Building Airport Systems for the Next Generation

Dealing with the uncertainties of airport development will require new strategies.

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Airports worldwide are struggling to keep up with demands. Many major cities must make do with collections of more or less inadequate and obsolete runways and passenger buildings, and most travelers know from experience the frequency of aircraft delays, missed connections, misdirected baggage, and uncomfortable crowding. We clearly need to rebuild and enhance our airport systems.

Money Is Available

Lack of money is not a fundamental obstacle to creating better airports. In fact, the air transport industry is committing huge sums to capital investments. To put the matter in perspective, airlines worldwide have ordered more than 900 new Boeing Dreamliners (B787s), which list for about $150 million each. The total value of this order book must be over $100 billion. Airlines have also ordered about 200 new double-decked Airbus A380s, recently listed at about $375 million each. This order book is worth about $75 billion. In short, the industry has access to huge pools of money.

In addition, large amounts of money are going into airport development. For example, Chicago's plan for modernizing O'Hare could cost as much as $10 billion; Terminal 5 at London/Heathrow cost about $8.5 billion; and the Toronto airport recently underwent a $4

billion rehabilitation. In the United States, billion-dollar projects are contemplated, under way, or have recently been completed at Atlanta, Boston, Dallas/Fort Worth, Las Vegas, Miami International, New York/Kennedy, Orlando International, Philadelphia, Washington/Dulles, and elsewhere. Brand-new or thoroughly reworked airports are also emerging in China and India—in addition to a string of ambitious airports along the Persian Gulf.

For further evidence of the availability of resources, one need only look at the private consortia lining up to invest in the privatization of airports; the most likely candidate in the United States is Chicago/Midway. Worldwide, investors are prepared to spend billions on airport deals in India and many other locations, such as Portugal. There is no doubt that money is available globally for the development of the closely coupled airline/airport industry.

What's the Problem?

So, if we recognize the need and we know the money is available, then why do airport delays, congestion, and aggravations seem to be getting worse? With so many skilled and smart people doing their best to make things better, why aren't we getting reasonable results?

More specifically, why is this happening now? Neither air travel nor air traffic is growing faster than it was a generation ago. In fact, in the United States, growth is slower than it was. The technological advances brought about by larger, carbon-fiber aircraft are no more momentous than the shift from propeller to jet aircraft or the introduction of the Boeing 747. So why do matters keep getting worse? Why aren't we succeeding as we did before?

The answer is almost surely that we are not working effectively in the current circumstances. Since we have the money and the technological know-how, by process of elimination we must conclude that something is wrong in the context, in the system around us.

Neither the institutional framework that defines the way we tackle issues nor the professional traditions that shape the way we think about possible solutions seem to be working. The political and personal approaches that worked reasonably well in the past are simply not up to the problems of today. Why is that?

Deregulation Destabilized the Airline/Airport Industry

The airline/airport industry is a profoundly different industry from what it was a generation ago. To be successful in these new circumstances, engineering practice must be adapted to the new reality. Traditional, historically successful ways of dealing with airport needs have to be refashioned. In short, we need a new paradigm for the way we design and implement our airport infrastructure.

Remarkably, the deep changes in the airline/airport industrial system have little to do with technology. Technologically, airlines and airports are functionally equivalent to what they have been for 50 years or more. Now, as then, passengers queue up for check-in procedures and walk onto a plane; meanwhile, their bags are tagged, sorted, and loaded onto carts and the aircraft; then pilots and flight attendants care for them during the flight. Interesting, cost effective technologies have found their way into various phases of the process—in the form of automatic check-in procedures, laser reading of bag tags, electronic instrumentation in cockpits, more efficient, quieter engines, and so on.

But none of these technological advances has changed the essential functions of or requirements for airport buildings, runways, or controls. From the overall perspective of airport performance, the technological advances are relatively minor adjustments that have not significantly impacted the structure of the engineering problem.

However, unlike airports, which have not greatly changed in terms of engineering system, the air transport industry of today is fundamentally different from what it was a generation ago. This is because economic deregulation (in 1978 in the United States, and at various dates in Australia, Canada, the European Union and the United Kingdom) radically altered the conditions in which airlines operate. In fact, what used to be a very stable environment is now a highly uncertain environment.

Economic deregulation of the airlines removed the bureaucratic processes that guaranteed a highly stable environment for airlines and, in turn, for investment in their facilities at airports. Before deregulation, highly legalistic regulatory processes, which entailed much time and expense and took years to process requests, controlled the way the airlines operated. For example, airlines would fight for years for the right to offer new service to a popular city, while airlines that already provided service to that city fought hard to prevent the new competition. This highly contentious process often took years to resolve. Sheltered by regulations that prevented sudden major changes, airline executives could reliably anticipate that the next year would be essentially the same as the last year.

Deregulation destroyed this stable world, and, in so doing, it created the conditions for innovation, low-cost airlines, cheaper fares, and what many consider overall economic benefits. However, deregulating the industry was like taking the shock absorbers out of a car—it turned what used to be a smooth ride into a chaotic experience. Along with greater economic efficiency, deregulation led to instability and uncertainty in the airline/airport industry.

Economic deregulation has given the airlines much more freedom (Table 1). They can decide to provide service to an airport whenever they want, and they can do so as fast as they can organize themselves to set up shop. Aggressive airlines such as Southwest and jetBlue (in the

United States) and Ryanair and easyJet (in the European Union) have routinely opened dozens of new routes each year, a tempo that was unimaginable before deregulation. Conversely, airlines can also abandon an airport or facility and shift their operations elsewhere, as US Airways did when it shifted its domestic hub from Pittsburgh and its international hub from Baltimore/Washington to Philadelphia.

Table 1 Freedom of Action for Airlines before and after Deregulation

Choice	Before Deregulation	After Deregulation	Implications of Deregulation
Routes	Strictly controlled	Freedom to change	Loss of secure tenure
Prices	Set by formula	Freedom to change	Price wars
Frequency of flights	Controlled	Freedom to set schedules	Capacity wars
Aircraft type	Often controlled	Freedom to choose	Capacity wars

Airports, which are closely coupled with the airlines and thus face the same kinds of uncertainties, are affected by deregulation the most. When Southwest, for example, moves into an airport and triples its traffic—a phenomenon popularly known as the "Southwest effect"—the entire airport infrastructure—runways, passenger buildings, parking facilities, and so on—is affected.

Deregulation especially impacts airport developers, who necessarily have large fixed assets. When US Airways moved its hub out of Pittsburgh, the airline was able to redeploy its fleet, but the airport and investors in its stores were stuck with under-used facilities. When Pittsburgh lost its main tenant, it lost much of its ability to repay the mortgage on the property—the bonds it had issued to finance the development of the facilities to serve US Airways.

Similar stories are common throughout the industry. Cincinnati built attractive facilities to serve Delta when the airline created a hub there and then was stuck with those facilities when Delta went bankrupt and dropped the hub. Raleigh/Durham became an international hub for American Airlines, serving traffic from Paris to Mexico, and then lost this traffic when American Airlines rerouted its services. Kansas City was left with empty, obsolete facilities when TWA moved its hub to St. Louis, which, in turn, later spent more than a billion dollars to build and open a new runway to serve this client. Yet TWA disappeared when it declared bankruptcy for the third time and traffic in St. Louis dropped from 30 to 15 million passengers annually (Masek, 2007). Nothing like this could have happened before deregulation. Airport investments have become very risky!

The Future Is Highly Uncertain

In the current climate, long-term forecasts cannot be developed with any degree of confidence. On the contrary, as has been extensively documented, forecasts of airport traffic today are "always wrong." For example, half of the time, five-year forecasts for individual airports in the United States have been off by 10 percent (Friedman, 2004). The track record is worse for longer term forecasts (Flyvbjerg et al., 2005).

Trend breakers, such as bankruptcies or mergers, cause immediate shock and realignments of the industry, further disrupting projections. The disappearance of TWA and Swissair totally scrambled the forecasts for St. Louis and Zürich. Trend breakers might be catastrophic events, such as 9/11, which led to new security requirements and disrupted the designs of airport passenger buildings everywhere, or they may be new political arrangements, such as the "Open Skies" agreement between the United States and the European Union (EU), which came into effect in March 2008.

The Open Skies agreement represents a major new phase of deregulation—and uncertainty. It eliminates the bi-lateral agreements, which had specified traffic rights between the United States and the EU countries and which had been very difficult to change. The new agreement permits any carrier from the United States to serve any point in the EU, and vice-versa. Thus it offers many new opportunities and challenges. Who knows what how this will change traditional gateways for European traffic? Who knows what new markets will open up?

Deregulation always makes the future more volatile (de Neufville and Barber, 1991). By enabling airlines to redirect their traffic, both massively (as by creating or abandoning hub airports) and in the short term (for a year or less, a tiny fraction of the life span of an airport facility), deregulation adds great uncertainty—and thus great risk—to airport development.

The Design Paradigm Is Inadequate

The traditional engineering paradigm for planning and designing airports and airport facilities is not suitable in a deregulated environment. The airline/airport system has changed fundamentally, from a stable environment with marginal changes to a fast-paced environment subject to repeated disruptive shocks. The design processes suitable for a stable, predictable system—the traditional paradigm of airport development—was based on the premise that we could correctly anticipate the future, which is no longer the case.

The standard approach was based on "master planning," which had two main phases (de Neufville and Odoni, 2003; ICAO, 1987; US FAA, 1985): (1) the determination of the correct forecast; and (2) the selection of a single (i.e., master) plan that best suited this forecast.

This approach was plausible when designers could assume that a forecast adequately represented the system. Such an approximation generally provided a reasonable working basis

for planning and design when traffic patterns changed slowly. Based on past successes, master planning became the established framework for airport development.

But historical inertia is no reason to continue to accept past practice now that circumstances have changed. In today's highly uncertain environment, it unreasonable to design for a single set of requirements, as was done in the traditional master planning process. A responsible design must deal with reality—particularly with the uncertainties in forecasts. In an uncertain environment, the right thing to do is to anticipate a range of scenarios and define a strategy for dealing with these scenarios as they might unfold over time.

Another reason for the inadequacy of the traditional process for developing airport infrastructure is that it focuses on components of systems. Indeed, the entire structure for financing and approving new projects required that airport owners operate only a few airports. Moreover, the old system can operate in metropolitan areas in which airports are run by competing organizations. For example, three distinct authorities run the three commercial airports that serve the San Francisco Bay area. Three authorities—in different states—operate the three major airports that serve Boston. The five London airports are managed by three different groups. Two different authorities operate the three commercial airports for Washington, D.C. The current, historically driven engineering practice concentrates on the components of each system, on individual nodes, rather than on the architecture of the nodes and their interrelationships.

In the deregulated environment, a good design must address the entire system, including upgrading and creating components that are in the best interest of overall performance. But this is not how we approach the development of airport infrastructure today. We are still repeating the historical pattern that focuses on fixing the "squeaky wheels" and trying to improve them.

Thus improving the Philadelphia airport has become a fast-track national priority because it is very congested, largely as a result of US Airways' decision to locate a hub there. If we consider airports as an engineering system, however, the focus on improving Philadelphia may not make sense. First, there is great capacity available close by, in Pittsburgh, and US Airways could decide to move again or might even disappear in another wave of airline consolidations.

As observed in many areas of investment in infrastructure, the national approach focuses on specific projects. Yet the "system" really should be defined one or two levels higher than is now possible in the current institutional and governmental context. Rather than design for one airport in a region, it would preferable to deal with all the airports in a region at once – and better yet to deal with the national system.

The current paradigm of airport planning and design is too narrow and misses opportunities in the new environment. It does not see the forest for the trees. We need a different approach.

We Need Strategic Thinking and Flexible Design for Airport Systems

We must begin to think strategically about developing the system of airports. We must also anticipate and design for a variety of possible scenarios. A fixed plan, built around a single prediction of the future is invariably ineffective. Excellent performance requires that designers think through the possible consequences of decisions, develop contingency plans, and commit to making only one move at a time.

Thinking strategically about designing the overall system of airport infrastructure represents a change in engineering practice. This shift in thinking is absolutely necessary to confront the realities of the new situation, but there is no doubt that the transition will be difficult. Old patterns of thought, however obsolete, are hard to change once they have been imprinted through practice.

The shift to a new strategic approach will require not only changes in the engineering paradigm, but also changes in procedures. Current research is being conducted to determine the best approaches to these changes. Procedurally, we must calculate the possible consequences of different developments under different scenarios associated with future uncertainties. In doing so, we will be able to identify unfavorable outcomes that we must protect against, as well as opportunities we must ready to exploit. As in good financial management, we need the equivalent of options—"puts" against the possible downside outcomes and "calls" on the upside opportunities; technically, these are "real options in the system".[1] There are many ways to develop real options in engineering systems, particularly in airports (de Neufville, 2007).

The essence of new strategic thinking about the development of infrastructure is flexible design, which involves components that system managers can adapt to future conditions as they unfold. For example, the design for the new passenger building at the Toronto airport includes a number of interior passageways that make it possible to use given gates for different kinds of traffic (such as international and domestic) that must be handled separately.[2] This arrangement will enable airport operators to adapt their facilities to handle a wide range of possible short- and long-term variations in traffic.

To design for the airport system as a whole, we can no longer simply repair the components that "squeak the loudest" or are the most politically expedient. We must develop a process for identifying what will be best for the system as a whole and then investing in those areas. Inevitably, this will mean investing in system components that do not currently have a large amount of traffic or support.

For example, a systems perspective on the development of additional airport capacity around Chicago would have considered the relative values of two alternatives: (1) building a brand new

airport on a green-field site; and (2) modernizing Chicago/O'Hare (the second-busiest airport in the world) while keeping it operational. In the current institutional framework, the first option could not be given serious consideration because the mayor of Chicago (traditionally a Democrat) would not allow the governor of Illinois (frequently a Republican) to control the process. Furthermore, statutes largely obligate the federal government to allocate airport funds to facilities in proportion to their traffic volume (by definition non-existent at a new airport).

Designing for the system as a whole will constitute a fundamental paradigm shift, which may be particularly difficult to achieve in the United States and EU, which both consist of separate states with the own entitlements. This circumstance may represent a grand challenge for the development of airport infrastructure—and, more generally, of rapid intercity transportation, which can be supplied by rail systems, such as the Japanese Shinkansen or the French TGV.

Conclusion

Designing for a range of possible scenarios will require flexible components that system managers can adapt to new conditions as they unfold. Specifically, this will mean designing "options" into the system. We must design for the airport system as a whole, rather than continuing to misallocate resources by patching up component parts. In short, we need a new kind of strategic thinking that takes into account the great uncertainties in the deregulated environment.

Further Reading

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Notes

[1] "Real" options concern the actual development of physical entities, in distinction to financial options on the price of an asset. Real options are "in" the design, because they are embedded in

physical features that designers have created. For example, designing a bridge with sufficient strength so that it can be double-decked if necessary (as was done for the George Washington Bridge in New York and the Ponte de 25 Abril in Lisbon) is a way of embedding a real call option on the opportunity to expand the system.

[2] Canadian airports handle three types of traffic: domestic, transborder to the United States (passengers technically enter the United States while still in Canada), and international. EU airports also handle three types of traffic: international, *Schengen* (from specific EU countries), and non-*Schengen* (from other EU countries).