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THE FUTURE OF SHORT HAUL AIR TRANSPORTATION SYSTEMS

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INTRODUCTION

The major development of air transportation over the past forty years has been in long haul intercity, and intercontinental travel markets. The air system which has evolved has offered improved services in the form of greatly reduced trip times, improved routings and frequencies of service, increasing levels of comfort, while lowering the relative cost to the traveller. These markets are now dominated by the air system, and we are turning our attentions to develop new kinds of travel and tourism in these markets.

However, there exists a large size market in terms of numbers of intercity travellers which has been a center of attention for air transportation planners for the past several years. It is the short haul intercity travel markets for trip distances less than 250 miles.

Why is a distance of 250 miles chosen to define "short haul"? If we examine Figure 1, we see the cumulative and simple percent of the distribution of the number of air passengers in 50 mile segments of trip distance. The peak of this distribution occurs at 250 miles, and there is a precipitous descent at shorter ranges, despite the fact that most of the volume of total intercity travel occurs over these distances. This travel is predominantly by private automobile, but also by public modes such as bus and rail. It does not travel by air because the present "airplane-airport" long haul air system is not designed for short haul air travel and does not offer either a time or cost advantage to the traveller. But the potential for entering new markets over short hauls with a different form of air system using technological developments such as computer based passenger processing, improved guidance and control, and V/STOL aircraft has caused a continuous stream of studies to determine if and when and where it might be feasible.

It is difficult to obtain a clear determination of this potential due to uncertainties in marketing and operations. No good example presently exists of an air system operating in competition with the automobile and other ground modes. The commitment to provide a new form of air system to test the market implies a number of large investments in aircraft, ATC, and metroports made by different actors of our society. It requires government leadership and policy making to coordinate these actors, and initiate services to demonstrate the viability and public value of these new forms of air transportation.

While this question of entering new short haul markets may be considered as the major issue in short haul air transportation, there is yet a second issue which has also been attracting attention and causing some confusion in the layman's mind. If we examine Figure 1 again, we see that the cumulative percentage curve shows that almost 50% of domestic U.S. airline passengers are travelling less than 500 miles.

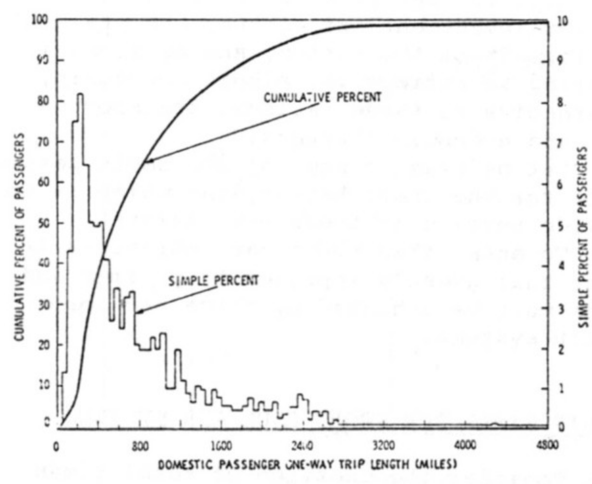

FIGURE 1. DISTRIBUTION OF PASSENGER ONE WAY TRIPS - DOMESTIC U.S.A.

Because of the structure of fares and costs for our present form of air transportation, it is difficult for today's airlines to earn a profit on this half of their customers. This has caused a second focus of attention for the air transportation planner on a modification of the present airline system to provide an improvement of service and lowering of operating costs for this bottom half of the present airline travel market. Here the studies turn their attention to relieving congestion at major airports by constructing additional short runways, to introducing services at small old or new metropolitan airports, and providing new quiet STOL or RTOL (reduced takeoff and landing) transport aircraft properly designed for this short haul mission.

This second issue is made easier to work on since existing markets and systems exist. However, a savings in operating cost is difficult to demonstrate, and the introduction of new services and aircraft by an existing airline would seem to have to be justified on the basis of reducing congestion costs for the long haul services, and the possibility of increased fares for providing more convenient service to the passenger.

While this second issue is of more immediate interest to existing aircraft manufacturers and airlines, the first issue is a much more fundamental one facing the long range planners of national transportation systems. National investments in highways, or improved forms of rail transportation are long term, major items, and the resulting transportation system greatly affects the urban form and industrial development of the various regions of the nation. The short haul air system seems to offer flexible, improved services for a relatively smaller investment spread over the years of development of the system, and as such, is offering an attractive, albeit uncertain, alternative to these national transportation and economic planners.

Let us examine some of the basic parameters for the short haul system which is to provide service in these new markets.

To enter this short haul market it is clear that greatly improved trip times and costs must be achieved by these new forms of air systems.

TRIP TIMES FOR SHORT HAUL AIR SYSTEMS

Consider the question of total times for the traveller. The total trip time is defined to be made up of the <u>vehicle</u> time (or block time), and of the <u>system</u> time (access, processing, wait for next service, egress). Historical scheduled times are shown in Figure 2 for existing jet subsonic CTOL transports, a turboprop STOL, an existing transport helicopter and are compared with a private automobile assumed to average 60 miles per hour.

The vehicle times show a zero distance intercept of 2 minutes for the helicopter, 11 minutes for the STOL, and 26 minutes at non-congested airports for the CTOL transport. This zero distance intercept is a function of normal operational factors and is caused by taxiing to and from the runway, maneuvering around the port for landing and takeoff, and a reduced speed during climb to cruise altitude. It is pertinent to note that the normal VTOL and STOL operations do provide much reduced intercept values and are "faster" than the CTOL over distances less than 100 miles.

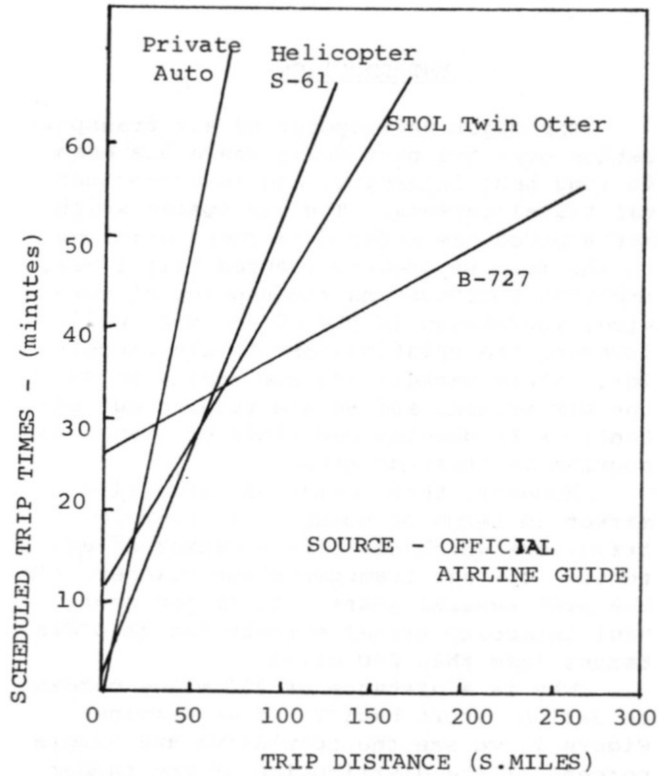

FIGURE 2. COMPARISON OF VEHICLE TRIP TIMES

The inverse slope of the trip time line is representative of the cruising speed of these vehicles. Improved technology now allows the construction of helicopters with speeds of 180 mph and higher, and STOL aircraft of 500 mph and higher. These improved vehicles are "faster" than the CTOL aircraft over increased distances such as 300 miles.

But the important time at these distances is the <u>system</u> time which does not depend on the cruise speed or takeoff and landing performance of the vehicle. It is a function of the accessibility of the parts for the system, the wait time (determined by the frequency of service) and the passenger processing in the terminals. The frequency of service and passenger processing time are not affected by vehicle type, but the access and egress times for new ports sited in urban areas are dependent on both the takeoff and landing performance and noise performance of the vehicles since these determine the land area and community acceptance respectively.

Notice the change of emphasis for the transport aircraft designer. Instead of maximizing cruise performance subject to constraints from takeoff and landing, and noise as for long haul aircraft, we now must maximize takeoff and landing performance, and perhaps most importantly, optimize the noise performance subject to constraints specified for cruise performance in terms of trip times and costs to provide an advantage over competitive ground modes. This is not the conventional design problem, and the results are not conventional transport aircraft.

Here we shall present trip times for two future short haul air systems designed using technology appropriate for introducing the service in 1980. The QSTOL-80 system uses a quiet STOL transport design produced by the preliminary design computer programs of the Flight Transportation Laboratory at MIT. It is an 80 passenger, 500 mile design range aircraft cruising at 500 miles per hour using Q-fan propulsion of bypass ratio 15. Takeoff and landing distances using externally blown flaps are less than 2000 feet, and it makes 98 PNdb for a 500 feet flyover during takeoff.

The Q-copter-80 system uses a quiet helicopter design produced by similar FTL computer design programs (Reference 2). It is a 50 passenger, 400 mile design range tandem helicopter cruising at 196 mph using a 6 bladed rotor of solidity $\sigma = 0.193$. It makes 79 PNdb at 500 feet during takeoff.

TABLE 1. ASSUMED SYSTEMS TIMES FOR SHORT HAUL

System	Access & Egress (minutes)	Wait & Processing (minutes)	System Time T_S
Auto-70	10	0	10
CTOL-70	60	60	120
QSTOL-80	45	35	80
	(STOLports save 15 minutes)		
Q-copter-80	30	30	60
	(VTOLports save 30 minutes)		

To present possible trip times for future short haul air systems, it is necessary to make critical assumptions about the form of future systems and their system times. Table 1 shows a set of assumed system times which are used with the vehicle times to produce the total trip times for future short haul systems in Figure 3. For these assumptions, it can be seen that the automobile at 60 miles per hour cruise speed will be the fastest system below 80 miles, the helicopter system is fastest between 80 and 250 miles and the STOL aircraft system is fastest between 250 and roughly 500 miles. The new short haul systems do show time advantages over the automobile and conventional airline systems between 80 and 500 miles; but these time savings are of the order of 20-50 minutes and can easily be eliminated by infrequent service or poor access and egress times. The results are conditional upon the value of the system time assumed, and one can show any pattern of results one wishes by making quite reasonable variations in these assumptions. It becomes difficult to generalize, except to state that newer forms of properly designed short haul air systems have the potential for offering attractive reductions in total trip time.

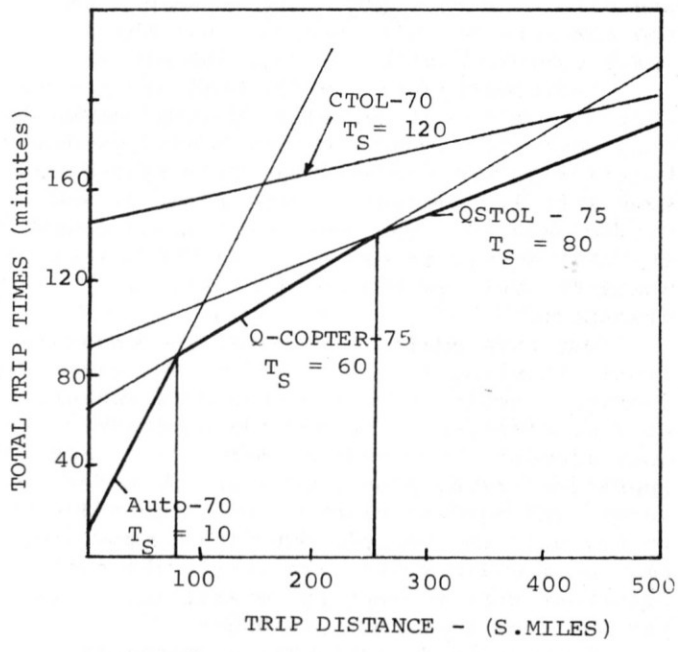

FIGURE 3. TYPICAL TOTAL TRIP TIMES

TRIP COSTS FOR SHORT HAUL AIR SYSTEMS

In a similar manner, we may define the total operating costs for short haul service into vehicle costs and system costs, and once again we shall find that the system operating costs will dominate at these short distances. Historical vehicle direct operating costs are shown in Figure 4 for the same set of helicopter STOL and CTOL aircraft, and are compared with a 4 seat private automobile. A typical long term, average cost of operating an automobile in

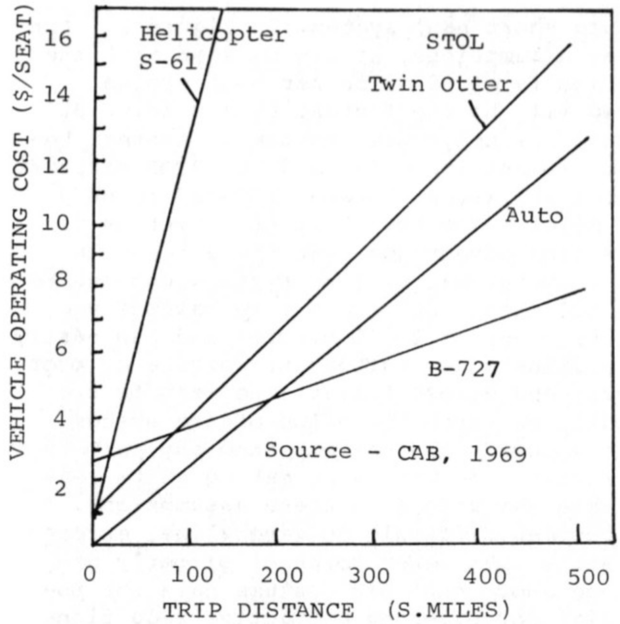

FIGURE 4. COMPARISON OF VEHICLE TRIP COSTS

the USA has been taken as 0.10$ per statute mile. On this basis, it is seen that the conventional air transport has the least vehicle cost/seat after 200 miles.

Improved technology for helicopter and STOL aircraft will decrease vehicle operating costs for newer short haul air systems relative to the conventional jet transport. Even with improvements, these types of vehicles only show cost/seat advantages over the CTOL at distances less than 100 miles, where the auto is the cheapest form of transport.

But once again, a reversal in conventional thinking must occur. The vehicle operating costs, normally used as a measure of cost efficiency are not the dominant cost element. The system costs, (indirect operating costs, plus traveller costs for access and egress) which do not depend directly upon the vehicle but rather upon the rest of the air system are easily the most important cost element in determining costs per seat, or costs per passenger.

Once again we must make assumptions concerning the probable cost per passenger for system costs of newer forms of short haul air systems, and the relative cost advantages are determined directly by these assumptions. A set of typical costs for processing passengers, and for access and egress to the system's parts are given in Table 2. These are combined with vehicle costs to produce Figure 5 which shows typical total trip costs per passenger for the new short haul systems compared with present automobile and conventional airline systems.

Where the new forms of short haul air show some advantages in total trip time, under the assumptions for Figure 3, the

TABLE 2. ASSUMED SYSTEM COSTS PER PASSENGER ($)

System	Access & Egress	Pax. Processing
Auto-70	0.50 (parking)	0
CTOL-70 Domestic Airline	8.00	12.00
QSTOL-80 Third Level Airline	5.00	6.00
Q-COPTER-80 Helicopter Airline	3.00	3.00

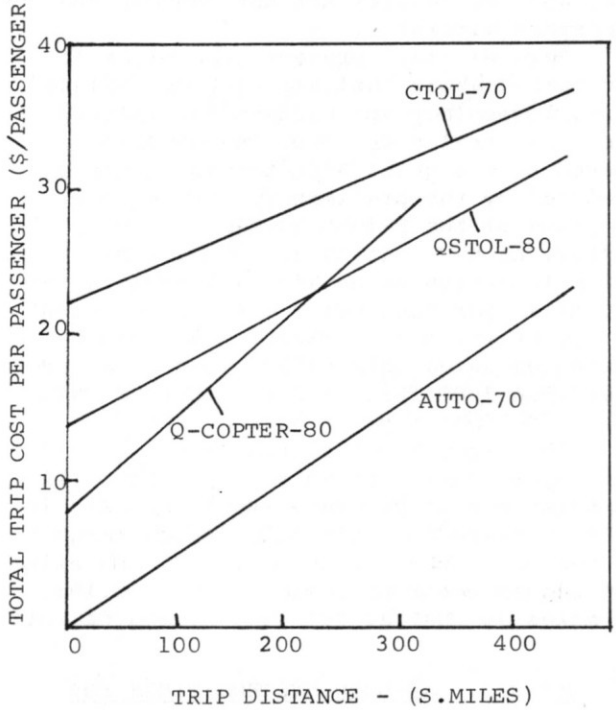

FIGURE 5. TYPICAL TOTAL TRIP COSTS

private automobile long term average total costs per passenger are significantly lower throughout the range from 0 to 500 miles. Because of assumed system advantages, not vehicle cost advantages, the new air systems do show cost advantages over the conventional long haul air system throughout this range.

The total trip time and cost curves presented identify the crux of the issue in introducing new short haul air systems. It is a marketing issue which may be stated as follows:

"What is the size of the travel market which will choose to pay higher costs compared to automobile or other ground alternatives to gain the time advantages offered by the new short haul air systems?"

Factors other than time and cost, such as comfort, reliability, and safety also affect this marketing issue. An answer to the question is not obtained by analytical studies, or by market research. The travelling public will not know its response in the absence of a live demonstration of the time and cost of a real prototype system.

Upon this crux, progress in introducing a new short haul air system is stymied. It seems unlikely due to institutional barriers, and the large risky, long term investments required that any coalition of entrepreneurs from the private sector would unilaterally embark on the initiation of a new system. It is very clear that leadership from a national government is required to provide a policy and program which enables both the public and private sectors to work together in developing a new form of air transportation. Since it is not clear what the answer to the marketing issue is, it is advisable to conduct a limited market demonstration to limit initial investments and allow a staged, logical development to occur. The Canadian government now is embarked upon this course of action, and may lead the rest of the world into introducing new forms of short haul air systems based upon QSTOL aircraft. The results of the live demonstration of city center to city center service from Ottawa to Montreal using STOL Twin Otters will be watched closely by all of us in aviation.

A PROGRAM FOR SHORT HAUL AIR TRANSPORT

This section will describe a suggested framework for a national plan for developing short haul aviation in the U.S.A. It was produced by a Summer Workshop on Short Haul Air Transportation at Waterville Valley, N.H. sponsored by NASA in August 1971, and ties together a number of problems in long and short haul air transportation with various technological developments. See Reference 1.

The major long term need for domestic U.S. air transportation is additional system capacity to accommodate future growth and to relieve present congestion and delay. The system capacity which is needed can be classified as ground facilities - runways, airports, metroports, or more precisely, concrete. There is a parallel need for improving the ATC system with improved technologies and procedures, but for the most part, the capacity restriction is not in the air, but rather on the ground.

But while the ATC system will be improved over the next decade, there is a serious barrier to providing additional ground facilities - community acceptance and the noise problem. Recent history at several U.S. cities has led many aviation leaders into publicly asserting that we have built the last major jetport in this country, and surrounding communities are now aware that any planned improvement to existing airports will expand its capacity to make noise. A new factor is the requirement for an environmental hearing before federal funds can be expended on additional runways, or airfield improvements. The community is thereby given an opportunity to block all increases in the capacity of existing airports, and will do so at most of the major jetports.

As well, the tenor of our times has led us into a political climate where local government actions may cause reductions in existing capacity. Curfews are current local issues at a number of airports, and more restrictive quotas or operational restraints are a threat for the coming decade.

The alternatives to solve the noise problems have been well discussed in recent years. Briefly they may be listed as:

1. Nacelle Retrofit Program
2. Re-engine Program
3. Remote or Offshore Jetport Construction
4. Land Acquisition around Major Airports
5. Avigation Noise Easements

For the U.S., all of these alternatives are generally multi-billion dollar, ten year programs, and much discussion has been generated concerning the costs, time scale, and noise benefits of variations or combinations of them. One or more of them must be adopted to ensure long term viability of the air transport system. The financing of any such solution will be undoubtedly done using the Airways-Airports Trust Fund although some amendment of the present legislation will be needed.

A new alternative has now emerged. It is mainly concerned with future course of developments in the short haul sector of air transportation, but provides an attractive solution to the long term problem of all of air transportation.

THE "QTOL" PROGRAM

The QTOL (Quiet Takeoff and Landing) Program is a suggestion that the air transport industry should dedicate itself to a long term program aimed at quietening the environment around aviation ground facilities, while at the same time continuing to improve short haul and long haul air services for the nation.

The first steps in this program may be said to already have occurred with the introduction of the DC-10. The quiet engine technology used on that medium-to-long haul aircraft (and the coming L-1011) reduce the noise footprint size to roughly one quarter of that of the prior DC-8 which carries only one half the passenger load. These new planes will gradually replace their noisy equivalents over the next several years.

The second step is to use still quieter engine technology in introducing a new set of short haul vehicles and an improved short haul air system. A gradual replacement of DC-9 and B-727 aircraft can occur as airline short haul traffic is diverted to the new quiet service. The elements of this system are now discussed in more detail. All elements have been tagged with a label "Q" to emphasize the thrust of the program in dealing with laymen and legislators. It is, quite frankly, a marketing device to continually remind the industry and the public of the major goal of the program.

Elements of the QTOL Program

a) Q-PLANES

A Q-PLANE would be defined as a vehicle with two distinct improvements in performance:

1) It meets some Q-CRITERION such as 95 PNdb at 500 feet when at full power, or a 95 PNdb footprint size less than some value.
2) It has improved navigation and guidance capabilities for steeper, more complex paths for approach and departure.

There are three classes of quiet short haul vehicles:

1. QVTOL (quiet vertical takeoff and landing).
2. QSTOL (quiet short takeoff and landing in less than 2000 feet).
3. QRTOL (quiet reduced takeoff and landing in less than 4000 feet).

These aircraft are now technically and operationally feasible for some size of vehicle, although they are in varying stages of technological development. If the Q-CRITERION for noise were placed at lower levels, the aircraft would be smaller in size and more costly to operate. As Q-technology in the form of improved quiet propulsion and new guidance systems is developed, the vehicle's size and economic performance will be improved.

b) Q-PORTS

A Q-PORT is a facility which accepts only Q-PLANES, and whose noise environment has been guaranteed to the surrounding community as part of the approval process for the facility. Automatic listening devices would monitor the noise environment, and enforcement of these guaranteed standards would be the responsibility of a non-aviation agency. Q-PORTS would be of two main types:

1) A conversion of an existing peripheral airport to handle short haul passengers. Improvements in runways, lighting, landing guidance, terminal buildings, parking and access roads would be made.
2) Construction of metroports of reduced acreage at suitable sites in existing urban areas for V/STOL Q-PLANES. These sites might be downtown at the waterfront, or at expressway interchanges.

As part of the Q-PORT development, route awards would be made to operators authorizing new short haul services from this site.

c) Q-WAYS and Q-PADS

A Q-WAY is defined as a new short runway restricted to usage by Q-planes and constructed at congested jetports to accomplish two objectives:

1) to provide less noise at the jetport by diverting short haul passengers from the present noisy jet transports to Q-Planes.
2) to increase the capacity of the jetport by diverting short haul flights from the presently busy jet runways to the additional Q-ways.

There is adequate space on major airports for the shorter Q-ways for both RTOL and STOL aircraft. One attractive layout would be to build a Q-way parallel to the main runway and centrally placed such that the approach and departure paths are both vertically displaced from the CTOL paths, and thereby, hopefully avoid the wake vortex interference problem. The improved navigation and guidance of Q-PLANES would be used to get into and away from Q-WAYS. For QVTOL aircraft, this improved guidance capability would allow paths directly to Q-PADS on the periphery of the terminal ramp area.

d) Q-FUNDS

The financial aspects of the QTOL program would be funded by establishing a landing charge for all aircraft based on the takeoff and landing footprint size above a given noise level. Credit would be given to operators who use technical or operational means to reduce their noise footprint. These charges would be part of the user charges of the Airways-Airports Trust fund, and would be earmarked for use in the QTOL program, or as a credit to the

Q-FUND account in the event that early QTOL program spending outdistances income from Q-FUNDS.

CONCLUSIONS

1. The potential exists for introducing new forms of air transportation to provide improved services for the short haul intercity passenger over distances from 100-250 miles in competition with lower cost ground modes.

2. This new service is distinct from a second potential to improve the service in existing short haul air markets.

3. To be successful, the complete new system including the parts must be carefully designed. System times and costs are more important than vehicle costs. Community acceptance of these new ports at desirable locations requires satisfactory noise performance from the vehicles. A less noisy vehicle which is slower and more expensive may be part of a faster, less expensive complete system of vehicles and ports.

4. Government leadership is essential in creating policies and programs which foster the development of these new forms of air transportation.

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