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Richard L. Clarke

Clemson University, South Carolina

Clinton H. Whitehurst Jr.

Strom Thurmond Institute, South Carolina

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U.S. AND EUROPEAN APPROACHES TO IMPROVING AIRSPACE CONGESTION

by

Richard L. Clarke, Clemson University, South Carolina

and

*Clinton H. Whitehurst, Jr., Strom Thurmond Institute,
South Carolina*

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It is evident to anyone who has recently travelled by a commercial airline in the United States or Europe that something needs to be done and done fast to relieve the ground and air congestion that exists at major air hubs. The February 1st, 1991 runway collision at Los Angeles International Airport in which 34 people were killed is the most recent, tragic example of what can happen when the infrastructure of a national aviation system becomes inadequate to meet the demands placed upon it.

As the number of saturated airports in Europe and the United States increases, federal aviation authorities on both continents are studying a number of ways to relieve airspace and airport congestion. The purpose of this paper is to identify and analyze the major options being considered. While all options will be examined, most attention will be focused on the airspace around airports and the air traffic control (ATC) system that regulates this airspace. Of all the components of an air transport system, airspace around an airport is the one that is absolutely constrained. It can be expanded by definition, but it cannot be expanded as a practical matter once defined.¹ The

four major approaches to airspace congestion reviewed in this paper are (1) new/larger airports, (2) greater use of surface transport alternatives, (3) rationing airspace and runways and (4) improved air and ground traffic control systems.

New/Larger Airports

This option to improve the air travel system is the most easily understood, yet is the most expensive in terms of construction costs, land acquisition, and environmental costs imposed on the surrounding area e.g., more traffic congestion and noise. Of the three costs, the environmental one generally receives the most publicity.

There are some major advantages and disadvantages of a new airport versus expansion of an existing one. One major advantage of building a new airport is that the airport design can be state of the art and built to allow expansion. A new airport can be located to maximize the air (control) space around the metropolitan area it serves and it can be located to maximize ground access to the airport. New airport negatives are (1) greater construction costs, (2) more contentious with respect to environmental impact, and (3) difficulty in making inter carrier connections. From an operational point of view, the third disadvantage evokes the most concern. It is the main reason all-cargo carriers are against all-cargo airports. In this respect it is argued:

- Such airports would be theoretically built away from the major cities where land is available for expansion. They could also be established at former military airports that are available for purchase from the federal government.

- The advantages of regular airports, such as proximity to population centers, and availability of connecting flights, far out weigh the benefits of more space and less congestion at an all-cargo airport.
- Most important, the vast majority of general cargo is carried in the bellies of passenger aircraft, not in freighters. No air carrier would be willing to divert a plane with passengers to an all-cargo airport to unload cargo.²

For the same reason, regional carriers, i.e., commuter airlines, resist the idea of being moved to so-called reliever airports. The concern of the commuter airlines has lessened, however, as the hub and spoke system has continued to develop, a system which depends upon small commuter planes feeding traffic into large hub airports.

Of the 40 largest metropolitan areas in Europe and the United States, 16 have two or more airports. None have an all freight airport although such was being considered for Frankfurt (Germany). Examples of two airport cities are Washington, DC, New York, (three including Newark), Chicago, San Francisco/Oakland, London, and Paris.

Airport expansion also has its problems. First, expansions create essentially the same problems with respect to inter-airline connections as do two airports serving the same metropolitan that are geographically separated. When a light rail system must be used to connect terminals within an airport (Dallas-Ft. Worth, Houston, Texas), an airport is probably very close to its optimum size. Nonetheless, even an expanded airport causes fewer connection problems than two geographically separate airports. Airports in the United States and Europe that have undergone major expansions include JFK International (NYC), Chicago's O'Hare, Los Angeles International, Baltimore-Washington International, Logan International (Bos-

ton), Zurich (Switzerland) and Heathrow (London). Examples of new, state-of-the-art airports in the United States are Atlanta, Georgia's Hartsfield International Airport and Denver, Colorado's Stapleton International Airport.

Alternate Surface Transport Systems

Surface transport systems are here defined to include highway (automobile, bus, truck), rail, passenger and freight, and to a lesser extent, rivers and oceans (barges, ocean carriers, ferries, and passenger ships). Over the past 20 years the option most discussed to improve overall transport efficiency has been to substitute high speed rail passenger transportation for the privately-operated automobile. The arguments for this substitution that are most cited include relieving highway congestion, lessening pollution caused by automobiles, and fuel conservation. As a practical matter the option has found more favor in Europe than in North American. France's Train a Grande Vitesse (TGV) began service between Paris and Lyon in 1983. It is the best known of the European high speed rail services. The TGV train travels at an average speed of 132 mph and covers the 244-rails miles from Paris to Lyon in two hours flat.³ It might also be noted that the train has paid all of its operating and construction costs from fares.

French plans to expand its TGV system can be summarized thus:

- Europe's railroads have cooperated for years in running international services, but the TGV prompted officials to take another step. They began to look at numerous routes between major cities where trains averaging in excess of 100 mph could be truly competitive with airlines.

- In France, plans are under way to expand the TGV network beyond Brittany and southeast France to include Brussels, Belgium, Amsterdam, the Netherlands; the French cities of Bordeaux and Strasbourg; and cities in West Germany and Switzerland.
- "In 1992, the railroads will find themselves in a different environment," said Dagobert M. Scher, vice president for French Rail, Inc. the North American marketing arm of the French National Railroad.
- "The goal is to tie together cities 200 to 500 miles apart at rail speeds fast enough to make the service truly competitive with airlines."⁴

Other planned high speed European rail systems include Milan, Italy to Rome; London via the Channel Tunnel to Paris, Brussels, Amsterdam, and Cologne; London to Folkestone, Glasgow and Bristol; and all major German cities to Europe. Projects to improve rail service are also in the planning stage in Portugal, Spain, Switzerland, and Austria.

In the United States and Canada it was the improved highway system that ended scheduled air service between cities less than 100 miles apart. And as planes became larger and faster direct air service between cities up to 150 miles apart decreased. The major exception to this trend was flights from cities 100-200 miles from major hub airports.

However, the possibility of United States high speed rail systems that would be competitive with airlines is an idea that will not go away. At different times proposals have been made for high speed rail service between San Diego and Los Angeles, Chicago and Milwaukee, Chicago and Minneapolis/St. Paul and upgrading the present 85-90 mph Amtrak routes in the so-called Northeast Corridor, that is, Boston to New York, and

New York to Washington, DC. The latest proposal is for a high speed magnetic train (magnetic levitation or maglev) to service the 265 mile route from Los Angeles to Las Vegas. The train would operate at speeds up to 300 miles per hour and cover the distance in 75 minutes.⁵

Although the United States has lagged Europe in upgrading its rail passenger service, its rail freight service has improved to a point where dedicated container trains, trailer on flat car (TOFC), and roadtrailers, successfully compete with trucks on many high density traffic corridors.

As the case of short distance airline service, an improved highway system which incorporated bridges and tunnels, all but ended ferry services in the United States. In Europe, however, ferries are still competitive in linking English Channel and North Sea ports. Hovercraft operate profitably between England and France. And in the United States, surface effect ship technology has attracted some renewed interest and investment. In New York City, for example, ferries have made a comeback as one means of avoiding highway congestion.

- While boats once were the only way into and out of Manhattan, ferry travel largely fell into disfavor after 1930 with the construction of New York's network of bridges, tunnels and highways.
- But in the past four years, seven private ferry operators have established 13 routes into Manhattan. The routes range from short hauls from new housing developments on the New Jersey side of the Hudson River to 45 minute runs from Monmouth County New Jersey, across Raritan Bay.
- The private ferries carry about 10,000 riders a day into and out of Manhattan.

- To city officials, the Metro Manhattan represents a technological advancement in ferry service that could make longer-distance commutes more feasible.
- The 110 foot vessel is what is known as a surface effect ship, a hybrid between a catamaran and a hovercraft. It rides on a cushion of air that lifts 85% of the boats weight out of the water. The limited contact with the water allows a vessel to achieve speeds as high as 48.6 knots-about 56 mph.⁶

Whether rail, highway, or short haul ferries, surface transportation options have received increased attention as an alternative to short and medium distance air service. To the extent that surface transportation can be competitive in terms of price and time with air, then to that extent congestion in European and North American air transport systems will be lessened.⁷

Table I contrasts airline distances, highway distances, and driving times between major United States cities, of which many are major air hubs. Table II shows airline distances and estimated high speed rail times between major European cities. An inspection of Table I indicates the extent to which highways are competitors to corresponding air services in the United States. Table II indicates the potential for European high speed rail service as a competitor to air transportation. And it takes no great amount of introspection to see the real possibility of United States high speed rail service, in time, becoming a significant competitor of airlines, especially over relatively short (200-500 mile) distances.

Table I
Airline/Highway Distances and Driving Times
between Major U.S. Cities

City Pairs	Air Distance	Road Distance	Driving Time	Est. TGV Time
New York-Buffalo	292	436	9 hrs.	
Cleveland	405	514	10 hrs. 15 min.	
Detroit	482	671	13 hrs. 55 min.	
Pittsburgh	317	386	8 hrs. 45 min.	
Boston	188	213	4 hrs. 35 min.	1 hr. 30 min.
Washington DC	205	229	5 hrs. 30 min.	1 hr. 50 min.
Philadelphia	83	93	2 hrs. 25 min.	
Chicago-Cleveland	308	344	7 hrs. 10 min.	
Omaha	432	493	9 hrs. 30 min.	
Minneapolis	355	411	9 hrs.	
Detroit	238	279	6 hrs. 05 min.	2 hrs.
Indianapolis	165	189	3 hrs. 50 min.	1 hr. 30 min.
Kansas City	414	503	11 hrs. 50 min.	
Louisville	296	305	6 hrs. 15 min.	
Pittsburgh	410	457	10 hrs. 15 min.	
Milwaukee	75	87	1 hr. 55 min.	
Kansas City-Omaha	166	198	4 hrs. 15 min.	
St. Louis	238	257	5 hrs. 25 min.	
Dallas-Houston	225	242	5 hrs. 10 min.	1 hr. 55 min.
Memphis	420	470	9 hrs. 45 min.	
New Orleans	443	504	10 hrs. 55 min.	
Los Angles-				
San Francisco	347	403	9 hrs. 35 min.	
San Diego	102	127	2 hrs. 50 min.	45 min.
Phoenix	357	398	9 hrs. 05 min.	
Los Vegas	229	272	5 hrs. 50 min.	

Table I continued

**Airline/Highway Distances and Driving Times
between Major U.S. Cities**

City Pairs	Air Distance	Road Distance	Driving Time	Est. TGV Time
Atlanta-New Orleans	412	480	11 hrs. 15 min.	
Jacksonville	280	313	7 hrs. 25 min.	
Charlotte	220	240	5 hrs. 20 min.	2 hrs.
Memphis	320	382	8 hrs. 55 min.	
Birmingham	135	150	3 hrs. 20 min.	
Chattanooga	90	113	2 hrs. 35 min.	

Sources: National Geodetic Survey as published in Reader's Digest These United States. (Reader's Digest Association, Pleasantville, New York, 1968) p. 170 and Rand McNally 1986 Road Atlas (Rand McNally & Co., Chicago, IL, 1986) p.2.

Range of highway speeds, 45-52 mph.

TGV estimated times based on Paris-Lyon TGV of 2 hours over similar terrain.

Table II
Airline Distances and Estimated TGV Rail Times
between Major European Cities^a

City Pairs	Airline Miles	Est. TGV Time (Hours) ^b
Paris-Lyon	240	2.0
Berlin	545	4.5
Rome	697	5.8
London	213	1.8
Brussels	163	1.4
Bonn	252	2.1
London-Brussels	200	1.7
Rome	887	7.4
Berlin	579	4.8
Brussels-Bonn	120	1
Madrid-Lisbon	320	2.7
Rome-Zurich	425	3.5
Milan	300	2.5
Milan-Vienna	385	3.2
Frankfurt-Brussels	188	.4
Zurich	193	1.6
Vienna	367	3.1

^aSources: Colliers World Atlas Gazette, (P.F. Collier & Son, New York, 1957), p. 144 and Encyclopedia Britannica as published in the 1990 Information Please Almanac (Houghton Mifflin, Boston MA, 1990). pp. 330-31.

^bCalculated on basis of Paris-Lyon TGV time. The 245 mile run takes a flat two hours at an average speed of 132 mph (Trains, V. 49 (April 1989) p. 53. Calculated as a ratio of $2/240 \times X/\text{airline miles}$. Example: Berlin is 545 miles from Paris. TGV time = $2/240 \times X/545 = 4.5$ hours, 30 minutes. No allowance made for differences in topography.

Rationing Air Space and Runways

Another option to improve air travel systems is to make more efficient use of existing air space and airport runways. Technically, runways are a physical part of the airport, and like terminals, can only be added to subject to the constraints of land availability, construction costs, and environmental concerns. Here, however, runways are considered together with local airspace, primarily because both are subject to air traffic control procedures that can be improved by investment in state of the art air and ground control electronic systems. This option is discussed in the next section.

There are several ways in which local airspace and runway congestion can be lessened without increased investment in air traffic and ground control equipment. One is to limit airport use to large, commercial passenger aircraft. In practice, all cargo aircraft, private and business aircraft, and commuter aircraft would use secondary (reliever) airports located in the general metropolitan area. Necessary inter-airline connections would be handled by ground transport systems linking the airports. Objections to this option have already been noted.

All-cargo carriers stress that dedicated freight airports are impractical because of the need to interline with commercial passenger plane--which carry a significant part of the air freight movement in their cargo bellies. Commuter airlines stress the fact that their "reason for being" is to feed traffic into large airports and in this they are supported by most major passenger carriers. Corporate and private aircraft make the same argument but are not as persuasive given the private, rather than public, nature of their operations. However, both represent potent political constituencies and have been quite successful in maintaining their accessibility to large airports in the United States.

A second alternative is to make better use of existing air and runway capacity. Basically, it is to "encourage" round the clock use of the airport, or at least to extend the peak use periods. One way is to recognize that a landing or takeoff time (a slot) is a valuable economic asset and as such should not be treated as a free good.

In 1969 the FAA implemented a high density rule at five major airports - Newark, La Guardia, O'Hare, Washington National, and JFK International. (Newark was later dropped from the list) The rule set a ceiling on the total number of slots available during each hour of the day...a so-called slot control system. The allocation of the slots was by a committee made up of carriers using the airport with the FAA in an oversight role. A chief criticism of the slot control system was that existing airlines at the four airports could keep competitors out through their control over an FAA fixed number of slots.

Following the air controllers strike in 1985, the committee system for allocating slots at the four airports allegedly broke down, i.e., the airlines could not agree among themselves. Allocation by committee was replaced with a lottery system administered by the FAA. In 1986 the lottery system was replaced by an open market system under which carriers were allowed to buy, sell, and lease their slots. Existing carrier slots were "grandfathered" to the then user of the slots. Essentially, the system of slot control was replaced by a slot market. David Graham of the Institute of Defense Analysis notes that some slots have sold for more than \$700,000.⁸

Another suggested approach to rationing air and runway space is for congested airports to establish market-clearing prices for take off and landing rights. In this case, higher prices would be charged during peak periods, and less during off peak periods. The argument here is that slot markets are difficult to operate and that a market-clearing price system would accomplish the same objective.

At airports, other than the four hubs cited above, takeoff and landing rights are handled by committees made up of existing carriers. In no United States airport are takeoff and landing fees used to allocate airport capacity. In most cases the fees are minimal, due, in part, to competition among airports.

The use of slot markets has not gone unchallenged. Some carriers urge that sale of slots to the highest bidder unfairly favors large carriers with deep pockets, while discouraging efforts by the federal and local governments to expand the number of airports and existing airport capacity. On the other hand, a number of carriers and some officials within the FAA are in favor of establishing slot controls at other high density airports. The counter-argument is that whether the slots are allocated by lottery or a market price, the present committee system would unduly favor existing carriers and inhibit competition, i.e. new carriers coming into the airport.

Improved Air Traffic Control and Ground Control

Airport capacity limitations are plaguing airlines and air travelers at a growing number of the world's major airports. The cost of delays and passenger inconvenience is in the millions annually. The impact of airport congestion hit hard in the United States in the early 1980's. The United States Federal Aviation Administration (FAA) formally recognized airspace capacity problems in 1982 and in 1983 announced a \$25 billion, 20 year-plan called the National Airspace System (NAS) Plan to reduce airspace congestion by the year 2000. The plan focuses on increasing airspace capacity by (1) the safe reduction of separation standards, horizontally and vertically, (2) real-time management of aircraft flow, and (3) increased productivity of the air traffic control (ATC) system. The plan does depend on building new airports or adding new runways at existing airports. In fact, only one new major United States airport (Dallas-Ft. Worth, 1973) has been built in the past 20 years and only one is planned for the 1990s (Denver 1995).

In 1981 the FAA created an Aviation Industry Task Force to conduct in depth research on what needed to be done, what could be done, what would work and what would not work, and how much proposed solutions would cost. The result was a comprehensive NAS plan that consists of 92 separate projects, including 12 major systems acquisitions costing over \$150 million each.⁹

Major technical efforts included in the NAS Plan include the following:

1. closely-space parallel runway independent IFR operations
2. reduction of IFR minimums on converging runways
3. reduction of longitudinal separation
4. exploitation of curved segmented approaches
5. advanced terminal area automation
6. application of cockpit traffic displays for pilots
7. application of computer modeling techniques for traffic flow
8. reduction of wake-vortex impacts
9. development and implementation of microwave landing system
10. development of improved airport surface surveillance system.¹⁰

When all phases of the NAS Plan are complete, airspace capacity around a number of major U.S. hubs will be significantly increased. Expected capacity increases vary by airport, aircraft type and other factors, but the FAA estimates, in general, that changes in ATC Procedures supported by new technologies can increase the capacity of existing airports by an average of 25- 30%. Detailed capacity increases suggested by the FAA Task Force are summarized in Table III. Of the actions listed in Table III, implementation of a new landing system, the microwave landing system or MLS, appears to offer the greatest potential for increasing airspace capacity. Problems addressed by MLS include more efficient management of existing airspace and

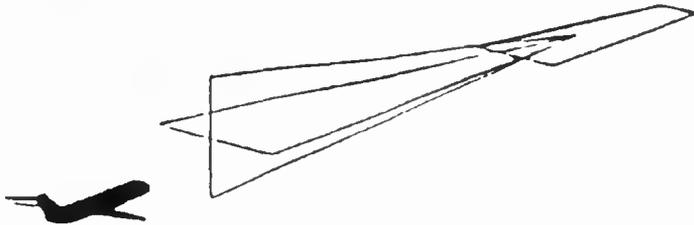
approach paths, as well as improving precision approaches in bad weather. The microwave landing system can provide increased airspace capacity because it is able to support curved and steeper angle approaches, multiple runways, and lower weather minimums.

Table III
Potential Airspace Capacity Increases

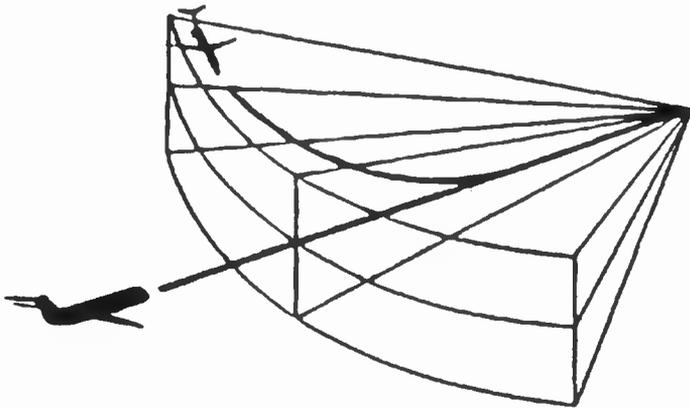
Action	Percentage Increase in Capacity
1. New runways or changed ATC procedures to allow new independent arrival streams	40-100%
2. Reduced separation standards	15-20%
3. Reduced system variabilities	10-15%
4. Average expected gain	25-30%

Source: FAA Task Force (see note 10)

Figure 1 shows schematically how MLS differs from the existing instrument landing system (ILS). The curved and segmented MLS approach capabilities enable air traffic controllers to minimize airspace conflicts, get more aircraft safely in the landing pattern, and reduce time in local airspace. The system accomplished these objectives thorough the use of "an electrically scanning radar capable of updating aircraft targets as often as two times a second as compared to once every five seconds for conventional airport surveillance radar."¹¹



Instrument Landing System (ILS)



Microwave Landing System (MLS)

Figure 1. Instrument Landing System contrasted with Microwave Landing System. The ILS provides a precise but narrow approach path. The MLS provides a wider area of navigation coverage and multiple precision approach paths.

The MLS technology has been developed and is currently undergoing extensive operational research and testing at two large United States airports (Memphis, Tennessee and Raleigh-Durham, North Carolina). Current FAA plans are to install MLS at the busiest United States airports. A major goal of this testing and research program is to show that aircraft can be controlled so accurately that bad weather landings can be made simultaneously on parallel runways spaced only 3000 feet apart. If the technology proves out, the FAA estimates bad-weather capacity can be increased by 25 percent at 12 major affected United States airports reducing delays by up to 250,000 aircraft hours in the year 2000.¹²

Another part of the United States plan to reduce airspace congestion is the Advanced Automation System (AAS). The AAS, at an estimated cost of \$5 billion, is the most expensive single project in the NAS Plan.¹³ The AAS includes the replacement of most current ATC computer hardware, software and controller work stations at airport tower, terminal area and enroute facilities. It also includes new software designed to precisely predict en route aircraft positions, identify potential conflicts and generate alternative solutions for controllers to resolve potential conflicts. The FAA hopes this project, led by the IBM Corporation, will (1) increase ATC system availability, (2) save fuel and flight time and (3) reduce FAA operating costs. By automating the process of getting clearance for altitude or route changes the AAS will reduce controller's clerical workload giving them more time to focus on keeping aircraft safely separated.

Another major United States program aimed at increasing flight safety, particularly in the airspace over busy United States air hubs, is a sophisticated aircraft collision avoidance system. By the year 2000 the FAA will require all airliners be equipped with a Traffic and Collision Avoidance System (TCAS). Each airliner will be equipped with a receiver, radio beacon and a computer. If two TCAS-equipped aircraft are on a collision course, the detector in each aircraft will activate a warning signal

in each cockpit. The computer will determine a course of evasive action and will automatically steer the aircraft away from danger or advise the pilot what to do. To reduce the danger of a small, private aircraft flying visual-flight rules (VFR) colliding with an airliner, the FAA will require all small aircraft be equipped with a Mode C transponder.¹⁴ The Mode C transponder will broadcast an enhanced radar echo showing altitude on the controller's screen and at the same time activate the collision avoidance system onboard the commercial airliner.

Ground Radar

The overall NAS Plan also addresses the need for improved ground control at major air hubs by including an airport surface detection (called ASDE 3) project. The purpose of this project is to provide state-of-the-art monitoring of aircraft and ground support vehicle movement on all airport surfaces such as runways, taxiways and aircraft parking areas. The FAA plans to install this innovative downward-looking radar equipment at 30 high-density U.S. airports by 1992.¹⁵ Ironically, Detroit is one of 30 planned implementation sites.

On December 3, 1990 two Northwest jets collided on Detroit's runway 3C killing nine people and injuring 21 others. The pilot of one of the aircraft apparently became confused in the dense fog and icy conditions which limited visibility to 800 feet. He turned onto the active runway and taxied his aircraft directly into the path of a B-727 on takeoff roll. The tower controller could not see either aircraft. At present, at all United States airports, the tower controller must rely on pilots to accurately report their location on the airfield.¹⁶ Had the new airport surface radar been operational at Detroit on December 3, 1990 this tragedy would probably not have occurred.

In addition to the above air traffic control systems improvements, the NAS Plan includes five other major programs. These are:

1. Automated Flight Service Station (AFSS)
2. Integrated Communications Switching System (ICSS)
3. Low Level Wind Shear Alert System (LLWAS)
4. Nondirectional Beacon (NDB)
5. Radio Communications Link (RCL)

The Automated Flight Service Station (AAFSS) is designed to improve flight planning by providing the latest weather, airspace, and general flying conditions information along the planned flight route. The FAA plans on implementing this system at 61 sites by 1995. The Integrated Communications Switching System (ICSS) is designed to enable controllers in air traffic control towers, terminal radar approach facilities and flight service stations to rapidly communicate with each other. The system will have basic intercom, interphone and radar capabilities. The ICSS is scheduled for installation at 221 sites by 1993. A third project, the Low Level Wind Shear Alert System (LLWAS), is aimed at detecting and informing pilots and controllers of dangerous wind conditions at or near airports. This important system will alert controllers and pilots to wind shear conditions and direct aircraft out of danger. The LLWAS will be installed at 331 United States airports by 1993. The Nondirectional Beacon (NDB) is an enhanced navigational aid that pilots use to determine bearing from or to the station. This new system will also help improve the precision of instrument landing approaches. The specific number of required NNB sites is undetermined pending the completion of FAA air network studies. The last NAS project considered is the Radio Communications Link (RCL). The RCL is designed to serve as a general transmission network for data and voice among FAA facilities. This system when fully operational in the mid-nineties will tie together all air control facilities.¹⁷

Summary and Recommendations

Congestion in air transportation systems is a major problem in Europe and in the United States. It is a problem that will likely get worse before it gets better. In the United States, decision makers, both in government and industry, have learned that there is no quick fix with respect to alleviating airport and airspace congestion. They have also learned that remedial programs take time—lots of time and lots of money. Also learned, often with hindsight, is that congestion problems are best handled when they first become visible, not when they have become so critical that safety is compromised. In Europe, the air system congestion problem is even more serious than in the United States. And with the liberalization of European aviation regulations after 1992, it will become worse.

This paper has reviewed four different major approaches to the air traffic congestion problems currently facing Europe and the United States. Of these four approaches, improving the air (and ground) traffic control systems by implementing state-of-the-art technologies appears to have the most merit. The cost is high and implementation difficult but this alternative is much cheaper and far more practical than building new airports or expanding existing ones in the world's major air hub cities. However, while U.S. and European aviation officials move to develop and implement improved air traffic control systems they should not overlook the power of rationing scarce resources. In this respect, the use of local airspace and airport runways is basically an economic problem involving the allocation of a scarce resource, i.e. takeoff and landing slots at particular times during a 24-hour day. Managers learned long ago that a pricing system based on supply and demand is often a most efficient and equitable way of allocating scarce resources among competing users. Market clearing prices and the buying and selling of slots should not be rejected out of hand by aviation authorities as ways to reduce congestion. Spreading out air traffic more uniformly over an 18-24-hour day at major air hubs offers a number of benefits at a relatively low cost.

One final observation, not a conclusion, is in order. Travel patterns in the industrially advanced countries in North America, Europe and the Pacific Rim will undergo major changes in the 21st century, if not before. While air will remain the preferred mode for long distance (over 500 miles) travel, present medium distance air routes will give way to high-speed rail. This is occurring rapidly in Europe and it is no longer a question of whether but when in the United States. And while the love affair between Americans and their private automobiles will slow the movement toward rail and other public transport systems, the movement will only be slowed - not stopped.

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¹⁷United States General Accounting Office, (1980), "FAA's Implementation of Modernization Projects in the Field," Report to the Chairman, Subcommittee on Transportation, House of Representatives, July, 1980, p. 21.