelerate this development.

4.7.5 Aviation

4.7.5.1 Evaluation and treat-ment of the conges-tion

25. Direction Générale de l'Aviation Civile (2004): "Indicateurs et définition". Table. http://www.dgac.fr/html/oservice/comuta/bil_2004/indicateur_definitions.pdf
Abstract: This table lists different indicators with their definitions such as indicators for aerodrome characteris-tics, delays, on-time flights and delayed flights, delays duration, causes of delays.

26. M. Raffarin, Ecole Nationale de l'Aviation Civile (2002): "Le contrôle aérien en France : congestion et mécanisme de prix ". Doctoral thesis.
http://www.recherche.enac.fr/leea/marianne/these.pdf
Abstract: The aim of this thesis is to analyse new pricing rules and allocation mechanisms for the air traffic control to reduce the delays. The first part is a diagnosis of air conges-tion. This diagnosis is built upon a detailed examina-tion of delays in the air transport in-dustry, followed by a presentation of the organisation and the economic characteristics of the air traffic control system. Moreover, the perception of those delays by air traffic con-trollers is based on a survey carried out among them. The second part presents different solutions for the problem of congestion. Inefficiency in the utilisation and the sharing of airspace is caused by the current pricing rule where fees increase with the weight of the aircraft and the rationing rule for allocating slots. A modelling of the verti-cal structure be-tween passengers, airlines and the air traffic control authorities leads to optimal charges decreas-ing with the weight, when the costs caused by the delays are taking into account. The use of second-degree price discrimination for air traffic control services is also consid-ered : while a peak load pricing does not seem appro-priate, due to the multiple produc-tion aspects of this activity, a priority pricing would be a way to minimise de-lay costs. Fi-nally, the setting up of a second-price auction with package bidding, is analysed.

27. S. Oussedik, Ecole Polytechnique (2000): "Application de l'évolution artificielle aux pro-blèmes de congestion du trafic aérien". Doctoral thesis.
http://www.recherche.enac.fr/opti/papers/thesis/sofiane.pdf
Abstract: Increase in traffic demand lead to airspace congestion. In the past, these conges-tion problems had been solved by increasing the capacity of airspaces and more particu-larly by reducing their size. Today, this method reaches its limit: it is no longer possible to reduce size of airspace.
As the traffic demand increases, the air traffic management organisations focus on a new way to reduce conges-tion. This new method consists of regulating the demand which means realising a better distribution of the de-mand within time and space. The linear programming is no longer applicable. It is thus necessary to use stochas-tic optimisation methods.

28. Direction Générale de l'Aviation Civile (2005): "Ponctualité". Web document.
http://www.aviation-civile.gouv.fr/html/actu_gd/trafic.htm
Abstract: This web document deals with the theme of on-time performance of air traffic. It presents the role of the DGAC (Direction Générale de l'Aviation Civile) in the control of delays, the causes of the delays, the optimisation of the airspace organisation and the French aviation delay observatory.

4.7.5.2 Policies to fight con-gestion

29. Conseil National des Clients Aériens (CNCA) with the cooperation of the Direction Générale de l'Aviation Civile (1st semester of 2005): "Observatoire des retards du transport aérien en France – Principaux résultats ou Synthèse ". Delay Observatory. http://www.aviation-civile.gouv.fr/html/oservice/comuta/comuta.htm
Abstract: The CNCA (Conseil National des Clients Aériens) has implemented a delay observatory for the French aviation. The results of this observatory are published twice a year: in March and September. These two documents (main results or synthesis) present the observatory results of the 1st semester of 2005. The following data are available in this report: causes of delays, flights punctuality, average time of delays, evolution of the average time from 2000, distribution of the passenger traffic by airport, etc.
The document also explains the method employed to evaluate those indicators.

4.7.6 All modes

30. DAEI, SES (2004): "La demande de transport en 2025". Study.
http://www.statistiques.equipement.gouv.fr/article.php3?id_article=235
Abstract: This document presents the results of the transport demand projections (time horizon 2025) for each mode of transport and market segment (passenger or freight).

4.7.6.1 Policies to fight congestion

31. Sénat (2000-2001): **"Financement des infrastructures de transport".** Information report of the Senate. http://www.senat.fr/rap/r00-042/r00-042.html
*Abstract **:** In this report, the Senate analyses the past public financing of transport infrastructures. Globally the amount of public investments has decreased and this reduction has had many consequences on the different infrastructures of every mode of transport, e.g. congestion.*
However, an increase of the public investments is necessary to deal with the projected increase of traffic on all transport networks. For that, the Senate describes at the end of the document its priorities for the next investment plan.

4.7.7 Additional references

4.7.7.1 Inter-urban roads

32 : SETRA and CETE (2006):"Les transports urbains en vallée du Rhône et dans le couloir Languedocien, perspectives d'évolution à 20 ans". Study. http://www.debatpublic-transports-vral.org/documents/etudes-et-rapports-realises-par-l-etat.html
Abstract : This document presents the evolution perspectives (for 20 years) of inter-urban traffic in the valley of Rhône and in the corridor of the Languedoc (A7 and A9).

33 : Ministère de l'Equipement, du Transport, du Logement, du Tourisme et de la Mer and Ministère de l'Ecologie et du Développement Durable (2003): "Couverture des coûts des infrastructures routières – analyse par réseaux et par sections types du réseau routier national". Study. http://www.debatpublic-transports-vral.org/documents/etudes-et-rapports-realises-par-l-etat.html
Abstract: This document proposes a global approach of the congestion costs covered by different road users and a detailed estimation of the social marginal costs on different road and motorway sections.

4.7.7.2 Urban roads

34. Prefecture de la Région d'Ile-de-France (2005): Les Déplacements sur le Réseau de Voies Rapides Urbaines d'Ile-de-France. Année 2003. http://www.sytadin.equipement.gouv.fr/ensavoirplus/stats/pdf/Deplacements_VRU_3Q_2004.pdf *Abstract: The statistical bulletin reports on the development of traffic volumes, travel times, share of traffic below 60 kph and the length of traffic jams on the express way road network of Ile-de-France. The indicators cover the period 1998 to 2003 and are differentiated by network type, time of day, day of the week and congestion causes.*

5 United Kingdom

This section conducts a brief overview of congestion and bottleneck issues in the UK and Ireland. The literature review is drawn from publicly available policy documents downloaded from various websites.

This section begins by discussing the definition of congestion, as used in the UK and Ireland, and then moves on to examine methodologies used to measure congestion and derive targets and identify bottlenecks. We have focused here on what we believe are the most useful reports in terms of providing definitions of congestion and identifying bottlenecks. Full information of all downloaded documents and data is given at the end of this section.

5.1 Road transport

5.1.1 Definition of congestion

In the document "A measure of road traffic congestion in England: method and 2000 baseline figures", the UK Department for Transport draws upon an existing definition of road traffic congestion which states that the average delay encountered by a vehicle travelling one kilometre is given by:[6]

$$\frac{\text{The total delay encountered on parts of the road network}}{\text{The volume of traffic (in vehicle-kilometres travelled)}}$$

Where the total delay encountered on parts of the road network is calculated by taking the difference between the actual speed encountered and a free flow reference speed.

This is similar to the definition used by the Scottish Executive. They argue that the primary measure of congestion is the speed of travel on all or part of journey, and whether it deviates from initial expectations. It is the additional time that is important to individuals. An important related concept to this is "journey time reliability/variation" (JTV). This is defined as unpredictable variation in journey times. One of the components of JTV is what are referred to as "day-to-tday variability" (DTDV) which include demand and capacity related effects. Formally, one can state JTV as:

$$\text{JTV} = \text{DTDV} + \text{Incident related variability}$$

Where DTDV = demand related incidents + capacity related effects

Although this definition has been derived with road traffic in mind, it could (theoretically) be adapted to other transport sectors, such as air travel. However, this definition may be less applicable to sectors where the number (or stock) of transport carriers is less important to congestion, for instance the rail sector. In such sectors, more accurate measures of congestion might refer to over-crowding in carriages or delays caused due to insufficient capacity. Using such a measure, it has been estimated that four out of ten London Underground operators exceed over-crowding standards.

[6] This definition was first postulated in "Tackling Congestion and Pollution"

Although appealing, the thought that a single congestion indicator can cover the whole country fails to take into account local situations. It is for this region, that congestion indicators are often broken down regionally. This has been the case for the UK, where England, Wales, Scotland and Northern Ireland are analysed separately. However, by analysing regions individually, one runs the risk that a reduction in congestion in one region may have only be facilitated by a rise in congestion in a neighbouring region.

5.1.2 The DfT's English measure of road congestion

Congestion in the UK is evaluated separately for England, Scotland, Wales and Northern Ireland. The Department for Transport carries out congestion surveys on the inter-urban trunk road network (DfT 2001, 2003 and 2005) and in major agglomerations above 250,000 inhabitants (DETR 2000, Crownhurst (2003), Wagner and Kehil 2005 in England where urban and inter-urban surveys are carried out in alternate years (. London surveys are the responsibility of Transport for London (TFL) and are carried out on a three-year cycle. In the inter-urban case measurements concentrate on the most busy trunk road sections. In the urban case all roads with an average daily traffic volume above a threshold of 10,000 vehicles per day plus a selection of less busy links with local importance are monitored. Thus the presented indicators diverge from the "true all roads" figure, but are well suitable to track the development of road congestion over time.

The measure of congestion used is the average time lost per vehicle kilometre. This is defined by dividing the total time lost on a particular part of the road network by the total corresponding number of vehicle kilometres. Time loss is determined by the difference of the average speed of vehicles and the free-flow reference speed.

Actual speeds by road segment and by day period are generated from floating car surveys carried out during six selected months (usually April to June and September to November excluding school holidays and other unusual events). The floating car technique involves the car attempting to equalise the number of vehicles overtaking it with the number of vehicles which it overtakes. The study assumption that there is no congestion during night time is kept under review. 21

The congestion data from different links for a specific time period are combined by weighting them according to the volumes of traffic on each link. The weighted average across all time periods is them determined respectively to produce the overall congestion level.

The reference speed is an estimate of the speed achievable on a particular stretch of road in free-flow conditions when there is very little traffic on that road. For the trunk road network, average speeds observed at low flows (without incidents/roadworks) during weekday off-peak periods are used. In urban areas, speeds collected during the night, when traffic is lightest, are used. In most cases these speeds are well below the roads' speed limits.

The results are presented by road class and by region in case of trunk roads and by size of urban areas, where London is subdivided in several districts. Sample results for 2000 are presented by the following tables:

Table 5-1: Congestion on English trunk roads by class (2000)

	Survey coverage road length	Average peak speed	Congestion (seconds lost per vehicle km)			
	Km	**Kph**	**Weekday am peak**	**Weekday off-peak**	**Weekday pm peak**	**All periods**
Motorways	2797	87.5	8.8	2.9	6.7	3.8
Dual carriageway A roads	3062	73.3	8.8	3.0	9.0	4.5
Single carriageway A roads	4077	57.3	7.7	4.4	8.1	4.7
All trunk roads	9936	77.0	8.6	3.2	7.6	4.2
Of which, inter-urban target	8522	82.6	-	-	-	3.2

Source: DfT (2000) Transport, Statistics, Roads (2000): A measure of road traffic congestion in england: Method and 2000 Baseline figures. London, 2000

The results are not surprising. The time lost to congestion is shown to be highest during peak weekdays periods.

Disaggregating England into the nine regions shows how congestion varies across the country.

Table 5-2: Congestion on trunk roads in England by regions (2000)

	Survey coverage road length	Average peak speed	Congestion (seconds lost per vehicle km)			
	Km	Kph	Weekday am peak	Weekday off-peak	Weekday pm peak	All periods
East	1381	78.4	8.4	2.4	7.3	3.8
East Midlands	1382	81.3	3.8	1.8	4.5	2.1
London	256	40.4	37.8	16.2	28.0	18.9
North East	478	79.8	5.5	0.7	7.6	2.7
North West	1405	78.0	9.3	5.1	8.2	5.0
South East	1506	79.9	9.7	2.8	7.4	4.2
South West	1292	88.7	1.6	0.5	3.7	1.1
West Midlands	1184	76.4	8.9	3.3	8.5	4.4
Yorkshire and the Humber	1052	82.4	5.8	2.2	5.0	2.7
All trunk roads	9936	77.0	8.6	3.2	7.6	4.2

Source: A Measure of Road Traffic Congestion in England: Method and 2000 Baseline figures

Table 5-3: Congestion in London and in large urban areas (2000)

	Survey coverage road length km	Average peak speed kph	Congestion (seconds lost per vehicle-km)		
			Weekday peak	Weekday off-peak	All periods
Greater London	2151	25.0	65.8	45.5	35.7
Central London	*174*	*15.5*	*120.0*	*134.3*	*69.3*
Inner London	*462*	*18.0*	*109.8*	*68.1*	*53.7*
Outer London	*1516*	*29.5*	*50.1*	*30.3*	*27.1*
Conurbations	2314	35.2	34.4	16.8	17.2
Other large urban areas	1161	33.6	36.9	18.4	21.0
All urban areas (Including London)	5626	30.4	46.4	27.6	24.8

Source: DfT (2000) Transport, Statistics, Roads (2000): A measure of road traffic congestion in england: Method and 2000 Baseline figures. London, 2000

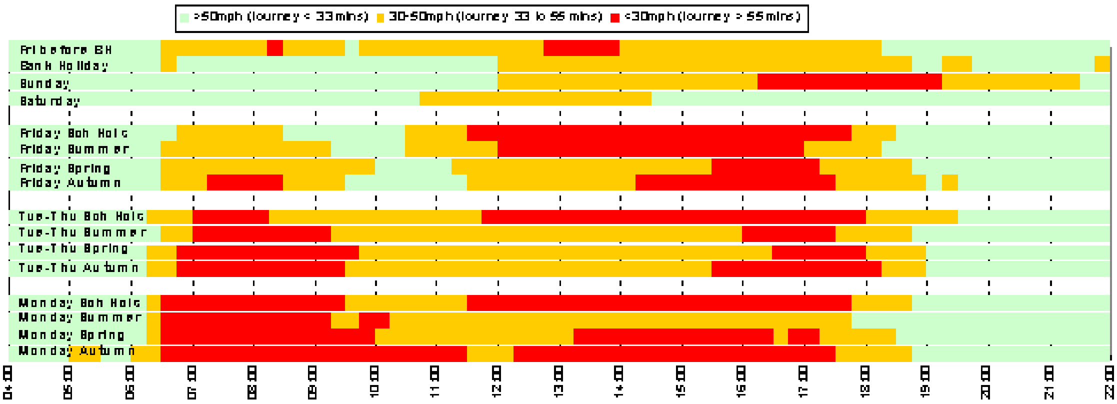
Figure 5-4 shows time series of congestion, measured in time losses against free flow speed, in English urban areas other than London from 1993 to 2004. The table shows that the degree of development of congestion figures is independent of the severity of congestion. However, it is to be noted that the methodology of speed recording between 1996 and 1999/00 has slightly changed and thus the development of the congestion indicator is to be considered carefully.

Table 5-4: Congestion in English large urban areas excluding London 1993 to 2004

Area	Average peak hour travel speeds (kph)					
	1993	1996	1999/00	2002	2004	Change 1993-2004
Teeside	50.6	46.4	49.4	55.0	49.6	-1.0
Brighton/Hove	37.1	41.0	42.7	42.6	47.0	9.9
Portsmouth			43.7	42.6	46.4	2.72
Tyneside	34.9	39.8	44.2	44.6	40.5	5.6
Plymouth	40.3	38.6	34.7	36.8	35.0	-5.3
West Midlands	35.5	32.3	33.9	33.4	33.0	-2.6
Leeds/Bradford	34.1	31.2	33.4	32.6	32.8	-1.3
Merseyside	34.2	33.8	30.7	34.6	31.8	-2.4
Hull	33.0	31.2	30.6	29.9	31.8	-1.1
Southampton	29.6	29.8	25.1	26.7	31.2	1.6
Bournemouth/Poole	37.3	32.3	32.0	33.6	31.0	-6.2
Blackpool			30.9	29.8	30.7	-0.16
Stoke/Newcastle-under-Lyme	30.1	33.1	36.8	38.6	30.1	0.0
Sheffield	27.4	27.7	27.4	30.4	29.9	2.6
Greater Manchester	33.1	34.1	29.9	31.4	29.0	-4.2
Bristol	30.9	29.6	29.8	28.0	28.5	-2.4
Nottingham	29.9	28.8	29.3	25.9	26.6	-3.4
Leicester	25.3	28.2	27.2	25.0	23.5	-1.8
All large urban areas	**33.6**	**33.9**	**33.0**	**33.3**	**32.5**	**-1.12**

Source: Wangeci C and Kehil M (2005): Traffic Speeds in English Urban Areas: 2004. Department for Transport. London, May 2005

The UK motorists forum suggests to supplement these aggregate measures by more user-friendly indicators of individual links. It is proposed to use the „journey Time Variability“, which is the 90% slowest trip (90-percentile travel time) minus the free-flow travel time. An example for the Brimingham Region is given below:



Th

Source: http://www.cfit.gov.uk/mf/reports/imcfinal/index.htm

Figure 5-1: Proposed presentation of local congestion indicators for the UK

5.2 The Scottish Executive congestion study 2003

In 2003 the Scottish Executive has carried out the first volume of a planned regular series of congestion monitoring studies. Data is delivered by roughly 500 monitoring sites in 10 areas. Actual travel speed is related to the undisturbed free flow speed determined on all network sections. In addition a floating car data survey by 4 to 6 vehicles per day with a total of 344 vehicle-days was carried out in order to calibrate total network results. Aggregations of local measurements over the entire study network provide the basis for the first set of indicators:

- Additional Travel Time per Annum: Total of actual additional travel time against free flow travel times. Result 2003: 7.1 billion hours.
- Average Time Lost per Vehicle Kilometre: This computes as total time losses divided by total vehicle kilometres and thus relates it to the users' perspective and allows benchmarking between regions. Result 2003: 4.95 seconds/vkm.
- Cost of Trunk Road Congestion per Annum: Total additional travel time is multiplied by value of time figures developed by DfT (10£/h) which provides a figure which measures the cost to the economy per annum caused by congestion on the trunk road network. Fuel and operating costs are not considered

In addition a series of Local Trunk Road Congestion Indicators on 44 distinct routes between 10 local areas are presented: Total time losses, average time losses per vehicle kilometre and total costs of time losses are computed as in the national case but related to single network segments. Moreover, the following additional indicators are computed:

- Journey Time Reliability: This is the share of journeys taking less than 115% of the average journey time.
- Total Time Lost per Km per Day. The indicator relates total time losses per day to the route length and thus provides a measure to compare total costs of different routes.
- Three Congestion Bands. This methodology separates the congestion experienced into three bands of Mild, Serious and Severe. This indicates the impact of congestion by the vehicles affected, the duration in hours and the time lost per route-km. If related to vehicle-km rather than to vehicles the first indicator and also total time lost per congestion band could well be applied to greater areas. The definition of the congestion bands and the 2003 results are as follows:

Table 5-5: Traffic levels by LOS cluster in Scotland

Congestion type	Speed drop	Vehicles affected		Congestion duration		Time lost per km (hrs)
		Number	%	Hours	% of day	
Mild	>10%<25%	26359	76.21%	16.25	67.71%	9.7
Serious	>25%<50%	1679	4.85%	0.5	2.08%	10.5
Severe	>50%	3799	10.96%	1.5	6.25%	76.3

- Annual Average Daily Congestion Index: ratio of the Free Flow Speed to the actual speed averaged over the whole day. This is used as a general indicator of congestion allowing comparisons over time but not between routes.

5.2.1.1 Policy Issues

It should be noted that London is normally considered a special case due the sheer density of traffic in the central and inner areas.

In July 2000, the UK Government published Transport 2010: the 10 Year Plan. For the period 2000 to 2010, total expenditure by Government in this sector was expected to reach £180 billion, which included £120 billion of capital investment. The figure also contains the contribution of the private sector through PPP projects such as the London Underground.

In the 10 Year Plan, the UK Government notes that while one of the main aims of its strategy is to arrest the rise in congestion, this does not necessarily imply that total eradication of congestion is possible, or even desirable. While congestion undoubtedly adds costs to the economy (in terms of lost time and increased vehicle emissions which affect the environment and health), reducing congestion also has costs (in terms of the financial and environmental cost of building new roads or providing public transport alternatives). Both costs must be considered when setting congestion targets.

Nonetheless, given the above proviso, targets were allocated for a number of outputs, in particular: rail patronage to increase by 50 per cent, rail freight by 80 per cent, bus patronage by 10 per cent and inter-urban road congestion to fall by 5 per cent.

In its Second Assessment of the 10 Year Transport Plan, the Commission for Integrated Transport, notes that the targets for congestion will not be met despite Government initiatives. They note that road congestion in 2010 is forecast by the Department of Transport to be 27 to 32 per cent higher than originally forecast. The implementation of the 10 Year Plan will only reduce this figure to between 11 to 20 per cent – still a net increase in congestion. This change is partially attributable to the original under-estimate of base level congestion and partially due to higher traffic levels as a result of higher economic growth forecasts.

The 10 Year Plan proposes a significant expansion of the road network in order to tackle congestion and alleviate existing bottlenecks. It states that "bottlenecks [will] be eased by targeted widening of 360 miles of the strategic road network…80 major trunk road schemes to improve safety and traffic flow at junctions…100 new bypasses on trunk and local roads to reduce congestion and pollution in communities…130 other major local road improvement schemes…completion of the 40 road schemes in the Highways Agency Targeted Programme of Improvements."

Well known bottlenecks to gain an extra lane include the M1 and M6 motorways.

However, despite such supply side solutions to bottlenecks, the 10 Year Plan does acknowledge that there is a risk that by increasing capacity simply increases road use as it serves pent-up demand. Thus behaviour changes need to be examined as well.

5.3 Case Study London

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Source: Questionnaire filled in for TFL.doc

5.3.1 Introduction

The London area is mostly urban. The outer areas (such as Croydon) are classed as outer London, and the areas containing the urban parts to this are known as inter-urban areas. However, all areas are normally considered to-gether.

5.3.2 Measurement of Congestion

There is manual method of counting traffic. This is the "count" method. It is car-ried out in three year rotating surveys for London's major roads. In addition, other count surveys focus on central, inner and outer London. These are carried out intermittently. Count surveys are also used on certain "stream lines" for par-ticular questions, such as examining traffic over the Thames and north-south traffic.

Automatic count methods are also carried out. There are around 100 monitors operating 24 hours daily. Half of these are operated by TFL (Transport for Lon-don), and the other half are operated by the boroughs on principle roads. This data is fed directly into a computer system that can be accessed in almost real time at TFL offices. The data includes measures of vehicle type (measured by vehicle length) and speed.

In addition, a GPS satellite system is also in operation to calculate average traf-fic speeds. This makes use of hundred of "tracking" vehicles. The average speed computed using the GPS are consistent with the results obtained with the conventional estimates (they are just a little bit higher). Other sources of data include: speed camera, the congestion charge monitoring system and traffic lights which are computer controlled and set on the basis of a traffic data-base.

To calculate congestion the following method is used. A daily flow rate is calcu-lated as the minutes travelled per kilometre. Then, the overnight flow rate is cal-culated and used as the benchmark for travel speeds. The difference between the two measures is the congestion level.

According to London's urban public transport data on the proportion of sched-uled service kilometres that is run is collected. The proportion of scheduled km which did not run is sub-divided by cause. One of these sub-divisions is "km lost due to traffic reasons", including service lost because of congestion. For pas-senger waiting time, we use measures designed to take account of the differing ways in which passengers use bus services, depending on whether their frequency:

- For high frequency routes (every 12 minutes or better) the majority of passengers ex-pect to be able to turn up at bus stops without needing to consult a timetable. Such passengers generally expect the planned inter-val between services to be maintained but they are not concerned about the precise time at which each bus is scheduled to pass their stop. Their experience is measured by sampling the difference between planned and actual waits, known as Excess Wait time (EWT).
- For low-frequency routes, passengers generally expect services to ad-here to the pub-lished timetable and we measure the percentage of ser-vices which run on time.

The data collection staff is instructed to stand at particular locations throughout the TfL area and record buses using hand-held data-capture devices for 2.5- or 3-hour shifts.

The data is then transmitted back to London Buses, where it is validated. At the same time, staff match the results against the timetable and the office reports on how much longer a passenger would have to wait than if the bus service ran exactly as expected.

An observation point will be surveyed 16 times during a 12-week period.

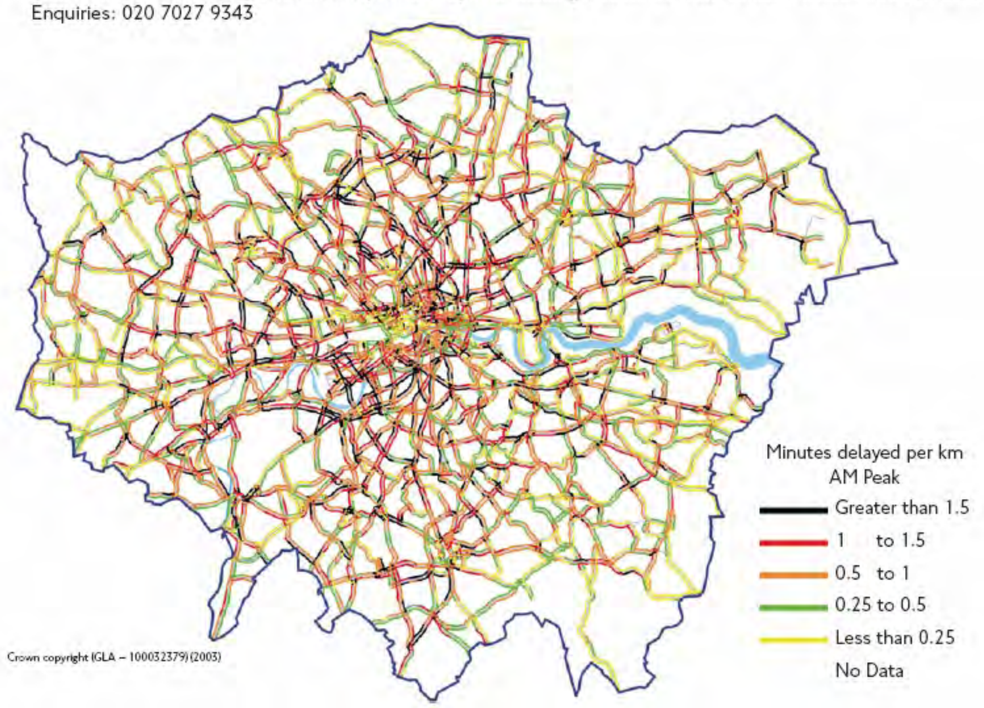
It is important to appreciate that bus service reliability is measured from a passenger point of view. This may mean, for example, that a bus running late may be treated as the next bus running early, as that is how it would be regarded by passengers.

5.3.3 Current Situation

The greatest congestion occurs in central London with the exception of the con-gestion zone:

Chart 3.2.2 Morning peak road network congestion map (2003)

Source: Information derived from data provided by ITIS Holdings, obtained from vehicles fitted with GPS devices
Enquiries: 020 7027 9343



(Source: London Travel Report 2005, page 31)

Figure 5-2: Peak road congestion in London 2003

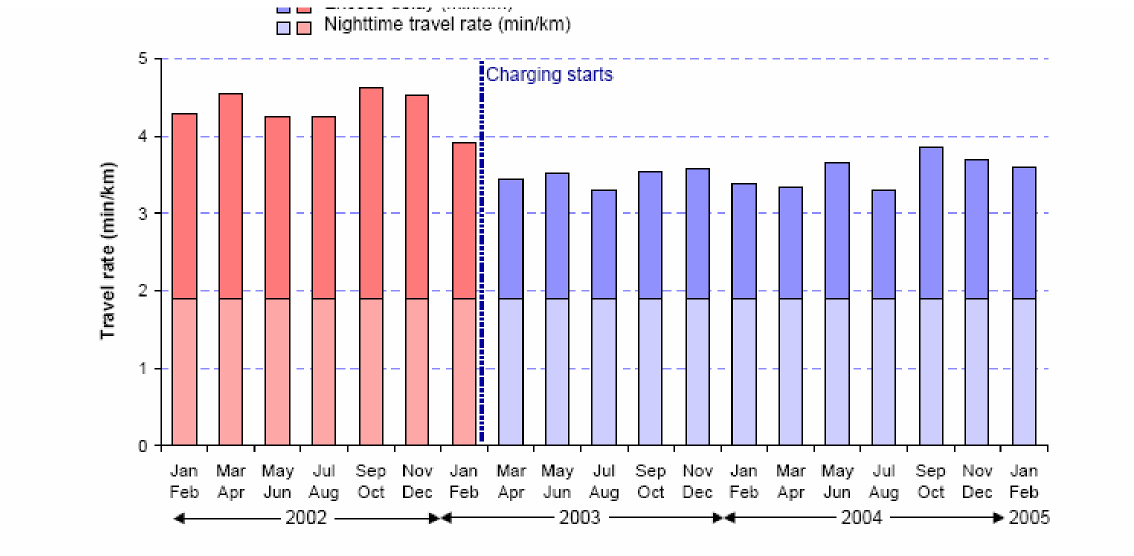
As a result of the Congestion Charging started on 17th February 2003 the num-ber of people entering central London during the morning peak has increased from 88.000 in 2002 up to 116.000 in 2004. An other impact is the reduction of people using cars from 105.000 in 2002 down to 86.000 in 2003 and 2004 (See the following chart)

Table 5-6: People entering central london during the morning peak

Year	All modes	Rail only	Rail with transfer to LUL/DLR	All rail	LUL and DLR only	Bus	Coach/ minibus	Car	Taxi	Powered two-wheeler	Cycle
1991	1042	258	168	426	347	74	20	155	••	12	9
1992	992	245	156	401	337	61	24	150	••	11	9
1993	977	214	168	382	340	64	20	150	••	11	9
1994	989	221	171	392	346	63	23	145	••	11	9
1995	993	221	174	395	348	63	21	145	••	11	10
1996	992	223	176	399	333	68	20	143	9	11	10
1997	1035	240	195	435	341	68	20	142	9	12	10
1998	1063	252	196	448	360	68	17	140	8	13	10
1999	1074	258	202	460	362	68	15	135	8	15	12
2000	1108	269	196	465	383	73	15	137	8	17	12
2001	1093	264	204	468	377	81	10	122	7	16	12
2002	1068	245	206	451	380	88	10	105	7	15	12
2003	1028	265	190	455	339	104	10	86	7	16	12
2004	1039	251	201	452	339	116	9	86	7	16	14

Source: CAPC Enquiries: 020 7126 4610
1. Taxi data unrecorded prior to 1996.
2. Revised since the publication of LTR 2004.

The next figure shows the reduction of the congestion in the charging zone during charging hours:



(Source: UK/third report of congestion charging, page 15)

Figure 5-3: Congestion in the chargin zone during congestion hours

The following figure points out the pattern of congestion across central and inner Lon-don since the introduction of charging. It is based on an average of several rep-resentative surveys from 2003 and 2004, and therefore gives a good spatial perspective of prevailing congestion patterns. It does not, however, take into account the absolute effect of congestion on driv-ers, as the size of the traffic flow experiencing congestion is not represented.

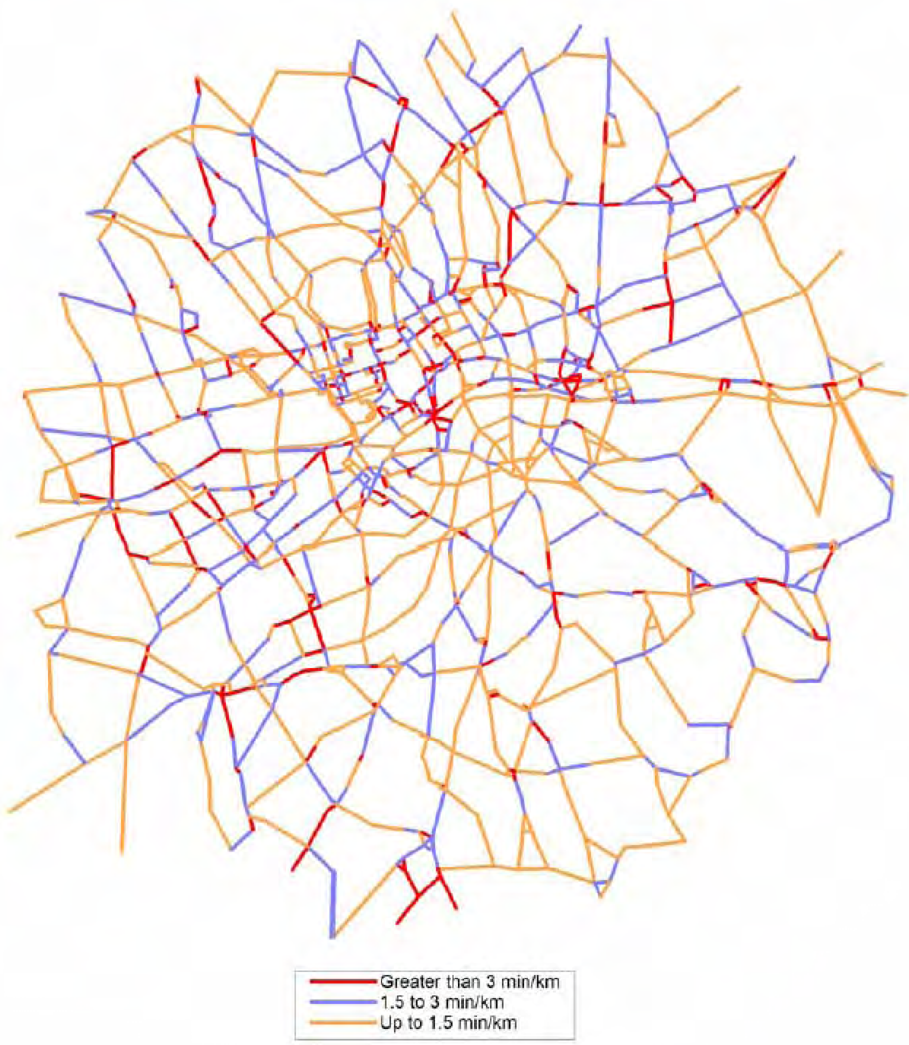


Figure 5-4: Excess delay (minutes per kilometre) during charging hours in London March to December 2003

The collected date on urban public transport is differentiated by high and low frequency routes (Table 5-7). The waiting time for high frequency bus services is continuously decreasing after a small peak in the year 2000. Since 1998 also the service reliability of underground services is monitored. Apart from some flucturation the figures show a stable value around 3.5 minutes per train run. Further, service reliability for the Docklands Light Railway and the Croydon Tramlink are monitored since 1997 and 2001 (Table 5-8).

Table 5-7: London Bus Service Reliability

Year	Percentage of scheduled kilometres operated (before traffic congestion)	High frequency services Average wait time (minutes)		Low frequency services Percentage of timetabled services on time
		Actual	Excess1	
1990/91	97.3	6.8	2.2	62.9
1991/92	98.3	6.4	1.8	66.4
1992/93	98.7	6.3	1.7	68.7
1993/94	97.7	6.6	1.9	66.7
1994/95	99.0	6.5	1.8	69.7
1995/96	99.0	6.5	1.7	71.4
1996/97	99.1	6.4	1.8	70.3
1997/98	98.7	6.4	1.8	70.0
1998/99	98.5	6.6	2.0	69.0
1999/00	97.5	6.7	2.1	67.8
2000/01	97.4	6.8	2.2	67.7
2001/02	98.4	6.6	2.0	69.4
2002/03	98.7	6.4	1.8	70.5
2003/04	98.9	5.8	1.4	74.6
2004/05	99.3	5.6	1.1	77.1
Percentage change				
1 year	•	*-3%*	*-21%*	
10 years	•	*-14%*	*-39%*	

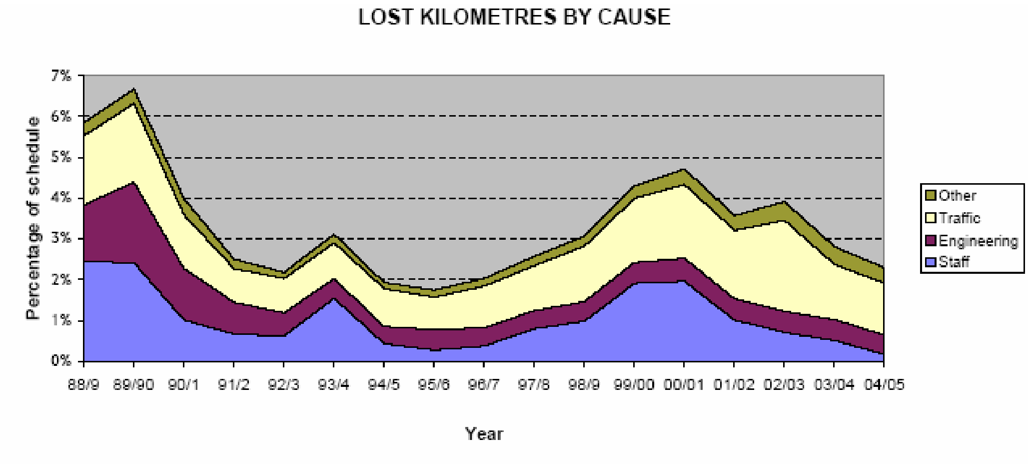
Source: TFL (2005): London Travel Report 2005

Table 5-8: Underground, Docklands Light Rail and Croydon Tramlink service reliability

Year	London Underground		Docklands Light Railway		Croydon Tram
	Percentage of scheduled kilometres operated	Excess journey times (minutes)	Percentage of trains on time	Percentage of scheduled service operated	Percentage of scheduled service operated
1990/91	95.0				
1991/92	97.2				
1992/93	97.5				
1993/94	96.5				
1994/95	96.8				
1995/96	96.2				
1996/97	94.5				
1997/98	95.5		95.6	89.6	
1998/99	93.6	3.15	97.5	92.0	
1999/00	94.3	3.21	97.8	93.7	
2000/01	91.6	3.69	98.2	96.3	
2001/02	92.9	3.44	98.3	96.6	99.1
2002/03	91.1	4.22	98.1	96.3	98.9
2003/04	93.1	3.36	98.2	96.6	99.0
2004/05	95.3	3.23	98.5	97.1	97.2

Source: TFL (2005): London Travel Report 2005

The main reasons for delays are traffic, engineering and staff. As the next chart shows the trend is similar to the one in the previous chart



Source: Information provided by Transport for London

Figure 5-5: Delay causes in London public transport 1988 to 2005

5.3.4 Policy Measures

TFL makes use of two models for congestion. The Strategic Policy Assessment Model (SPAM) is a spreadsheet model that can analyse changes in traffic after changes in pricing. It also looks at changes in usage. The LTS model is a geo-graphic model with multi-modal stages which captures geographic changes in transport. The LTS and SPAM models can make projections about traffic flows. Most existing models predict transport as a function of demographics and eco-nomic growth. More details can be found in the Mayor's London Plans.

Bottlenecks are not normally defined. The closest counterparts are "pinch points" which are the ten most congested areas to be targeted for congestion reduction.

Work is also being carried out by TFL in conjunction with other transport agen-cies and the Department for Transport to create a national "people/journey time indicator" which will allow one to measure the occupancy of vehicles in relation to the time it takes to complete a journey.

5.3.5 Additional information (Addresses, ...)

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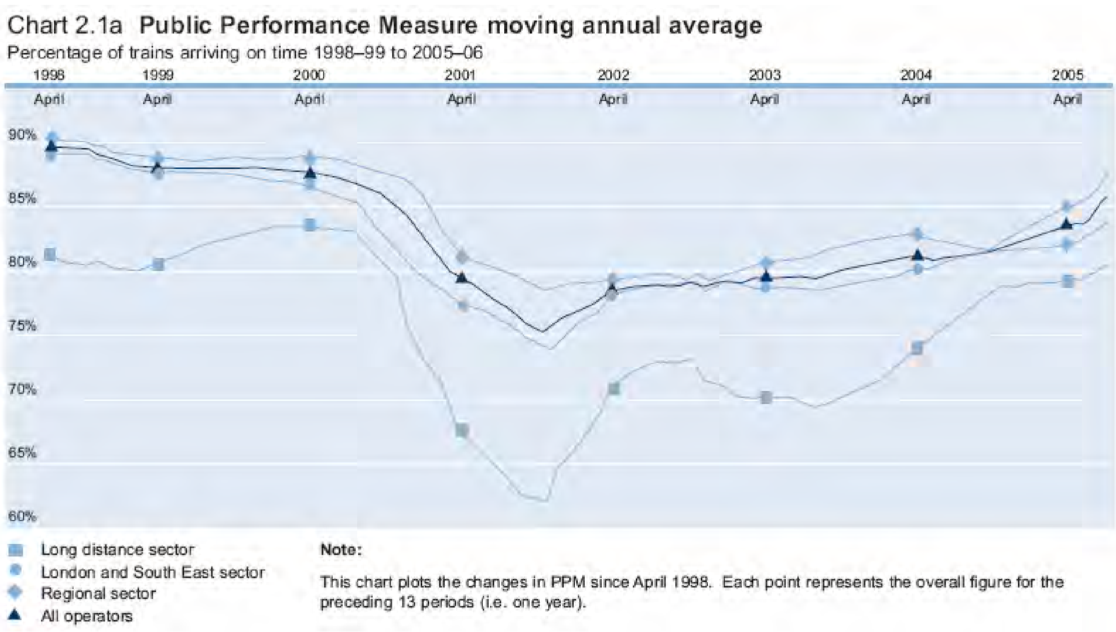
5.4 Rail transport

5.4.1 1. Measurement of Congestion

Railway performance in the UK is commonly described in two ways. Firstly there is the Passenger Performance Measure, counting trains that arrive at their final destination within a five or ten minute threshold, as covered in National Rail Trends



(Source: (http://www.rail-reg.gov.uk/upload/pdf/265.pdf)

Figure 5-6: Performance measure for UK rail transport

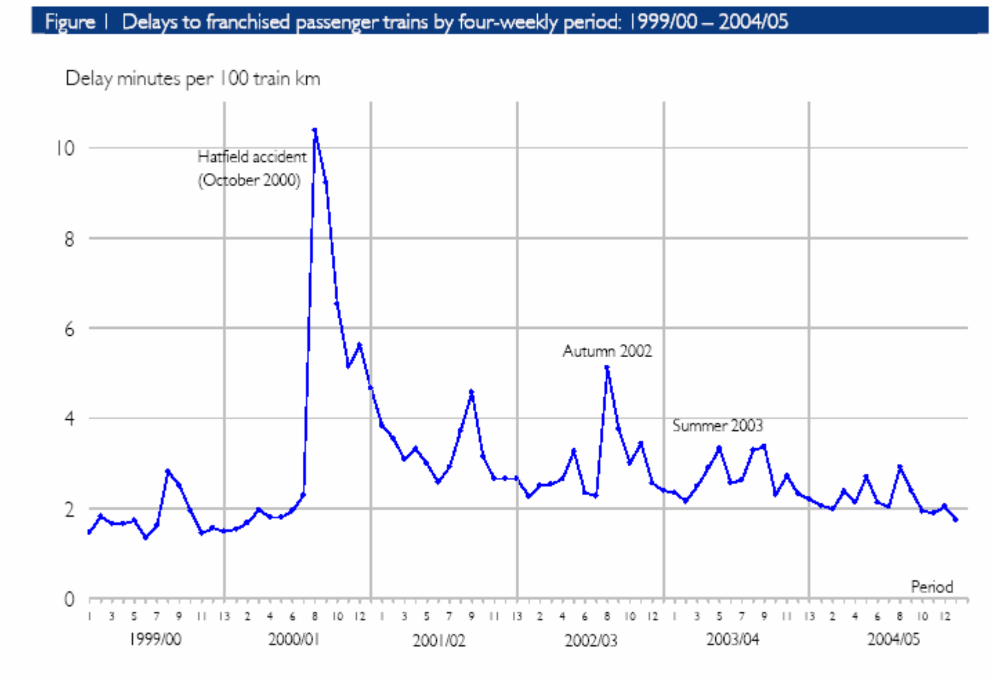


Figure 5-7: Delays to frenchised passenger trains in the UK

Secondly there is extensive use made of Delay Minutes, as described in Net-work Rail's Annual Return:

Table 5-9: UK national rail delays by cause 2003 – 2005

Table 12 National delays to passenger and freight trains by summarised category groups – trend								
Category group	2001/02		2002/03		2003/04		2004/05	
	Total delay minutes	Delay minutes per 100 train km	Total delay minutes	Delay minutes per 100 train km	Total delay minutes	Delay minutes per 100 train km[1]	Total delay minutes	Delay minutes per 100 train km[1]
Track defects and TSRs[2]	3,024,543	0.66	2,514,840	0.54	2,128,394	0.44	1,399,184	0.29
Other asset defects[3]	4,058,661	0.88	4,656,471	0.99	4,510,007	0.94	3,667,027	0.77
Network management/other[4]	3,547,582	0.77	4,041,872	0.86	3,884,869	0.81	3,601,440	0.76
Autumn leaf fall and adhesion[5]	476,773	0.10	529,550	0.11	469,113	0.10	287,282	0.06
Severe weather/structures[6]	778,207	0.17	1,042,184	0.22	737,445	0.15	796,378	0.17
External factors[7]	1,498,606	0.33	1,881,478	0.40	1,943,899	0.41	1,617,636	0.34
Total minutes	13,384,372	2.90	14,666,395	3.13	13,673,727	2.86	11,368,947	2.40
Train km (million)	460.94		468.47		478.30		474.35	

Source: Network Rail (2005), p. 30

Neither of these measures isolates the effect of congestion from other factors such as equipment failure, adverse weather, etc.

Most of the UK rail network is covered by recording equipment that captures the passage of all trains. By reference to other systems necessary for the safe operation of the railway it is possible to review the number of movements (and other characteristics such as gross tonnage) that has occurred at most locations. The data currently has to be extracted by special enquiries and is not normally accessed or held by the Office of Rail Regulation (ORR). The network operator (Network Rail) has the most direct access to the data but often uses consultants to extract and manipulate it. The absolute volume of usage is of limited value in itself (apart from for purposes such as assessing rates of wear and tear) unless related to available capacity. So far as ORR is aware, the measures described above are evaluated irregularly by Network Rail, but as frequently as necessary to ensure that maintenance planning is keeping abreast of actual usage.

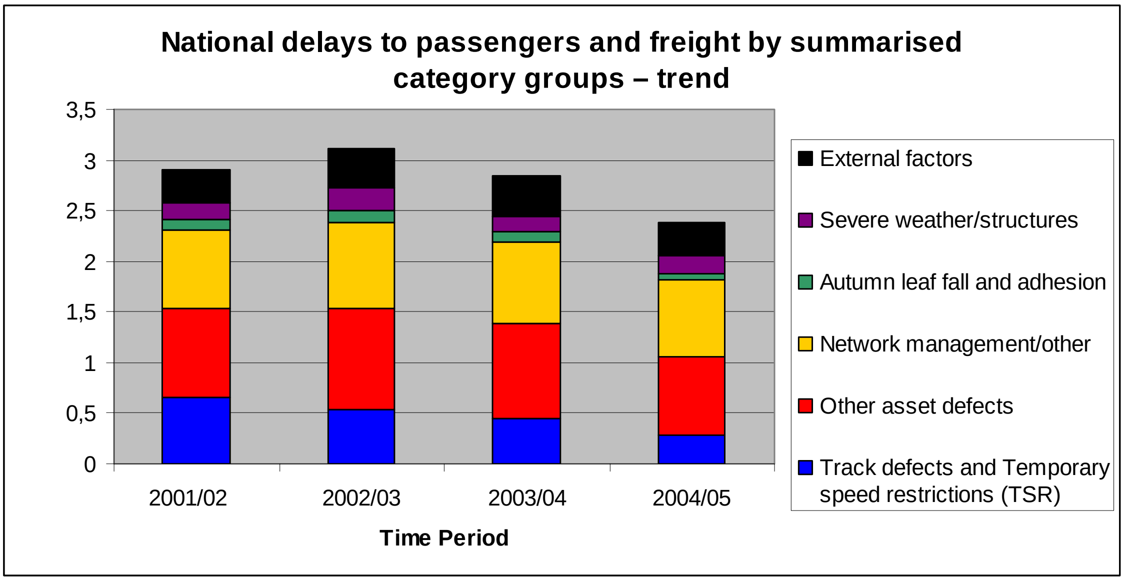


Figure 5-8: National delays to passengers and freight by summarised category groups - trend

The rail network is divided into a large number of small local elements (or 'arcs') for most data capture and analytical purposes. Hence studies can be focussed on particular sections of route or key junctions. Because the time of passage of trains is captured for network management and performance incentive regime purposes, it is at least theoretically possible to distinguish it by particular time segments.

5.4.2 Current Situation

At a general level congestion is most noticeable in respect of commuting into London and some other major cities, largely due to the rapid growth in employ-ment and also road congestion over the past decade. Given the significant in-crease in train services generally (approaching 30% over ten years) many other congested locations are emerging. Another important influence has been major changes in patterns of freight movement, particularly in terms of imported coal for electricity generation in replacement of indigenous supplies and the growth of imported manufactured goods in containers through a limited number of key ports.

5.4.3 Forecasts and Policy Measures

In general terms the continuing growth in employment, increase in the number of dwellings/households and general economic growth will increase demand. The extent of this growth is being assessed by Regional Planning Assessments prepared by the UK Department for Transport (and an equivalent process in Scotland). An example can be seen at http://www.dft.gov.uk/stellent/groups/dft_railways/documents/downloadable/dft_railways_611208.pdf

The Network Rail Route Utilisation Strategies, described in section 6, will iden-tify 'gaps' (where predicted demand exceeds capacity) and propose the most efficient means of filling the gap, e.g. through enhancement such as providing longer station platforms. These schemes will have (at least in outline) business appraisals attached. The Department for Transport (and other funding bodies such as Passenger Transport Executives and the National

Assembly for Wales) will be able to specify if it wishes to follow up these options by funding them.

5.4.4 Additional Information

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- Scottish Executive: http://www.scotland.gov.uk/Topics/Transport
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6 Italy

6.1 Inter-urban roads, motorways

Procedures for monitoring congestion have been only designed for motorways, where the general availability of information signalling system allows the users to be informed about the presence of congestion on the route. In case of forecast of particular adverse meteorological conditions, e.g. intense snow, local authorities, police departments and the local motorways provider are involved in a common strategy for informing the users. Technologies for monitoring motorways congestion involve cameras and sensors for checking traffic flows and message communications technologies for informing users.

6.1.1 Real-time traffic information

The largest motorway network provider in Italy, the 'Autostrade per l'Italia' group, provides a real-time traffic information system on the World Wide Web, where the actual traffic situation on the complete Italian motorway system is shown. The interactive map shows where delays have to be expected, where the traffic situation is critical and at which locations there are even congestions (see Figure 6-1).

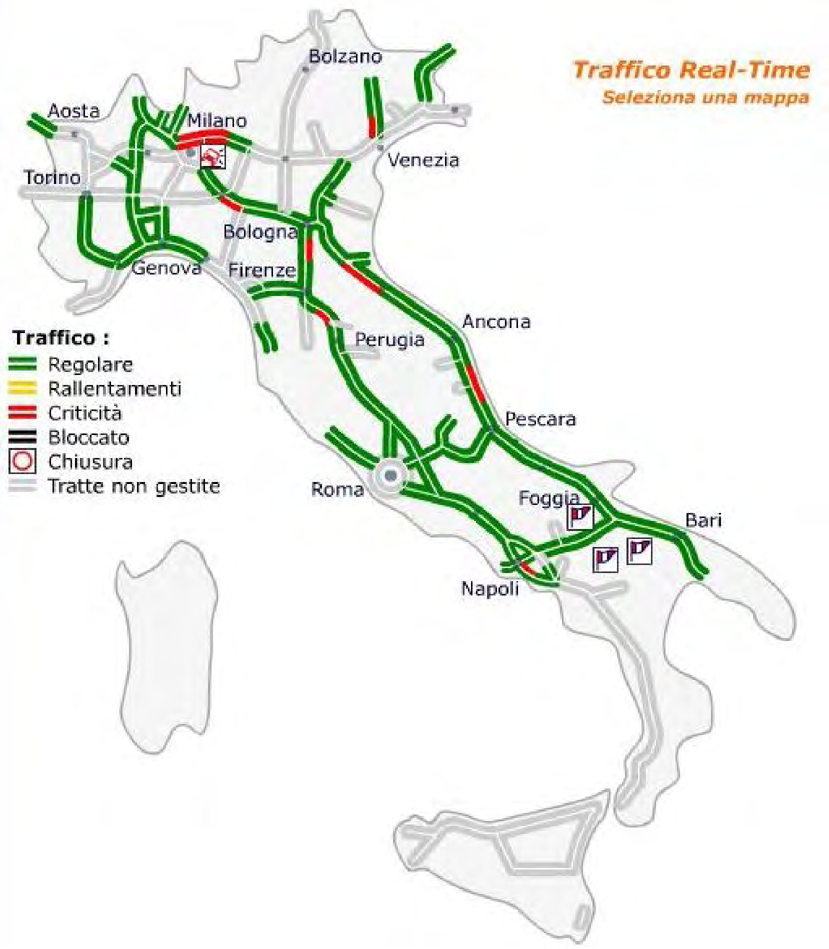

Figure 6-1: Real-time traffic information system on the internet provided by Autostrade per l'Italia (http://www.autostrade.it/autostrade/traffico.do, 4.7.06, 11.30 am)

The real-time traffic information system not only gives an overview about the whole national motorway network, but also gives detailed information about the motorways in urban areas (such as the Milan area in Figure 6-2).

Figure 6-2: Real-time traffic information system for the Milan area, provided by Autostrade per l'Italia (http://www.autostrade.it/autostrade/traffico.do, 4.7.06, 12 am)

6.1.2 Congestion figures

Recent figures about congestion on motorways in Italy are not available, since in general local motorway providers do not deliver data on congestion in their facts and statistics sheets. Data from motorway providers are usually private data, which are not published and difficult to obtain. The only example of available figures concerns the infrastructure provider Società Autostrade per l'Italia, managing more than 50% of national motorways network. However, these data are only from 1995. More recent data are not available. Data about congestion and other traffic disturbances on the motorways A8/A9 (Milano-Laghi (Varese/Chiasso)) and A14 (Bologna-Taranto) can be seen in Table 6-1. It has to be stated that these data only cover around 15% of the total motorway system in Italy. In 1995, there were 1'804 disturbances on the three motorways A8, A9 and A14, which means an increase of 24% compared to 1994. 49% of the congestions and disturbances have been caused by to much traffic. The second important factor causing disturbances on motorways were accidents (35% of all disturbances), whereas road works was only responsible for 12% of all congestions. Other reasons accounted for the last 4%.

In total, there were 10.66 million vehicles involved in congestions on the three motorways A8, A9 and A14 in 1995 (+28% compared to 1994). On average, each vehicle involved in congestion travelled 2.45 kilometres in queue and lost 30 minutes (see Table 6-1). This means, that on these three motorways, 5.33 million hours have been lost in 1995. If one takes an average rate of 20 Euros per hour, the external congestion costs of only these three motorways makes up somewhat over 100 million Euros.

Table 6-1: Number of congestions / disturbances on the motorways A8 / A9 / A14 of Autostrade per l'Italia (1995). Source: Autostrade per l'Ialia.

	Reason for congestion / disturbance				
	Traffic (in abundance)	**Accidents**	**Road works**	**Other**	**Total**
Number of congestions / disturbances					
January	15	30	4	2	51
February	26	28	6	0	60
March	45	29	4	2	80
April	105	42	2	1	150
May	64	40	12	9	125
June	116	64	36	13	229
July	153	101	33	4	291
August	106	97	17	7	227
September	75	51	18	9	153
October	79	58	47	10	194
November	46	49	21	6	122
December	58	43	17	4	122
Total 1995 (change 1994-95)	**888 (+34%)**	**632 (+20%)**	**217 (+56%)**	**67 (-47%)**	**1'804 (+24)**
Total vehicles involved			10'660'000 (+28%)		
Km travelled in queue by each vehicle involved			2.45 (-4%)		
Minutes lost in queue by each vehicle involved			30.0 (-2%)		

6.2 Urban roads: Rome

6.2.1 Traffic information system 'InfoTraffico' Rome

In Rome, the city administration has introduced a traffic information system, called 'InfoTraffico'. This information system is provided by ATAC, the 'Agency for mobility in the City of Rome' (Agenzia per la mobilità del Comune di Roma). ATAC is the cities public transport agency ('Agenzia per i Trasporti Autoferrotranviari del Comune di Roma'), that is not only responsible for all kind of public transport modes but also for private transport services such as the traffic information system.

The information system 'InfoTraffico' is a web-based service that helps people planning their journeys and provides real-time information about possible congestions and distributions. The 'InfoTraffico' consists of four main elements:

- Traffic map ('mapa del traffico'): The traffic map shows the whole road system of Rome and indicates the traffic situation on every single road: free-flow, heavy traffic without congestion, stagnant traffic, congestion.
- Live cameras ('telecamere'): Live cameras on more than 40 locations in the city of Rome. With the help of the live cameras, that are updated every 5 seconds, road users can quickly see which roads are congested at the moment.

- Traffic bulletin ('bolletino de traffico'): The traffic bulletin describes the content of the traffic map in words. For all zones, it provides the actual road situation.
- Special events bulletin ('bollettino eventi'): The special events bulletin provides information about road closures, diversions, road works, activity times of the zone with limited traffic ('zona traffico limitato', ZTL), closures of any type of public transport services, etc.

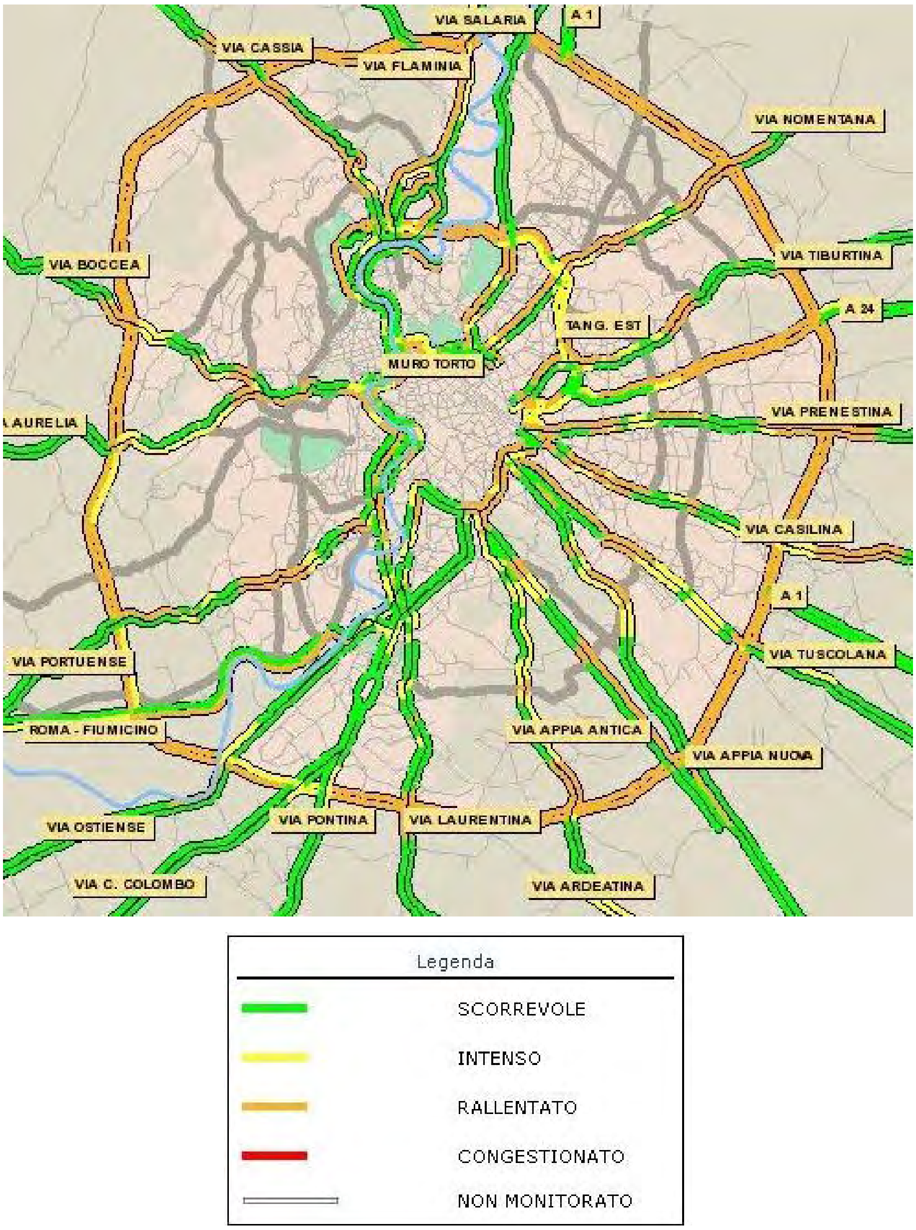

Figure 6-3: Traffic map of the Roman traffic information system (http://www.atac.roma.it/, 4.7.06, 10.30 am)

Figure 6-4: Example of a live camera ('telecamera') picture at Prenestina in Rome (http://www.atac.roma.it/, 4.7.06, 16.30)

6.3 External costs due to congestion

There exist several different studies about the external costs of congestion in Italy. The results of two studies are presented here.

a. ANFIA 2001, The valuation of the road congestion costs in Italy (part of the study 'External costs and benefits of transport'): This study calculates the external costs of congestion of road traffic. It is the application in Italy of the Prud'homme's econometric approach for assessing congestion.

b. FS 2002, The environmental and social costs of mobility in Italy ('I costi ambientali e sociali della mobilità in Italia'): This study from the Frieds of the Earth ('Amici della Terra') on behalf of the national railway company FS calculates the external costs of congestion of all transport systems (road, rail, air) based on top-down assumptions about mileage and congestion delays.

According to ANFIA 2001, the total costs of congestion in Italy made up **2.84 billion Euros** in 1998. Only 18% of the costs (0.52 bn Euros) can be attributed to congestion on motorways. More than 80% of the costs (i.e. 2.32 billion Euros) come from congestion on the subordinate road network (main roads and side roads, communal and urban roads). The time value applied was 12.9 Euros per hour (= 25.0 Lire per hour, analogue to Prud'homme).

The results from FS 2002 strongly differ from the above-mentioned data from ANFIA 2002. In total, congestion costs of road transport are estimated to be **11.1 billion Euros** (data for 1999). 70% of these costs can be attributed to passenger transport (above all private transport) and 30% to freight transport (see Table 6-2).

Table 6-2: Time lost due to congestion and relating external costs of road transport. Data for 1999. Source: FS 2002.

Transport mode	Time lost due to congestion (in billion hours)	External costs of congestion (in billion Euros)
Private cars	1.61	7.51
Public transport (buses and	0.21	0.31

coaches)		
Total passenger transport road	*1.82*	*7.82*
Light duty vehicles	0.14	1.51
Heavy duty vehicles	0.07	1.82
Total freight transport road	*0.21*	*3.33*
Total Road Transport	**2.03**	**11.15**

In road transport, more than 2'000 million hours are lost per year due to congestion. Only 10% of the time lost can be attributed to freight transport. Nevertheless, freight transport has to bear 30% of the total road congestion costs since the value of time is considerably higher in commercial freight transport than in individual passenger transport.

6.4 Rail transport

For rail transport, no detailed congestion data are available for Italy. The only information available is the above-mentioned study about the external congestion costs of transport from FS (2002), According to the results of this study, in Italy 9.7 million hours were lost due to congestion in rail transport (data for 1999). In monetary terms, this means 36 million Euros of external congestion costs, which is only 0.3% of the total congestion costs in road transport.

6.5 Aviation

6.5.1 Delays on the airports

The Association of European Airlines (AEA) publishes annually a punctuality data for 27 of the largest European airports. In this statistics data from the three Italian airports of Rome Fiumicino (FCO), Milan Malpensa (MXP) and Milan Linate (LIN) are available, too (see Table 6-3) . According to this statistics, 26.7% of the departing flights at Rome airport are delayed and therefore Rome Fiumicino is one of the three poorest European airports concerning delays. At the airports of Milan Malpensa and Milan Linate delay situation is better than in Rome. However, also at the two Milanese airports more than 20% of the incoming flights are delayed by more than 15 minutes. The two most important reasons of delay are late arrival (reactionary) and problems concerning airport and air traffic control.

Table 6-3: Punctuality data for the three largest Italian airports 2005. Source: AEA 2006.

Airport	Punctuality ranking*	% of flights delayed **	Average delay (min.)	Reason of delay (in % of flights) **				
				Load & Aircraft Handling Flight Ops	Maintenamce/ Equipment Failure	Airport & Air Traffic Control	Weather	Reactionary (late arrival)
Rome Fiumicino	25.	26.7%	44.0	4.6%	3.2%	8.9%	0.9%	9.2%
Milan Malpensa	16.	23.0%	44.6	3.7%	2.8%	7.4%	1.1%	8.1%
Milan Linate	12.	20.2%	41.6	2.1%	1.0%	8.9%	1.3%	6.9%

** Ranking out of 27 European airports.*

*** Flights delayed by more than 15 minutes are counted. Data are referring to departing flights.*

The following table shows the development of the delays on the three largest Italian airports in the last three years. The airports Rome Fiumicino and Milan Malpensa managed to slightly reduce the share of delayed flights between 2003 and 2005. At Milan Linate the delay situation got somewhat worse. Compared to the other large European airports Rome stayed at the end of the ranking whereas Milan Linate stayed amongst the top twelve. Milan Malpensa, however, improved from the end of the ranking in 2003 to the 16th position ion 2005 since the share of delayed flights at Milano Malpensa decreased slightly whilst it increased at most other European airports during the last three years.

Figure 6-5: Development of delays for the three largest Italian airports in the last three years

Airport	Punctuality ranking*			% of flights delayed **		
	2003	2004	2005	2003	2004	2005
Rome Fiumicino	26.	21.	25.	28.7%	23.5%	26.7%
Milan Malpensa	24.	15.	16.	24.4%	18.6%	23.0%
Milan Linate	12.	9.	12.	17.1%	16.3%	20.2%

** Ranking out of 27 European airports.*

*** Flights delayed by more than 15 minutes are counted. Data are referring to departing flights.*

6.5.2 External costs of congestion

The above-mentioned study about external congestion costs of the FS (2002) also calculated the congestion costs of air transport. According to the result of this study, 1.3 million hours were lost in air transport due to congestion in Italy (1999). This means 6 million Euros of external congestion costs, which is only 0.05% of the congestion costs in road transport.

6.6 Literature

AEA (2006): "AEA Punctuality Data, Annual 2005". Association of European Airlines (AEA), Brussels.

ANFIA (2001): "I Costi e i Benefici Esterni del Trasporto". ANFIA (Associazione Nazionale Fra Industrie Automobilistiche), ACI (Automobile Club d'Italia) and Centro Studi sui Sistemi di Trasporto (CSST), Torino.

FS (2002): "I costi ambientali e sociali della mobilità in Italia, quarto rapporto". Ferrovie dello Stato (FS) and 'Amici della Terra', Roma.

7 Spain

7.1 Contacted Entities

The information on the situation of congestion in Spain was requested to key contacts from the following institutions, using the standards COMPETE questionnaire:

- Road: Directorate General for Road Infrastructure (http://www.fomento.es/MFOM/LANG_CASTELLANO/DIRECCIONES_GENERALES/CARRETERAS/_INFORMACION/ORGANIZACION_Y_FUNCIONES/)
- Railway: ADIF, Railway Infrastructure Manager (http://www.infraestructuras-ferroviarias.com/);
- Ports: State Ports agency (*Puertos del Estado*, http://www.puertos.es/);
- Airports: AENA, Airports and Air Navigation agency (http://www.aena.es/).

No answers to the questionnaire were received.

7.2 Overview - Present situation

In general terms, the information concerning congestion in the different transport modes in Spain is disperse and scattered. It often appears linked to transport planning activities or included in reports on infrastructure investment. Urban road congestion is the one treated more thoroughly as is the one that presents higher levels. Interurban roads have in general low congestion levels (except for specific network bottlenecks or in some periods of the year, like summer holidays), as well as rail transport. Ports have, in general, spare capacity due to the large investment programs undertaken in the last decade, with additional important investment budgets planned for the near future. Airports, mainly Madrid and Barcelona, suffer from congestion due to the large increase of air transport demand in the last decades, but these problems have been solved with important investments in capacity. The congestion in the rest of the airports is (mainly) seasonal, focused in those airports located in tourist regions (Canary and Balearic Islands, Andalusia and the Mediterranean coast regions).

7.3 Inter-urban roads

The Spanish road network is divided into several categories of infrastructures under the responsibility of several administrative levels. The classification is as follows:

- State Road Network (RCE, *Red de Carreteras del Estado*) that includes most highways (tolled and non-tolled) and main conventional roads ("national" roads). The tolled roads are concessions to public and private firms;
- Regional Road networks, that includes roads of lesser importance within the territory of each regions, and lately some highways concessioned directly by the Regional Governments;

- Urban road network, under the responsibility of each municipality. The urban traffic web sites from Madrid and Barcelona are presented in this report.

Responsibility for road congestion monitoring falls in the owner of each infrastructure: the National Government monitors congestion in the State Road network, Regional Governments on its network[7], and municipalities in the urban road networks. The measures to tackle congestion and potential investments associated are also undertaken by the responsible authority.

7.3.1 National road network

Two entities of the National Government have responsibility concerning congestion monitoring and action. On one hand, the Directorate General for Road Traffic (DGT, *Dirección General de Tráfico*) of the Ministry of Internal Affairs, monitors congestion and applies measures concerning management of the existing network. The DGT also holds the maximum responsibility for coordinating the road police operating in the National and Regional road networks (*Guardia Civil de Tráfico*)[8]. On the other hand, the Directorate General for Roads (DGC, *Dirección General de Carreteras*) of the Ministry of Transport and Infrastructures (*Ministerio de Fomento*) has full responsibility for planning and investment activities in the National Road Network.

The **Directorate General for Road Traffic** (DGT) monitors and acts on traffic conditions using a network of cameras, meteorological stations, traffic counting devices and road information panels[9]. The information from such system allows the DGT and other public bodies (like the DGC) to plan and act when persistent congestion problems are detected. The DGT provides in its web site a large amount of information concerning traffic situation in the State Road Network. There are three relevant online facilities where users can know the situation of the road traffic, which are:

1) **Traffic situation facility**[10]: centralises all information concerning traffic situation in all roads of the Country, except for urban roads. The facility consists of a map of Spain where regions and provinces can be selected (see Figure 7-1). The user can select as well the type of incident or congestion source to be located: road works, meteorological conditions, etc. The facility provides subsequently the situation of the roads of the selected province, with a colour scale associated that indicated the con-

[7] This activity is very limited, as the regional road networks are formed by secondary roads, rarely congested, being supported if required by the institutions of the National Government. Only the Basque Country and Catalonia have full responsibility of traffic management over all roads within their territory, including the roads belonging to the National Road Network.

[8] Catalonia and the Basque Country have their own Regional Police Agencies, with powers concerning traffic issues within their territories.

[9] Apart from the supporting activities undertaken by the road Police.

[10] http://www.dgt.es/trafico/estado_circulacion/estadoCarreteras.htm

gestion level (see Figure 7-2), informing about the type of occurrence, kilometre, direction, last update, etc[11]. The scale is as follow:

- **White**: normal conditions, no congestion;
- **Green**: intense traffic with speed under 100 km/hour in highways and 80 km/hour in conventional roads;
- **Yellow**: very intense traffic with sporadic stops and speed under 60 km/hour;
- **Red**: very intense traffic with habitual stops and speed under 30 km/hour;
- **Black**: road closed or traffic totally stopped.

Figure 7-1 – Front page of the DGT's traffic situation facility

Source: DGT web site

[11] The example provided corresponds to the situation of the Valencia province roads.

Tipo de Incidencia	Causas y observaciones	Provincia	Población	Fecha-Hora Inicial	Nivel	Carretera	Km de-hasta	Sentido	Hacia
OBRAS	GRANDES OBRAS	VALENCIA	BARIG	2005-10-08 17:03		CV-675	9.5 - 9.6	DECRECIENTE DE LA KI	GANDIA
OBRAS	TRABAJOS DE MANTENIMIENTO	VALENCIA	BENIARJO	2006-04-03 20:11		CV-680	5.5 - 5.8	CRECIENTE DE LA KILO	VILLALONGA
OBRAS	REASFALTADO	VALENCIA	GANDIA (V)	2006-05-12 15:11		N-332	225.5 - 228.5	CRECIENTE DE LA KILO	VALENCIA
OBRAS	OBRAS EN GENERAL	VALENCIA	MANISES	2006-07-15 11:00		CV-370	5.5 - 4.8	DECRECIENTE DE LA KI	MANISES
OBRAS	GRANDES OBRAS	VALENCIA	MUSEROS	2006-03-25 11:51		CV-32	8.1 - 8.1	CRECIENTE DE LA KILO	A-7
OBRAS	OBRAS EN GENERAL	VALENCIA	OTOS	2004-12-20 16:48		CV-615	7.9 - 13.7	AMBOS SENTIDOS	AMBOS
OBRAS	OBRAS EN GENERAL	VALENCIA	PATERNA	2006-06-19 21:15		CV-35	9.0 - 12.0	CRECIENTE DE LA KILO	ADEMUZ
OBRAS	GRANDES OBRAS	VALENCIA	PICANYA	2006-03-09 08:14		CV-36	3.5 - 3.5	AMBOS SENTIDOS	TORRENTE
OBRAS	REASFALTADO	VALENCIA	ROTGLA Y CORBERA	2006-07-19 11:56		CV-60	33.8 - 34.8	AMBOS SENTIDOS	GANDIA
OBRAS	GRANDES OBRAS	VALENCIA	VENTA DEL MORO	2006-03-29 09:00		A-3	268.0 - 267.2	DECRECIENTE DE LA KI	MADRID
OBRAS	OBRAS EN GENERAL	VALENCIA	VENTA DEL MORO	2006-03-28 10:30		A-3	267.2 - 268.0	CRECIENTE DE LA KILO	VALENCIA
RETENCION	ACCIDENTE	VALENCIA	CARLET	2006-07-28 12:21		N-340	877.0 - 875.0	DECRECIENTE DE LA KI	CADIZ
RETENCION	CIRCULACION	VALENCIA	PATERNA	2006-07-28 19:00		CV-35	11.0 - 7.0	CRECIENTE DE LA KILO	ADEMUZ
RETENCION	CIRCULACION	VALENCIA	VALENCIA	2006-07-28 20:00		CV-500	8.0 - 5.0	CRECIENTE DE LA KILO	SUECA

Niveles

Circulación interrumpida .
Carretera Cortada
Para incidencias meteorológicas la carretera se encuentra intransitable para cualquier tipo de vehículo y existe un claro riesgo de quedar inmovilizado en la carretera por períodos prolongados de tiempo.

Circulación difícil.
Circulación muy lenta con paradas frecuentes y prolongadas (congestión circulatoria).
Para incidencias meteorológicas indica que la calzada se encuentra completamente cubierta de nieve, siendo sólo posible la circulación haciendo uso de las cadenas o neumáticos especiales, a una velocidad máxima de 30 Km/h.

Circulación irregular .
Circulación lenta con paradas esporádicas.
Para incidencias meteorológicas indica que la calzada comienza a cubrirse de nieve, prohibiéndose en este nivel la circulación de camiones y vehículos articulados y circulando los turismos y autobuses a una velocidad máxima de 60 Km/h.

Circulación condicionada.
Circulación a velocidad moderada.
Para incidencias meteorológicas indica que la circulación no se ve afectada aunque conviene extremar la prudencia y se recomienda no sobrepasar la velocidad de 100 Km/h en autopistas y autovías y de 80 Km/h en el resto de carreteras.

Circulación normal.
Circulación fluida.
Condiciones meteorológicas normales.

Figure 7-2 – Information on road condition congestion levels from the DGT's traffic situation facility

Source: DGT web site

2) **Traffic map12:** that centralises the information from the network of cameras, meteorological stations, traffic counting devices and road information panels that can be consulted online. The information does not cover the same amount of roads that the traffic situation facility, as only provides information on those roads with such integrated traffic control systems, which are mostly highways13. The facility presents and interactive map where regions of Spain can be selected, including a zoom, and uses the same colour scale for reporting the traffic situation: from white (no congestion) to black (traffic stopped), that is presented over the road map for the selected area (see Figure 7-3). Apart from the map information and congestion levels, the facility provides:

- Traffic images from the cameras in the road stretch selected;
- Measures of average speed, traffic density in vehicles per hour;
- Composition of the traffic mix in terms of percentage of light vehicles over total traffic;
- Historical data on traffic density and traffic mix for the stretch;

12 http://infocar.dgt.es/etraffic/dgt/marcoDGT.html?idioma=castellano

13 There are some highways not included in the facility, as do not have such traffic management systems installed.

- Causes of the congestion level, with a series of icons indicating, for instance, different types of road works underway, weather conditions, etc.

The information of the facility is complemented by a trip time calculator for the whole network.

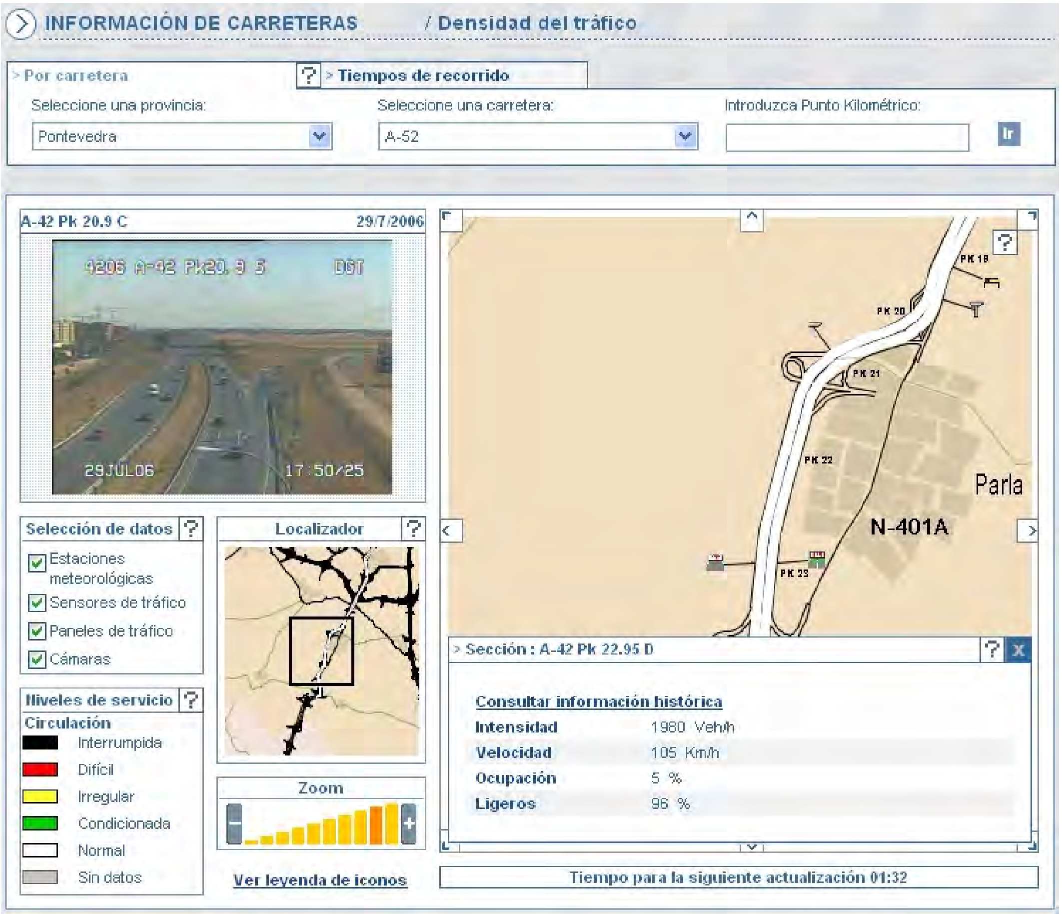

Figure 7-3 – Information on road condition congestion levels from the DGT's traffic map facility

Source: DGT web site

3) **Road cameras facility14:** in this web page the traffic cameras of the network can be consulted. It must be highlighted that only the most important highways of the National Road Network have traffic cameras. At this moment, operational cameras provided on line images to the web site can be found only in the main roads in the Madrid area, those connecting the capital with the peripheral regions.

14 http://www.dgt.es/trafico/camaras/carreteras.htm

7.3.2 Regional level

Only two regions have full competencies concerning road traffic management: the Basque Country and Catalonia. Both regions have traffic departments within their regional departments of internal affairs. The departments have web sites where the situation of traffic in all interurban roads of the Region is presented.

The Basque Country presents a very complete interactive map that provides information on traffic density, congested stretches and causes such as road works, accidents, sports events, etc. The information is updated constantly showing hour where the incident occurred, how the road is affected, etc[15].

Catalonia presents also a web site with comprehensive information concerning road traffic. The information available includes text information concerning traffic situation in all roads of the region (including information on road works, accidents, sports events, etc) and a web page with on line images of all operational traffic cameras (only placed in the hihgways)[16].

7.4 Urban roads

In the following the urban traffic web sites from the Madrid and Barcelona city governments are presented.

7.4.1 General policy issues

In Spain, at this moment, urban mobility matters are in the political agenda. The reason is the launching by the Ministry of Transport and Infrastructures (Ministerio de Fomento) at the beginning of this year of the Strategic Plan for Transport Infrastructures (Plan Estratégico de Infraestructuras de Transporte, PEIT). This plan is intended to be the strategic reference for policy and planning transport between 2006 and 2020. The PEIT has been developed from and integrated perspective of the transport system, putting mobility concept and the satisfaction of mobility needs of all citizens as its main objectives, fulfilling a series of conditions related to the promotion of intermodality, support of environmentally friendly solutions and sustainable modes, reduction of CO2 emissions, etc.

Concerning urban transport, the PEIT present a diagnosis of the situation concerning urban mobility and its parameters: motorisation rate, modal share between private-public modes, motorised-non motorised modes and travel cause. Concerning the use of private vehicle, the tendency in all large cities is the increase in the use of private car with a reduction in the use of public modes and non-motorised modes. Interestingly, this tendency is more developed in cities under 500.000 in habitants than in the big cities as Madrid and Barcelona (also Valencia, Sevilla and Zaragoza), where the good supply of public transports is a key factor.

In Madrid and Barcelona (as well as in the rest of the major cities) mobility and congestion are considered a major concern. The mobility issue is seen from the perspective of enhancing mobility, as stated in the PEIT. And urban congestion is seen as a problem hindering adequate mobility in terms of travel times, quality of transport and general quality of life in urban

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15 http://www.trafikoa.net/index.asp?menu=11&lang=es

16 http://www10.gencat.net/ptop/AppJava/es/mobilitat/carreteres/index.jsp

areas. The strategic guidelines for policies and measures aimed at the enhancement of mobility and reduction of congestion caused by the high rate of private vehicle use are two-fold:

a) Make the use of private vehicle more expensive when used in the city centres: through more expensive surface parking tariffs (for public parking in the streets) and the introduction in the near future of urban tolls (this measure is been evaluated by city governments, it is not proposed by the national strategic planners);

b) Increase the supply of public transport, improving the connections and number of services, improve quality of service, coordinate timetables and ticketing, etc. These measures are of particular importance in larger cities where trips are longer and a large proportion of people lives in suburban areas. The PEIT proposes the expansion of suburban rail services combined with intermodal stations (park and ride schemes, bus-train stations, etc) in the suburban areas and urban rail-underground facilities.

7.4.2 Madrid

The Madrid city Government provides an on line facility for traffic congestion monitoring in coordination with the Regional Government. The web site has several pages that provide the following information[17]:

- Traffic measures, forecasting per city areas and expected traffic constraints (in text);
- On line map with the scheme of main works underway affecting traffic with links to pages with the description of the works, characteristics and duration (see Figure 7-4);
- Traffic situation map with several options including zoom for specific areas. It provides updated information on congestion with a very similar scale to the one used for the National Road Network, from green (no congestion) to black (traffic stopped), as well as information on road works, relevant accidents affecting traffic, location and available capacity of parking facilities, etc (see Figure 7-5);
- Traffic camera facility: a city map with the situation of all operational traffic cameras of the city. City areas, corridors and single streets can be selected, being possible to survey several cameras at the same time;
- AADT (average annual daily traffic) information facility: database that provides information on the AADT of the main streets of the city, including historical data. The last actualisation corresponds to 2004, and can be consulted in the web page using city maps. AADTs are presented using a colour scale: from light yellow (less than 1.000 vehicles/day) to black (more than 100.000 vehicles/day). It includes also interannual variations and comparisons (see Figure 7-6);
- AADS (average annual daily speed) information facility: very similar to the AADT facility, it provides a database with the average speed per street. The las data correspond to 2005, and can be consulted using maps where the AADS are presented using a colour scale, from yellow (speed under 10 Km/hour) to black (speed over 50 Km/hour, which is the maximum speed in urban areas in Spain).

17 http://www.munimadrid.es/movilidad/

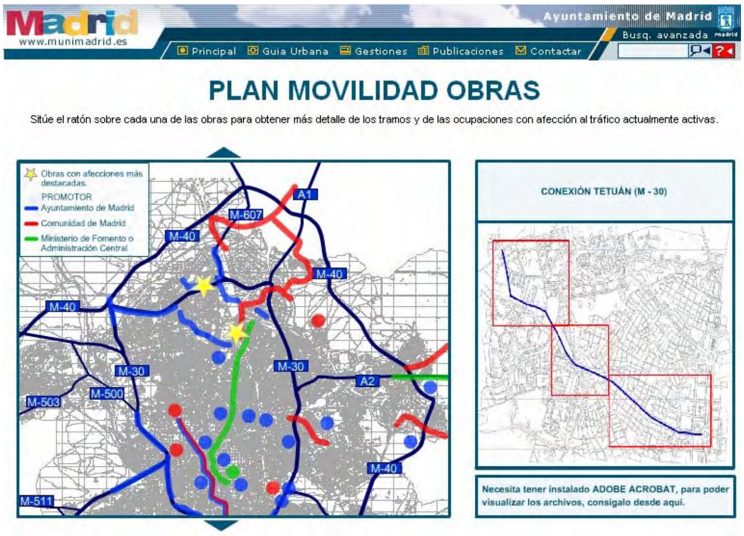

Figure 7-4 – Map of works underway affecting traffic

Source: Madrid City Government web site

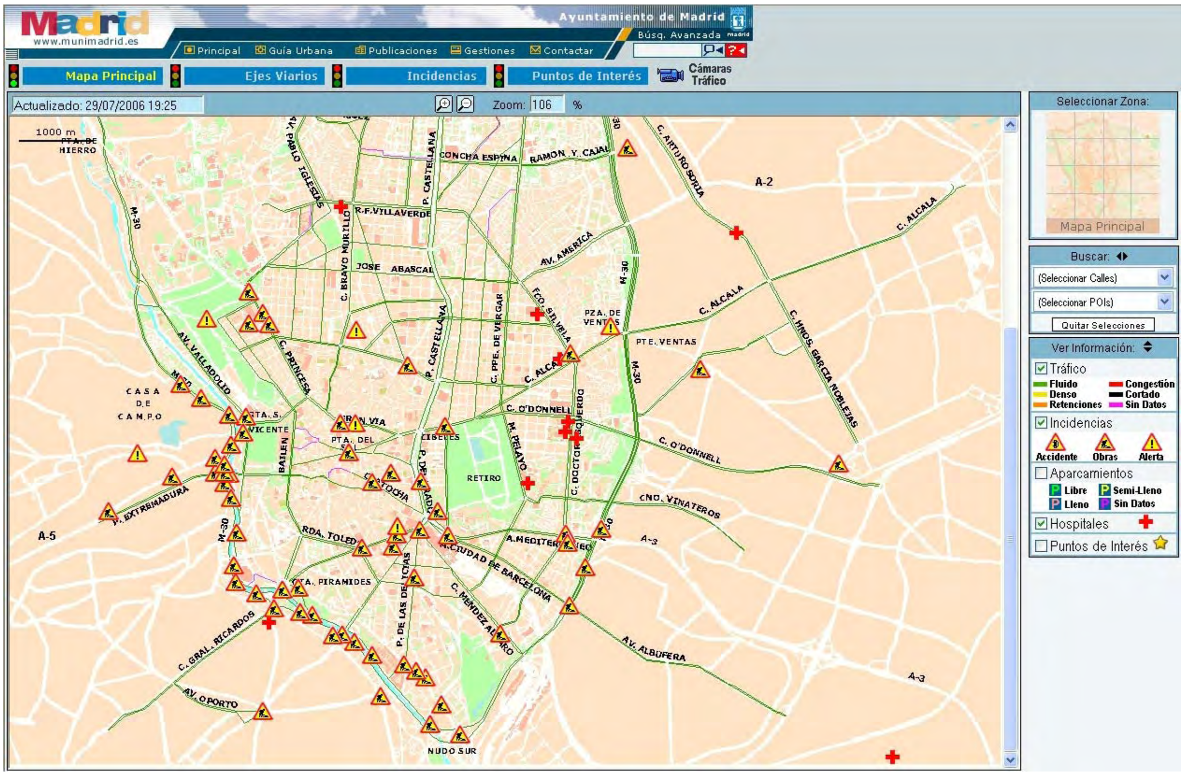

Figure 7-5 – On line traffic situation map of Madrid

Source: Madrid City Government web site

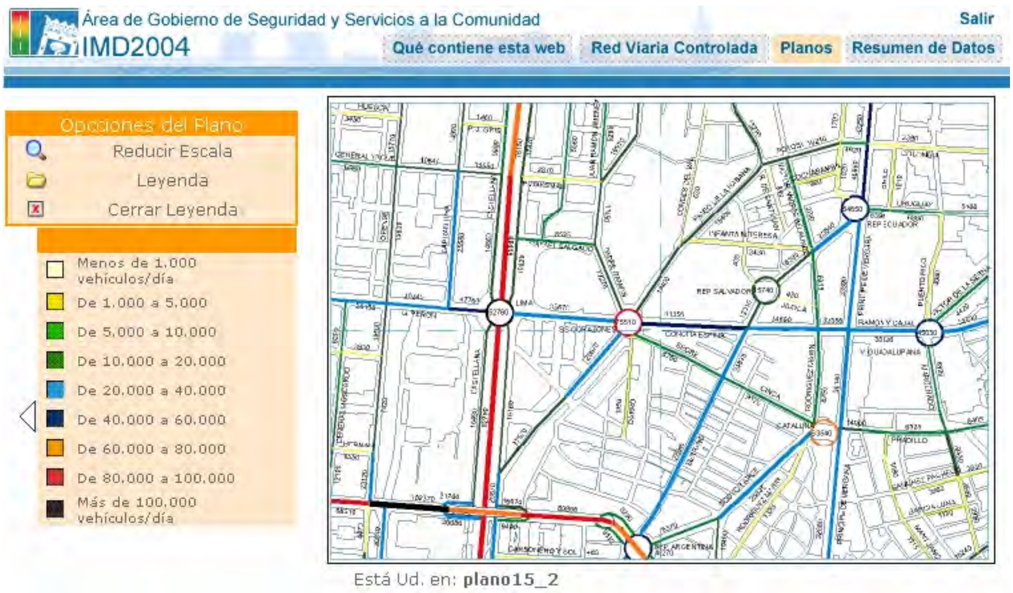

Figure 7-6 – AADT on line information facility and database

Source: Madrid City Government web site

7.4.3 Barcelona

The Barcelona City Government offers in its web site a very similar facility to the one of Madrid for urban traffic and congestion monitoring. It gathers information concerning several traffic-related issues[18]:

- Traffic situation map (see Figure 7-7): it provides updated information on congestion for the city, with zoom to specific areas. It uses a similar scale to the one used for the National Road Network and Madrid, from light blue (no congestion) to black (traffic stopped). It provides as well per road stretch the expected trip time at this moment and the forecast for the next 15 minutes;
- Traffic camera facility: a city map with the situation of all operational traffic cameras of the city (see Figure 7-8);
- Interactive city map with indication of the location of all events affecting urban traffic and potential causes of congestion: works, demonstrations, cultural or sports events, etc;
- Interactive city map with indication of the location and available capacity of parking facilities.

18 http://www.bcn.es/infotransit/ewelcome.htm

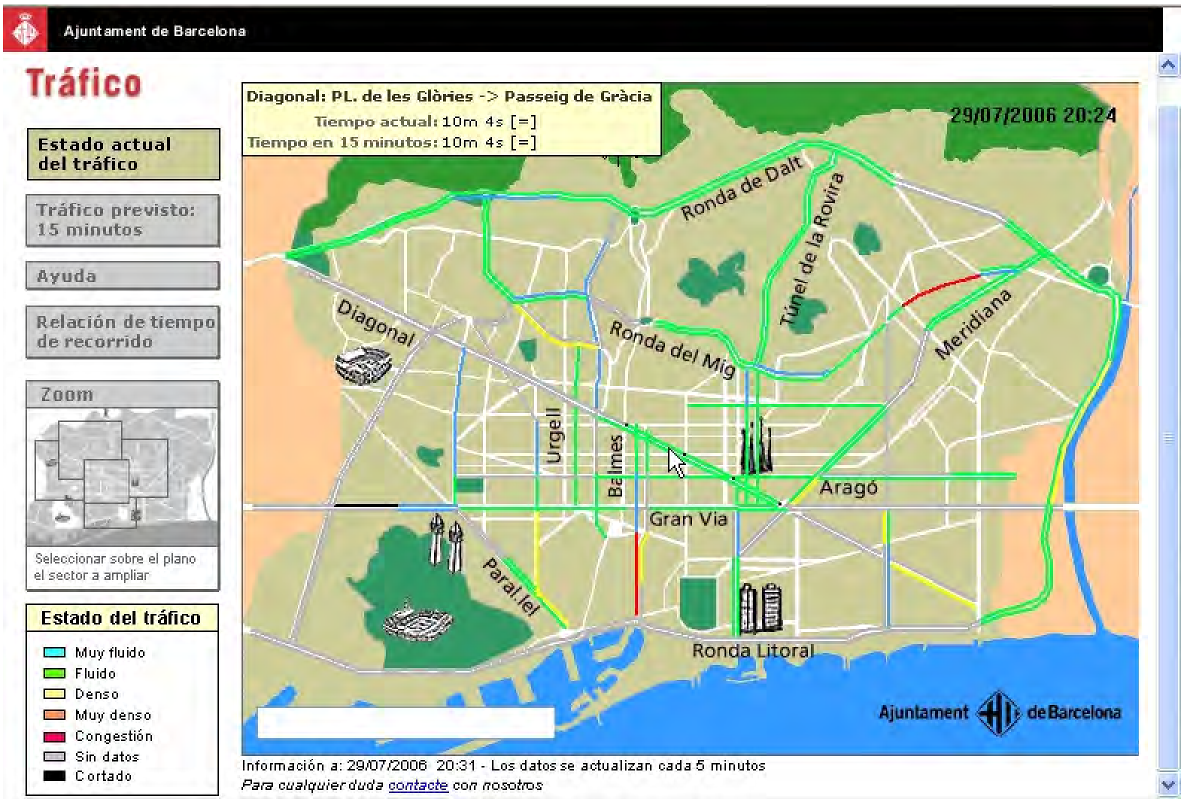

Figure 7-7 - On line traffic situation map of Barcelona

Source: Barcelona City Government web site

Figure 7-8 – Urban traffic cameras facility

Source: Barcelona City Government web site

7.4.4 Congestion cost estimates

Official estimates of urban congestion in Spain do not exist. Nevertheless, some figures are available from "Muñoz de Escalona, Francisco: *La congestión del tráfico urbano. Causas, medidas, costes*. Contribuciones a la Economía, Septiembre 2004[19]". The complete text can be found at: http://www.eumed.net/ce/2004/fme-atascos.htm. The paper is briefly introduced in the folloiwng paragraphs.

7.4.4.1 Brief summary

This paper intends to reflect on traffic congestion problems, causes and measures adopted, intending to provide an estimation of passenger transport costs due to congestion in Spanish large cities. The author divides his work into three chapters dealing with congestion causes, measures to fight it and calculation of congestion costs in Spain.

7.4.4.2 Causes of congestion

The author determines the main cause is demographic and economic growth and the subsequent rise of the Spanish GDP, family income and motorisation rate, especially regarding private vehicles.

The author focuses in the example of Madrid and its region, and presents several data of interest. For instance, during the 90s the number of motor vehicles in the Madrid region changed from 1.81 to 2.41 millions, an increase over 33% in just one decade. Population growth in Madrid metropolitan area and surrounding region and the subsequent increase of mobility needs area also causes of high congestion rates in suburban roads and access roads to Madrid.

7.4.4.3 Measures to fight congestion

The measures taken to fight congestion in the Madrid area during the last two decades are quite diverse, but can be classified into five groups:

- Increase the availability and capacity of road infrastructure, which also has allowed a more intensive use of private vehicles for trips in and out the city;
- Rise of tolls and creation of new tolls and tolled roads;
- Increase of public transport supply, affecting urban and interurban buses, underground and suburban trains;
- Creation of bus dedicated lanes, both in urban and interurban roads;
- Introduction of information technologies in traffic and congestion management.

The author also lists some measures studied but not applied, or in process of application, such as the introduction of tolls for the access to the metropolitan area with private vehicles or the introduction of electronic road pricing measures to the more congested roads or in periods of the day with higher congestion levels.

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19 The title translated into English would be: *Urban traffic congestion. Causes, measures, costs*.

7.4.4.4 Results

The author does not specify the formulae used for the calculation of congestion costs, but gets a figure for 2004 of 901 million € per year, only for the central zone of Madrid metropolitan area. The basic figure for the calculation is a number of 430.000 vehicles circulating in the central zone of Madrid metropolitan area per working day.

Muñoz compares his outcome with that from other authors, Robusté and Monzón[20], that calculated congestion costs in 1995 for Madrid and Barcelona metropolitan areas (see Table 7-1). These calculation provided a much high value for Madrid congestion costs, almost 1.500 million € per year, around 601 million € more than the figures from Muñoz. Robusté and Monzón provide a disaggregated calculation for total congestion costs into three figures both for private and public transport vehicles (buses): time costs derived from extra time spent due to congestion, extra operation costs and pollution costs. The formulas and values used for the calculations are not provided by Muñoz, being impossible to reproduce or update the calculations[21].

The main result from Table 7-1 is the ratio between the total population and the cost per inhabitant per year. The different values of the yearly cost per inhabitant, higher in the larger city, mean that the congestion costs grow more than proportionally with the size of the cities in terms of population: the bigger the city, the larger the cost per inhabitant.

Taking the two values as starting points (population, yearly cost per inhabitant), Muñoz extends the ratio to adjust a line that provides a relationship between population and congestion costs per inhabitant per year. It is a simple linear relationship:

$$Y = 263.74 + 0.000151 \times X$$

Being Y the yearly cost per inhabitant and X the population of the city.

The author estimates the congestion costs for the different Regions of Spain, only for cities over 200.000 inhabitants, using 1996 data. Total congestion costs for Spain are estimated in 2.467 million € (see Table 7-2). According to Muñoz, there are only two sustainable solutions to avoid these high costs:

- Mobility changes for people using private cars, including the improvement of the entire public transport network;
- Rational adoption of land use and urban growth models.

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20 Robusté, F. y Monzón, A.: *Una metodología simple para estimar los costes derivados de la congestión del tráfico en ciudades. Aplicación a Madrid y Barcelona*. Congreso Nacional de Economía. Las Palmas de Gran canaria. Diciembre, 1995. CIES, vol. 3 “Economía del Transporte”, pp. 117-123.

21 The original text from Robusté and Monzón is dated in 1995, but the original data seem to be from 1991, according to Muñoz.

Table 7-1 – Congestion costs for Madrid and Barcelona (€)

	Barcelona	**Madrid**
Inhabitants	**1.607.400**	**3.084.673**
Private vehicles (€):	**322.923.804**	**1.300.848.629**
- Time costs	282.926.448	1.162.958.422
- Operation costs	32.683.038	129.055.329
- Pollution costs	7.320.327	8.834.878
Urban buses (€):	**101.018.115**	**198.922.986**
- Time costs	99.834.121	192.912.865
- Operation costs	1.069.802	4.934.309
- Pollution costs	114.192	174.294
TOTAL (€):	**423.941.918**	**1.499.771.615**
- Time costs	382.760.569	1.356.772.805
- Operation costs	33.746.830	133.989.639
- Pollution costs	7.434.520	9.009.171
Ratio per inhabitant: (€ per inhabitant per year)	**264**	**486**

Source: Muñoz from Robusté and Monzón

With a linear regression on total congestion costs, including time, operating and pollution costs for cars and urban buses, Muñoz (2004) over the results for Madrid and Barcelona the cost values in Table 7-2 for all Spanish cities above 200’000 inhabitants (1995 data) are received.

Table 7-2: Calculation of congestion costs for Spanish cities over 200.000 inhabitants (1995 data)

	Inhabitants (X)	€ per inhabitant per year (Y)	Total Congestion Cost (€)
1 Andalucía			**181.276.478**
Córdoba	306.248	67,93	20.804.483
Granada	245.640	58,78	14.439.122
Málaga	549.135	104,61	57.444.675
Sevilla	697.487	127,01	88.588.198
2 Aragón			**67.714.061**
Zaragoza	601.674	112,54	67.714.061
3 Asturias			**26.670.941**
Gijón	264.381	61,61	16.288.918
Oviedo	200.049	51,90	10.382.023
4 Baleares			**20.576.960**
Palma de Mallorca	304.250	67,63	20.576.960
5 Canarias			**37.493.384**
Las Palmas de G. C.	355.563	75,38	26.802.344
Santa Cruz de T.	203.787	52,46	10.691.040
6 Castilla - León			**22.380.131**
Valladolid	319.805	69,98	22.380.131
7 Cataluña			**425.008.455**
Barcelona	1.607.400	264,41	425.008.455
8 Madrid			**1.503.702.892**
Madrid	3.084.673	487,48	1.503.702.892
9 Murcia			**25.551.455**
Murcia	345.759	73,90	25.551.455
10 País Vasco			**38.808.543**

Bilbao	358.875	75,88	27.231.480
Vitoria	214.234	54,04	11.577.063
11 País Valenciano			**117.723.262**
Alacant	274.577	63,15	17.339.847
Valencia	746.683	134,44	100.383.415
TOTAL NATIONAL			**2.466.906.562**

Source: Muñoz (2004)

7.5 Railways

Currently infrastructure and operation management are separate activities in the Spanish railway sector. There are two key institutions: ADIF, the railway infrastructure manager, and RENFE, the sole national operator of the system. In January 2005 enter in force the new Law for the Railway Sector which finished off RENFE's monopoly in providing railway transport service in Spain[22]. In the near future it is expected the entry of rail operators, starting with the freight market.

Neither ADIF nor RENFE provide any information concerning congestion of the rail network. RENFE monitors delays of the several types of trains operating in the ADIF network. RENFE is organised in Business Units, corresponding to the types of services and trains associated to them, which are:

- Suburban trains operating in the following areas Madrid, Barcelona, Valencia, Bilbao, Málaga, Asturias, San Sebastián, Murcia, Sevilla, Cádiz and Santander;
- Regional trains, providing intercity services within each region of Spain, operating in Catalonia, Andalusia, Castilla-León, Madrid, Galicia, Castilla-La Mancha, Valencia, Aragón, Basque Country, Extremadura, Navarra, Murcia, La Rioja, Cantabria and Asturias;
- High speed trains, operating at this moment between Madrid and Seville and Madrid and Tarragona[23], that comprises AVE trains (high speed with few stops) and Talgo 200 trains (high speed shuttles with more stops);
- Long distance trains, operating the long distance corridors of the country;
- Freight trains[24].

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22 Several Regional Governments have public railway companies owning networks and operating services on them. However, the importance of such services is quite small, and limited to the operation of suburban or regional services, like in Valencia and Catalonia.

23 This line will link Madrid and Barcelona in 2007.

24 RENFE does not provide information concerning delays of freight trains.

Table 7-3 – RENFE: percentage of punctual trains evolution

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Suburban trains (Delay under 10 min)	97,3	98,5	98,4	98,6	99,0	99,1	99,1	98,9	98,8	98,4	98,9
Regional trains (Delay under 10 min)	91,6	94,8	94,7	95,1	96,1	96,6	96,9	96,8	96,8	94,6	94,3
High Speed Trains – AVE (Delay under 3 min)	99,6	99,9	99,8	99,3	99,7	99,7	99,8	99,8	99,8	99,8	99,8
High Speed Trains – Talgo 200 (Delay under 10 min)	97,8	98,0	98,3	98,3	98,8	98,6	98,5	98,2	97,8	97,0	97,5
Long distance trains (Delay under 10 min)	91,5	93,6	94,0	94,2	95,4	95,0	95,5	95,7	94,8	90,4	95,9

Source: own elaboration from RENFE annual reports and accounts

Table 7-3 provides the percentage of punctual trains for each of the train groups operating passenger services. The definition of "delayed train" varies a little according to the type of train: all but AVE trains are classified as "delayed" when have a late arrival of 10 minutes over the scheduled hour. For the AVE trains this threshold is reduced to 3 minutes. In overall terms, it can be remarked the very high punctuality rate of AVE trains, always above 99%, even with the higher standard of the 3 minutes threshold for delays. On the other hand, the most unpunctual trains are the long distance ones. These figures can be found presented in graphical term in Figure 7-9.

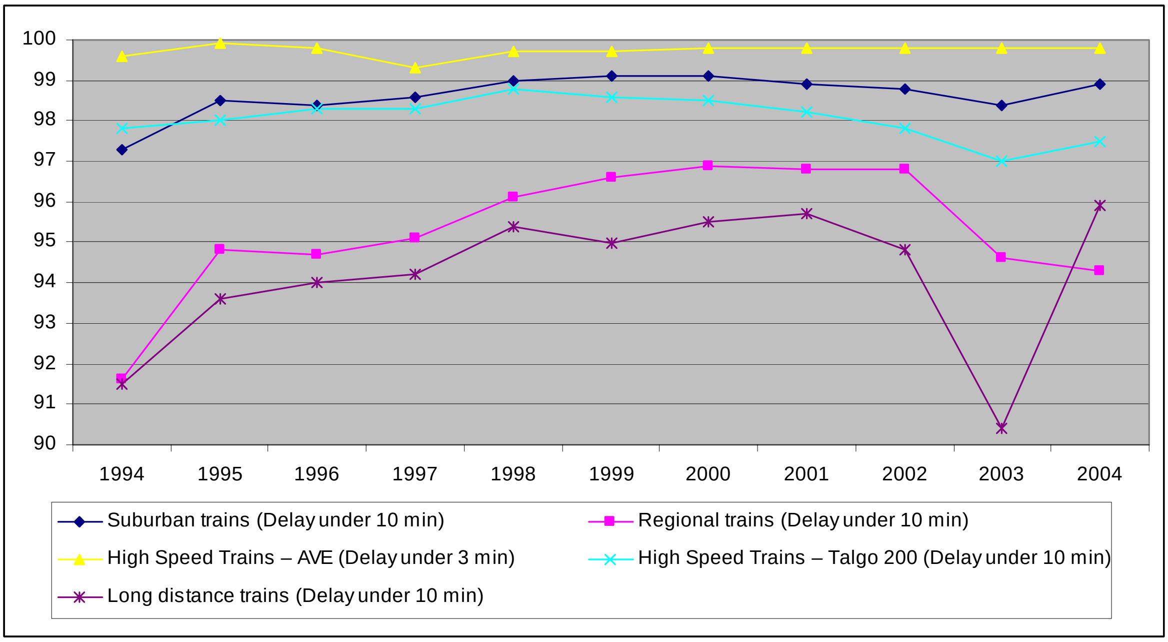

Figure 7-9: RENFE: percentage of punctual trains evolution
Source: own elaboration from RENFE annual reports and accounts

7.6 Ports

The Spanish port sector has grown steadily in the last 10 years, as shown in Table 7-4. During the period, the growth of the total tonnes transported has been of 56.2%, with an average annual rate of growth of 6.2% per year. Maritime transport is nowadays the most used transport mode for Spanish external trade.

Table 7-4: Evolution of the total tonnes transported through the Spanish port system

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total tonnes (millions)	282,4	291,5	303,9	321,1	338,4	349,7	366,5	381,9	410,5	441,1
Evolution index	100	103,2	107,6	113,7	119,8	123,8	129,8	135,2	145,4	156,2

Source: own elaboration from State Ports (Puertos del Estado) data

Port planning and investment activities are coordinated by the Spanish Ministry of Transport (*Ministerio de Fomento*) through the public agency State Ports (*Puertos del Estado*). Although the management of each port is undertaken by each port authority, State Ports centralises all planning activities, as well as price setting rules[25]. This means that the port sector in Spain is taken as a whole, with a high degree of control from the State and a high degree of coordi-

[25] The Spanish ports follow the landlord port model, having their terminals concessioned to private operators. Pricing schemes for the port services are fixed by law, with several degrees of liberty allowing the port authorities to introduce variations. Port concessionaires price their services according to their concession contracts with the port authorities.

nation as well, that leaves very little room for competition between ports. In fact, planning and investment is characterised by a certain degree of specialisation in port activity, being the competence between ports with common hinterlands very limited. Ports sharing hinterland normally specialise in different kinds of traffic, thus avoiding direct competition. This means that capacity and congestion are tackled using an integrated and coordinated approach by the State Ports agency.

Currently the State Ports agency is basing its investment policy on traffic forecasting that goes on until 2020. The on going port investments are based in those results, being the overall aim to cope with the forecasted demand growth (and thus avoiding congestion and the creation of bottlenecks in the port facilities) within the adequate quality standards. The specific objectives of the investment programme are the following:

- To adequate port facilities to the forecasted demand growth;
- To promote ports as major multimodal freight centres within the Spanish transport system;
- To promote short sea shipping, especially within the EU;
- Reduce any bottleneck still existing (or potentially existing in the near future) derive from inadequate connections of ports with land based transport networks;
- To improve the efficient use of port facilities;
- To guarantee safety and security of port operations.

Three of the above mentioned objectives tackle directly existing and potential congestion and bottlenecks in three different fronts:

1) **Increasing the operational capacity of ports** trying to avoid bottlenecks derived from the inability for coping with actual demand growth experienced in the most recent years and the demand scenarios forecasted until 2020;
2) **Improving efficiency of port operations**, making handling operations faster and more reliable, including the minimisation of negative effects derived from bureaucratic issues;
3) **Improving the connectivity of ports to the land based transport network**, avoiding bottlenecks emerging from inadequate (or even non-existing) road and rail links. At his moment, this can be pointed, in general terms, as the weakest point of the Spanish port system.

The current investment plan (2007-2013) devotes 5.268 million € to port investment in the whole Spanish system.

7.7 Airports

The main problems on congestion concerning the Spanish airports are concentrated in the two main hubs of the system, Madrid and Barcelona, and in the tourist regional airports of the Canary and Balearic Islands, Andalusia, Murcia, Valencia and Catalonia. The Spanish Ministry of Transport (*Ministerio de Fomento*) has undertaken important investments in the last decades through AENA, the Spanish public body that owns and manages all civil airports, in order to adequate the infrastructures to the ever growing demand for air transport. This means that there is a coordinated plan for tackling demand increases and congestion problems taking all airports in a joint manner. Table 7-5 presents the evolution of the total demand for air transport in terms of total passengers transported in the Spanish airport system in the last 5 years. The total growth of the total passengers transported since 2001 is over 25%, even with a brief reduction during 2002. This represents a 6.25% annual average rate of growth.

Table 7-5: Evolution of total passengers transported in the Spanish airports

	2001	**2002**	**2003**	**2004**	**2005**
Total passengers	143.121.251	141.592.040	152.232.132	164.389.355	179.643.919
Evolution	100	98,9	106,4	114,9	125,5

Source: own elaboration from AENA data

As referred previously, AENA has undertaken important investments in capacity in most of the airports. These investments have been coordinated through the so called "airport master plans" of each infrastructure. The investments have been undertaken accordingly to the category of the airport, its importance in the present and the forecasted needs. The more relevant investments undertaken in recent years (or still underway) are the following:

- Madrid-Barajas master plan, that included the construction of the new Terminal 4, recently opened to operations (March 2006). The new terminal provides a maximum operational capacity to Madrid-Barajas over 70 million passengers annually, handling by itself more than 35 million[26]. The strategic plan for Madrid-Barajas includes the reinforcement of the intra-EU connectivity and the strengthening of the airport as the main European hub handling traffic for Latin America, taking the new spare capacity as a base for the future developments expected;
- Barcelona-El Prat master plan, finalised in 2004, that included the improvement of the operational capacity of the airport. The strategic vision was to consolidate the airport as a major Top10 European hub mainly devoted to south European flights. The improvements undertaken included a second terminal building and a third runway.

In the near future, more precisely between 2007 and 2013, AENA plans to invest over 2.758 million € in the whole airport system. The main strategic objectives of the period are: **1)** to invest in capacity mainly in regional airports and in others serving the most important Spanish metropolitan areas, creating available slots providing conditions for the entry of new operators, especially low cost carriers, in order to improve the national and the intra-EU connectivity; and **2)** to rise the overall safety, security and quality standards of the operations.

[26] Before the opening of the new infrastructure, Madrid had already entered the Top20 of the World airports with almost 42 million passengers, according to ACI (Airport Council International) data cited by AENA.