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# ADDRESSING THE CHALLENGE TO THE AIR TRANSPORTATION SYSTEM THE COMMUTER AIRLINE GYRODYNE

## Introduction

The tragedy of 9/11 and the economic downturn have sharply reduced commercial air traffic demand from its peak levels of 2001. As a result the massive problems of air traffic congestion suffered by passengers that summer have largely been forgotten and efforts at solution put aside. Now this issue has come to the forefront again with the issuance of a Report entitled "Securing the Future of U.S. Air Transportation: A System in Peril[1]" by the prestigious Aeronautics and Space Engineering Board (ASEB). The ASEB is a constituent of the National Research Council and advises NASA, the FAA and other agencies on aerospace research priorities.

This Report clearly identifies that *"the continued success of aviation and the benefits that it provides will require changes to accommodate increased demand"* and that *"this is the most critical long-term issue facing all aspects of the air transportation system."* It recognizes the need to greatly increase the baseline capacity of the system and that "This may require widespread adoption of operating concepts that use runways and aerospace in new ways". Quite specifically, it declares that *"Business as usual, in the form of continued evolutionary improvements to existing technologies, is unlikely to meet the challenge of greatly increased demand over the next 25 to 50 years".* [2]

The ASEB Committee has performed a valuable service in highlighting both the criticality of addressing the need to meet air transportation demand and the difficulty of achieving effective results without radical new approaches. It voices a clear call for a bold new vision for air transportation. This paper is intended to advance that vision by advocating an approach that is radical, yet practical, and promises to be fully consistent with available technology, economic requirements and social needs.

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[1] *Securing the Future of U.S. Air Transportation: A System in Peril.* The Committee on Aeronautics Research and Technology for Vision 2050, ASEB, National Research Council, Prepublication Edition (Subject to Further Editorial Correction). National Academies Press, September 2003.
[2] Ibid P.9 , para. 2.

## Managing the Capacity Shortfall

In order to contend effectively with the projected inability of the air transport system capacity to cope with future demand, it is critical to understand both the nature of the likely bottlenecks and the acceptability, economically and socially, of potential solutions. While other elements intrude at times, and contribute to congestion, such as aircraft shortages, pilot shortages, gate limitations, ground access, curfews, weather impact, security requirements or labor unrest, these problems are generally cyclical or short term. There is general agreement that the primary, and most intractable, factors are lack of runway capacity and lack of air traffic control capacity. This paper is therefore focused on a means of substantially increasing those capacities.

There is no shortage of proposed solutions among which include:

- Building more airports;
- Building more runways;
- Building bigger airplanes;
- Barring small airliners from commercial airports;
- Increasing peak hour landing fees;
- Redistributing congested hub traffic;
- Using small, single engine airplanes using small airports;
- Improving the efficiency of the air traffic control system;
- Enabling “free flight” navigation.

Conceptually, each of these solutions could make a significant contribution to the capacity shortage. Each, however, faces practical problems, either environmental, technical or are counter-productive to an efficient transportation system. It has been possible to build only one major airport (Denver) in the past 40 years; new runway construction is increasingly difficult, long drawn out or impossible; larger aircraft will only impact a very small part of the demand; peak pricing is economically sound, but limited in effectiveness; professional pilots being used for very small aircraft is very costly. Improvements to the ATC system, while essential, only address parts of the problem and can only be effective as an integrated part of a runway capacity solution. Thus even collectively these proposal are not likely to significantly diminish the challenge.

The scale of that challenge, and the costs of not meeting it, have been clearly identified in a paper presented to the American Helicopter Society (AHS) by NASA and industry experts in May 2003[3]. Quoting a study by the Logistics Management Institute, the paper noted that the traffic delay at 64 major US airports responsible for 84% of air carrier operations averaged 6.7 minutes in 1997. Using FAA forecasts, the study estimated that the projected delay in 2017 would grow to 86.5 minutes, a 1300% increase. While the recent economic downturn may delay such a hugely disruptive impact on the US transportation system, these results clearly point to the magnitude of the problem.

## The "Runway Independent Aircraft" Concept

The AHS paper points toward the basis for a very significant contribution to solving both runway and ATC capacity shortage by identifying the prime users of those capacities. In particular, it notes that in the United States *"forty percent of aircraft operations carry only twenty percent of the passengers and these flights are normally less than 300 nautical miles"*[4]. Therefore, if a significant portion of this traffic could be economically and effectively accommodated outside the conventional runway and ATC system using Runway Independent Aircraft (RIA), a major breakthrough would be accomplished.

The AHS paper describes the RIA concept as *"one of complementary and integrated IFR operations based on rotorcraft unique performance capabilities when operated as an ESTOVL [Extreme Shorthaul Take-Off and Vertical Landing aircraft]. Increased demand with a fixed number of runways leads to delays of individual flights and to the whole system and these delays increase costs. One solution to the delay would be to remove small aircraft and shorthaul aircraft flights from the long jet runways and replace those flights with RIA flights from existing stub runways and vertical operations from helicopter landing pads. The RIA terminal area and approach and departure paths are along the simultaneous and non-interfering (SNI) routes, avoiding flight paths of jet aircraft. This concept of RIA operations can increase capacity by relieving runway congestion or can add significant passenger through put at equal runway congestion."*

The research that underlay the AHS paper and is reflected in its conclusions established desirable parameters for RIA vehicles. It concluded that such aircraft should require no more than a 300 by 500 feet area to be able to:

- Take-off from very short stub runways
- Convert to wing-borne flight in less than one minute
- Climb to a comfortable altitude
- Cruise at 300 knots with a range up to 600nm[5]

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[3] "Technology Development for Runway Independent Aircraft" presented at the American Helicopter Society 59th Annual Forum, Phoenix, Arizona.
[4] "Technology Development for Runway Independent Aircraft" presented at the American Helicopter Society 59th Annual Forum, Phoenix, Arizona.
[5] This range was premised on the desirability of avoiding refueling after every shorthaul flight.

- Execute a steep descent profile using GPS-based RNAV navigation
- Decelerate to helicopter mode
- Complete a steep approach and hover to a vertical landing

After establishing the criteria essential for a RIA vehicle to be effective, the AHS paper goes on to assess various aircraft concepts proposed by major rotorcraft manufacturers and to identify the quite demanding technology advances necessary to bring each of them to the marketplace.

**The Optimal Runway Independent Aircraft Solution – the Gyrodyne**

Groen Brothers Aviation, Inc (GBA) fully endorses the conclusion of both the ASEB and AHS studies that the air transportation system will again become critically overcrowded. It further endorses ASEB's conclusion that *"Business as usual is unlikely to meet the challenge."* And it believes that the RIA vehicles such as those outlined in the AHS paper represent the vision called for by the ASEB.

GBA considers, however, that a much more immediate RIA solution, requiring far less technological risk, is potentially available, based on established gyrodyne technology.

The FAA defines a Gyrodyne as, *"A rotorcraft whose rotors are normally engine-driven for take-off, hovering and landing and for forward flight through part of its speed range, and whose means of propulsion, consisting usually of conventional propellers, is independent of the rotor system."* In accordance with this definition, a gyrodyne's rotors are typically powered by rotor blade-mounted independent reaction drives. Since the rotor is not driven by an airframe-mounted power system, the gyrodyne, like the gyroplane, has no requirement for a tail rotor.

A gyrodyne differs from a gyroplane in that its rotors may be powered for part of its flight regime, allowing it to take-off vertically and to hover. It differs from a helicopter in that it obtains its forward momentum from a propeller, rather than from a tilting of the rotor. Therefore, it does not suffer the loss of aerodynamic efficiency or suffer the instability inherent in requiring the rotor to provide both lift and thrust.

A principal virtue of the gyrodyne is its enhancement of passenger safety. Gyrodynes, like gyroplanes, cannot stall, are easier to fly, and are only slightly more complex mechanically than a fixed-wing airplane. In an emergency and even with a total power failure, the gyrodyne can land softly anywhere that is relatively flat, in a space only twice the size of its rotor diameter. All fixed-wing airliners need a runway to make a safe landing, and a powered-rotor helicopter requires a combination of sufficient speed and/or height to achieve auto-rotation and a successful landing after power loss.

If, for any reason (except running out of fuel), the main propulsion engines of the gyrodyne fail in flight, the aircraft can be flown to safety by reigniting the rotor tip jets, thus powering the main rotor. In the event that the tip jets cannot be relit for vertical landing, the gyrodyne can still land safely as a gyroplane with an ultra-short ground roll.

With its absence of mechanical power to the rotor and corresponding the absence of a requirement for a tail rotor, the gyrodyne is also far less complex, (and far less expensive to own and operate), than any other powered rotor VTOL aircraft. This lack of complexity gives the gyrodyne much greater in-flight reliability as well as sharply reducing downtime for maintenance.

For many applications, the gyrodyne can be much cheaper than alternative modes of travel. As noted, its simplicity in comparison to a helicopter makes its acquisition cost, its utilization, and its operating costs much more favorable than a helicopter. Although its operating cost per seat-hour will be higher than that of a comparably sized fixed-wing aircraft, the ability of the gyrodyne to fly directly point-to-point and to avoid air and ground delays will generally achieve shorter journey times and thus competitive seat-mile costs. Additionally, if airport authorities and airlines properly recognize the contribution to their cost reduction from congestion decline, even more favorable charges would be appropriate.

The gyrodyne technology, unlike commercial tilt-rotor and other VTOL options, uses proven technology that has been demonstrated in real city-center to city-center operation by the British Fairey Aviation Company of the 1960's with its revolutionary aircraft, the Rotodyne.

**The Fairey Rotodyne**

The Fairey Rotodyne

The Fairey Rotodyne was a 44-passenger gyrodyne that used reaction-drive jets mounted in the tips of its four rotorblades. The rotor being driven from its tips was torqueless, which kept the aircraft simple, enabled vertical takeoff and landing, and, if necessary, the ability to hover.

Within 30 seconds of accelerating to forward flight, the tip jets were shut down and the Rotodyne continued in "autorotation" as a gyroplane for the remainder of the flight. Two turboprop engines propelled it forward to just over 200 mph. Landing could be accomplished like a gyroplane with an ultra short ground roll or the tip jets could be reignited and the aircraft could land vertically in a space not much bigger than its rotor diameter.

The Rotodyne at that time demonstrated its ability to provide fast city-center to city center transportation by flying with a full load of passengers between downtown London and downtown Paris. Its cruise speed of over 200 miles per hour was sixty miles per hour faster than any other rotorwing aircraft of that day - an amazing speed even by today's standards. If the Rotodyne existed today, even without the improvements that modern aerospace technology could bring, it would still be the fastest way to get between those two city centers.

The Fairey Rotodyne

There were no technical reasons for that aircraft not to have been produced. The decision not to produce the Rotodyne was entirely for reasons unrelated to whether or not it worked. Even the noise problems from the tip jets had been solved before the project was canceled. From the record, it appears that the cancellation of a large order from their primary customer, BEA, was the main factor in the cancellation of the project.

## GBA Gyrodyne Technology

GBA has spent the past seventeen years developing technologically advanced gyroplanes and has developed a reputation as a world leader in understanding autorotative flight. It is autorotative flight that makes possible the safety, simplicity and low operating cost of which gyroplanes, and gyrodynes, are capable. The Company's Hawk 4 Gyroplane, the first turbine-powered gyroplane, has demonstrated those capabilities and their suitability for, among many applications, cost-effective surveillance through its valuable participation in the security arrangements for the 2002 Winter Olympics.

GBA has taken its gyroplane experience to the next stage to demonstrate the application of its technology to conversion of fixed-wing aircraft to autorotative flight. In August 2001, GBA began flying its RevCon 6G, that was built using the airframe of the Cessna 337 Skymaster fixed wing airplane, and the rotor system of GBA's Hawk 4 Gyroplane. The wings of the Skymaster were shortened and the tail was turned upside down for rotor clearance. The two piston engines were removed. A Rolls-Royce model 250 gas turbine engine was installed in place of the forward engine and a large cargo door was installed in place of the aft engine.

GBA RevCon 6G

This conversion, using minimal assets, which took less than one year from first conception to first flight was done to prove the theory of using current production, certificated, commuter airliner designs, as the primary airframe for a modern gyrodyne. By using an existing certificated airframe design, a modern gyrodyne airliner can be designed, built, tested, certificated, produced and delivered in a fraction of the time, and therefore a fraction of the investment, that could normally be expected.

The use of engineering, drawings and production tooling already created for a production airliner type-certification would provide the bulk of those requirements for a gyrodyne based on a reconfigured production airplane. Additionally the production line, quality assurance system, materials management, production control, FAA qualified supplier network, etc. would all be in place.

Certain candidate aircraft, as now produced, would need only minor changes. For example, wings might need to be shortened in span and the vertical stabilizers reversed to lower the tail for rotor clearance the wing carry through structure might need to be strengthened to support rotor system ground loads. These slightly modified airframes would be built under contract. They would then be delivered "green" to the gyrodyne production facility for installation of the rotor system, flight control system, avionics, instruments, and turboprop engines. This would be followed by production flight testing and then to the completion center for final paint and preparation for delivery to the customer.

## The GBA GyroLiner

In researching potential production aircraft to become the first GBA GyroLiner, GBA has identified the 18-passenger Antonov AN28as a prime candidate for conversion to a gyrodyne on these principles. This aircraft originally built in Ukraine is now available as a JAA type certificated airplane built in Poland. The existing production configuration of the AN28 would need only minor changes. As was done on the RevCon6G, the vertical stabilizers would be turned upside down thereby lowering the tail for rotor clearance. As the AN28 is currently available with Pratt & Whitney PT6 engines, power up-rated versions could be used. An artist's impression is shown below.

The GBA GyroLiner

This first GBA GyroLiner would have a range in excess of 350 miles, cruising at 250 mph. Block to block, a 350 mile flight would take 1.5 hours, very close to meeting the AHS criteria.

The AN 28-based GBA GyroLiner will have a much lower cost per seat mile than any comparably sized rotorcraft, although higher than a similar fixed wing airliner. This, should, however, be offset by lower landing fees, reflecting its not requiring usage of high cost runways. Its lower cruise speed than regional jets will be offset by its ability to fly point-to-point and avoid the ground and air congestion delays of runway dependent aircraft. Because of GPS navigation and precision approaches, and the gyrodyne's ability to send warm air into the rotor blades and head to prevent icing, all weather operations will be possible. Few other rotorcraft can operate in icing conditions.

The higher utilization capability resulting from the avoidance of congestion delays, the inherent mechanical reliability of the gyrodyne concept and its all-weather capability, should enable the GBA GyroLiner to achieve reliability and utilization levels far higher than any previous rotorcraft in commercial airline operation. This utilization advantage, coupled with the lowered acquisition costs inherent in the use of a previously certificated airframe, avionics and propulsion system, should result in attractive capital costs per flight hour. The mechanical simplicity of the gyrodyne, together with its limited number of critical safety-sensitive systems can be expected to reduce its maintenance costs and out-of-service time well below that of other rotorcraft types.

## Increased Demand for Large Jet Airliners

The introduction of GBA GyroLiners into the commercial aviation market will have the important ancillary effect of sharply increasing the potential for sales of large jet airliners. Runway and air traffic congestion at major airports, most critically in North America, Europe and Asia, has either prevented airlines operating service into those airports or limited them to operating at less desirable times. The earning potential of an airline company's aircraft is therefore materially constrained by these limitations.

Approximately one third of the 21,000 airliners world wide, however, are commuter airline size aircraft, operating short distance routes. The introduction of GyroLiners will permit airlines to remove their small short-haul airliners from the runways by using GyroLiners to transport those passengers off runway. As a result that thousands of new landing slots would become available each day, opening up attractive opportunities for efficient operation of new large jet airliners. Replacement of even one quarter of the current commuter airliners with new longer range aircraft would represent a new market opportunity valued at more than $100 billion for the aircraft manufacturers.

Resolving the airport overcrowding problem by using larger jet airliners in these landing slots is a more efficient, cost effective, and more profitable solution, and far more easily attained, than the conventional approach of attempting to build new runways or new airports.

## Follow-on Developments of the GBA GyroLiner

The Groen Brothers Aviation gyrodyne technology is scaleable to essentially any size aircraft, small or large. GBA analysis indicates that its GyroLiners would function well and have market appeal as a shorthaul commuter aircraft in sizes up to 70 or 80 passengers. For military missions much lager gyrodynes have the potential to be very valuable, particularly for the kind of future warfare likely in the post cold war environment. Characteristic of this scalability is GBA's Gyrolifter proposal to DARPA in response to the US Army's Advanced Maneuver Transport Rotorcraft program. Again, it is proposed that an existing production airplane be used as the primary airframe for this concept.

GBA GyroLifter - Advanced Maneuver Transport

## Conclusion

The conclusion of the ASEB that the air transportation system is in peril in the United States from looming under-capacity, is real. The peril is real too in Europe and many other parts of the world. Equally true is the ASEB conclusion that conventional means will not provide the solution. The conclusion of the NASA and Industry experts that runway (and ATC) independent approaches show real prospect of providing a viable and meaningful solution, strongly suggests that this is a non-conventional means that should be vigorously pursued.

Although runway-independent, helicopters as presently configured cannot meet the criteria to perform this role. They cannot be made to fly fast enough, cannot be made reliable enough, large enough, simple enough, nor operate at an affordable cost per seat mile. Other VTOL designs being tested or evaluated could very likely achieve the speed, range and size requirements. Their complexity, technical risk in development and in passenger acceptance, and inevitably high acquisition and operating costs, however, mean that such approaches are likely to be a long way from commercial production. Only the relatively straightforward approach of the GBA GyroLiner is likely to achieve the goals in the necessary timeframe.