FAA RE&D Committee Vertical Flight Subcommittee

Tiltrotor and Advanced Rotorcraft Technology in the National Airspace System (TARTNAS)

Final Report

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Prepared by the FAA Research, Engineering and Development Subcommittee addressing Tiltrotor and Advanced Rotorcraft Technology in the National Airspace System (TARTNAS)

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Abstract

Purpose

— To determine what activities/ efforts and criteria are necessary to establish how the combination of satellite-based Global Positioning System (GPS) assets, tiltrotors and advanced vertical flight technologies can best be exploited to address the current and future problems effecting air commerce worldwide.

Scope

This study addresses the above purpose in four sections: The Aircraft; Operational Considerations; Air Traffic Control, and Public Acceptance. Panels of experts were formed for each section. Representation included manufacturers, civil users and operators, military and government users and operators, and the Federal Aviation Administration. Literature searches were made of the volumes of documents addressing various aspects of their general areas and are included as references. Each section provides specific recommendations to accomplish the purpose of this effort.

Conclusions

1. The current Air Traffic Control (ATC) system is not capable of exploiting or even optimizing the capabilities provided by vertical flight aircraft.
2. Tiltrotors and advanced vertical flight aircraft such as advanced helicopters can make a significant contribution to the reduction in the current and future system congestion and delays and provide significant increases in aircraft and passenger capacity.
3. The current and programmed future Air Traffic Control System and its regulations pertaining to flight operations safety *can be adjusted without undue burden* to accomplish number two above. In

fact, the means are already contained within existing regulations and operational procedures - they need only be applied on performance-based principles.

Executive Summary

Man has long had the desire to fly "like a bird", going from where he is to where he wanted to be without being inhibited by obstacles such as mountains, buildings, oceans, etc.

By the early 1900's, flight was becoming a reality, but not flight "like a bird." A lack of adequate light weight power to provide vertical takeoff and landing required man to settle for an alternative, the fixed-wing airplane. The fixed-wing aircraft brought with it the requirement for a runway for landing and takeoff leading to development of the airport with its growing size and facilities.
Since the number airports and urban population grew together, there was soon a problem in siting both, thus resulting in a shortage of airports, or more exactly, the required runways.

The capability for point to point travel provided by the horse, and later the omnipresent automobile, had to be given up for the inconvenience of the urban mono-modal transportation facility, where surface transport and its associated congestion provided access to the air facility with its inherent congestion. It was much the same for railroad stations and seaports.

The technology generated by the demands of World War II provided the efficient airplane with advancements in greater performance, size, speed, altitude capability and endurance.

By the early 1950's, the availability of surplused and new aircraft, the use of radar (radio detection and ranging) for safe and efficient air traffic control, and the advent of the turbine engine made the airplane the preferred mode of transportation for passengers and cargo worldwide. The public acceptance of the sleek and faster jets as a safe and efficient means of transportation, added romance to air transportation and fueled the explosion of the air transport age throughout the world.

But in the 1940's, vertical flight was becoming a realty with the arrival on the scene of the first efficient helicopters. Yet the accomplishments of these early helicopters were greatly overshadowed by the public's acceptance and the rapid growth of the fixed-wing industry.

These helicopters were slow, looked ungainly, were noisy, and did not fly as high or as fast as any fixed-wing aircraft! Even with the extensive and effective use by the military in the Korean War and the "helicopter war" in Viet Nam did not gain helicopters the public acceptance warranted. They still were not as accepted as airplanes.

In many cases, the helicopter's image was tarnished by being envisioned as a costly and complex "military-only" and an industrial application aircraft, or as a luxury, only affordable by the affluent.

While helicopters were growing in size and capability, the air traffic control system was being optimized for, based on the speed, maneuverability and altitude requirements of, fixed-wing aircraft. Long, shallow-angle instrument approaches and missed approaches were designed to provide adequate safety for fixed-wing aircraft with one engine inoperative. ATC procedures were designed to accommodate the turning radii, speeds and climb/descent capabilities of fixed-wing. Essentially, the ATC system failed to allow for the performance capability and associated dispatch reliability that modern vertical flight aircraft provide.

As we proceed into the 21st century, we find vertical flight aircraft of a greatly enhanced capability. These advanced vertical flight aircraft, can perform point to point flights under all weather conditions with speeds approaching the nominal fixed-wing speeds of 300 knots, with a maximum endurance capability of over five hours, enabling them to cover distances of one thousand miles or more at altitudes of 25,000 feet or better.

These new vertical flight aircraft, such as the tiltrotor - an aircraft that is a high performance fixed-wing aircraft with the unique capability that permits vertical takeoff and landing - or any powered-lift vehicle can safely and expeditiously carry up to 100 passengers in fixed-wing comfort, at fixed-wing speeds over fixed-wing distances. Yet it does not require sequencing with fixed-wing traffic, and does not require a runway, thus removing the primary cause of air traffic delay - runway occupancy time.

Yet public acceptance lags… Why?

- They are perceived as a noisy and unfriendly neighbor, caused in part by an ATC system that forced vertical flight aircraft to operate at altitudes lower than optimal to avoid the flow of the less-maneuverable fixed-wing traffic.
- The are envisioned as unsafe, possible by operating at the lower altitudes and possible by memory of the very few public mishaps of the past. Vertical flight aircraft are inherently *more safe*, since they do not require a runway to land, only a relatively small obstacle-free area.
- They are perceived as expensive to purchase and operate. True, they may be more expensive than some fixed-wing aircraft, but provide utility far in excess of the fixed-wing assets when permitted to operate in a simultaneous and non-interfering ATC system, complementary to fixed-wing traffic.
- They are perceived as only able to operate in good weather. Not so! Modern advanced vertical flight aircraft possess the full capability of their fixed-wing brethren, with every system available to airplanes, including flight management systems and de/anti-icing capability, as well as weather radar and collision and terrain avoidance systems.

By utilizing the advanced vertical flight aircraft, in a system that provides simultaneous and non-interfering operations (SNI) thus removing the vertical flight aircraft from the flow of fixed-wing traffic, safer and more expeditions handling of all traffic can occur. We can provide fast, safe and timely transportation of passengers, directly from origin and to destination as well as feed to airports easily within 300 nautical miles.

By removing vertical flight-capable aircraft as well as smaller regional fixed-wing aircraft from the arrival/departure streams on the large runways, we can actually reduce delay by permitting closer sequencing for the larger, faster, fixed-wing carriers. Those same passengers will arrive via vertical flight. Replacing a smaller regional aircraft in precious runway occupancy "slots" with a larger aircraft increases capacity while simultaneously reducing delay. Vertical flight aircraft "pick up the slack" in the system and provide additional passenger seating. Measurable data indicate that a 40% increase in passenger throughput capacity can be gained in this manner.

The new capability provided by the GPS systems, ADS-B and upgraded flight management systems have enabled a new age in aviation, not seen since the advent of radar - the Simultaneous and Non-Interfering IFR system or SNI.

Vertical flight and SNI provide a capability not available before, a capability to safely and expeditiously transport passengers and cargo to sites either on or off airports, in all weather operations, using a system of GPS-based airways and performance-based (based on the using aircraft aerodynamic performance) procedures.

From this study, we examine the advanced aircraft. We determine what the operators and users need. We address the capability of the current ATC system and what needs to be changed. We investigate the public's perceptions of vertical flight, and what needs to be changed.

When the report is complete, we have addressed in detail the advanced aircraft, the operational requirements around which to build a new, efficient ATC system, and we know what we need to address in changing the public's perceptions. It will take a concerted effort by industry, the government and the public - it's the passengers need to travel that drives the industry ↓ the need to "get somewhere" in a timely, efficient, cost-effective and *safe* manner.

What remains to be done?

1. A review by appropriate government agencies to provide acceptance and consolidation of recommended efforts to achieve the stated goals of reducing aviation congestion/delay and increasing passenger access and throughput through the judicious and site-specific implementation of GPS and SNI.

2. Provide a detailed plan of execution with appropriate time lines and task assignments, with accountability through the appropriate agencies.

3. Establish secure funding in appropriate categories, to be submitted in budget cycles, for the appropriate agencies/industry cooperatives to accomplish the requirements/goals in a timely and efficient manner.

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Section 1

The Aircraft – and Associated Requirements

INTRODUCTION

The current generation of advanced technology helicopters and the new civil tiltrotor aircraft are mature, safe, and reliable. They offer the ability of true Class 1/ Category A performance operations with continued flight with one engine inoperative (OEI). Thus these vehicles are comparable to operations with fixed-wing passenger carrying airplanes.

Modern rotorcraft have, with the exception of flight in continuous icing conditions, the capability for all weather operations. Flight speed has been increased with modern helicopters having cruise speeds of 130 to 150 knots. Civil Tiltrotors (CTR's) or NASA 's Runway Independent Aircraft (RIA), offer even greater potential with the Bell Agusta BA 609 planned to have a cruise speed of 275 knots. This makes advanced technology helicopters and civil tiltrotors extremely attractive as corporate/executive transport aircraft and open the opportunity for longer RIA's for scheduled passenger service. If some existing airspace limitations could be removed or modified, performance can be expected to increase further.

The larger advance technology helicopters, like the new EH Industries EH 101 currently in limited service in Japan and with the UK military, the Sikorsky S-76C+ and Bell 412/430 in current service, and

Sikorsky S-92 undergoing final stages of development, offer increased potential for scheduled passenger operations. Since such vehicles can use airspace and airport infrastructure not currently utilized by fixed-wing aircraft, they offer the opportunity to *dramatically reduce delay and congestion* at airports and in the ATC system. Future larger passenger carrying power-lift (tiltrotor) aircraft like the proposed CTR 2000 (based on proven systems and components of the V-22 Osprey military tiltrotor) offer even greater potential through higher flight speeds in the order of 400 knots and ranges well in excess of 600 miles.

It is against this background that such rotorcraft (vertical flight aircraft) must be considered. They should not be confused with smaller utility helicopters, which although playing a vital role in overall aviation picture, are not as well suited to offsetting congestion or providing the basis for commercial passenger transport system.

Although in the 1970's and 1980's, major operations took place in the San Francisco, Los Angeles, Chicago and New York areas, it should be noted that to date, there are, with the exception of the Helijet Airways operations between Vancouver, BC, Canada and Seattle, WA, no scheduled rotorcraft-based services in the US. Scheduled helicopters operations, however, in addition to that in Canada (Helijet), do exist in the United Kingdom (UK), other parts of Europe and Greenland.

In more recent times, there have been scheduled helicopter passenger operations in the Los Angeles Basin (Airspur), New York metropolitan area (Pan Am, Island, National and Resorts Aviation), Houston and in Boston, (HUBExpress). The last of these ceased operation about seven years ago for a number of reasons, notably the lack of economical IFR infrastructure, access to airspace and related ATC issues. At the present time the preponderance of corporate helicopter transport operations are in the Northeast (Boston – New York – Philadelphia – Washington DC) and Los Angeles area, with a large offshore resource exploration support passenger / cargo transport operation in the Gulf of Mexico. Spread across the US are numerous emergency medical services (EMS) operations. Although some are small single engine helicopters, in the main, medium twin engine helicopters are used, with many operations based on the Sikorsky S76, Eurocopter AS-365, BK-117 and other similar helicopters

ALL WEATHER/IFR OPERATIONS

Current modern rotorcraft are well equipped for IFR operations, and with the exception of anti/de-icing clearance, they are capable of all-weather operations. The BA 609 and future CTR's/RIA will have advanced all-weather capabilities. However, deicing and anti-icing capability and regulatory clearance remains an issue . With the exception of the Eurocopter Super Puma Mk1, which uses heated main and tail rotor blades, there are no other civil helicopter approved for flight into known, or forecasted, icing conditions.

Flight in *Known Icing* Conditions

Anti-/De-ice

Helicopter (as well as conventional fixed-wing aircraft) engines are generally protected with 'bleed air' (from the engine compressor section) and / or use of 'electrical mats' on the engine air inlets and inlet guide vanes. This typically provided de-/anti-ice capability and meets the necessary requirements for operating in either 'known or forecast icing conditions.' The fuselage, including the tail plane/fin, is not normally considered a problem with regards to ice build up. The situation with the main and tail rotor blades is, however, a very different situation. Anti/de-icing systems based on the use of heated blades, or heated prop-rotors in the case of a CTR/RIA, are planned for new helicopters such as the EH 101 and S-92 and BA 609 CTR. Because of the complexity in obtaining certification for the heated element systems, it has been stated that such units will not be available to meet the desired operational requirements on early versions of the EH 101 or BA 609. The anti-/de-icing systems employed to date on helicopter rotor blades and tiltrotor prop-rotors are based on the use of electrically heated elements demanding high levels of electrical power. The systems are heavy and costly to maintain. Thus the current anti/de-icing systems have a significant adverse influence on the operating costs and, even if available, are unlikely to be considered an attractive or economical solution.

As a consequence of these icing limitations, research and development effort is required to determine, develop, and provide alternative methods. Methods embodying the use of other concepts (e.g., electro-expulsive) and making use of 'smart materials' have been suggested at a research level by a number of the academic institutions and NASA, but these have NOT developed into practical solutions. Such solutions need to be considered for the long term. In the meantime, since true all whether operations and flights in IMC (Instrument Metrological Conditions) will require clearance for flight in 'known icing conditions' it is be necessary to address these issues initially by purely operational means. This is a significant factor in the case of helicopters operating at heights of 2000 to 4000 ft AGL, an altitude prone to 'ice generating conditions.'

Ice Detection

The detection of icing conditions is now well advanced and may offer a potential way of determining when 'icing conditions' are encountered in flight. When combined with 'limit period icing' clearance for helicopters and CTR/RIAs combined with early detection means may offer a way to resolve this issue in the short term, since if detected early, time will be available to find either an alternative 'non-icing altitude', area or a suitable divert facility. This will, however, require flexible air traffic management route planning and altitude management.

In this context it is worth noting that weather prediction for 'known icing conditions' are based on a very conservative assessment and often icing conditions are *not actually present*. This aspect will have less impact on CTR/RIAs since they will normally climb quickly through the ice-generating layer for cruise flight at high altitudes (in the order of 18000 ft. to 25000+ ft.). Even so, if the CTR/RIAs are required to operate at 'low altitude' in metropolitan areas for ATC reasons, particularly in the conversion and/or helicopter modes, the impact will be the same on them as for helicopters. A potentially satisfying interim solution is removal of the restriction on filing into *forecast icing conditions* permitting such flight until actual pilot reports (PIREPS) or electronically-generated automatic "pilot reports" (E-PIREPS) record ice accretion at a significant (to be determined) rate.

It is fairly clear that if this issue cannot be resolved by the adoption of appropriate operational procedures, then at least for the current generation of advanced rotorcraft, it could severely curtail or at least hinder true all weather /IMC operations by rotorcraft.

Certification

Another issue related to anti-/deicing is the current certification process. This is costly and time consuming since it does not really allow a "read across" from one set of conditions or tests to another. Currently testing to achieve certification can extent over three or four winters with the associated high costs. This is undoubtedly a contributing factor to the lack of such systems on some helicopters. An examination by the FAA on methods to streamline the certification process is required. Reduction in the cost of and time to perform certification testing with its associated reduction in acquisition costs would lead to more helicopters with anti/ deicing capabilities.

LOW VISIBILITY APPROACHES

Helicopters and CTRs/RIA will need to be able to safely make low visibility approaches to heliports, vertiports and airfields if the all weather operational potential is to be fully exploited. Work on this and simultaneous non-interfering operations (SNI) is currently underway but the focus needs to be enhanced if solutions are to be found in the short/ medium time frame. In addition to the use of advanced systems such as DGPS, WAAS, LAAS, and the European-developed dGPS/Loran C system, etc., further consideration needs to be given to the requirements for low speed approaches (in the order of 60 to 70 knots) from the air vehicle, vehicle management systems and instrumentation side, to minimize the protected airspace required for such operations. Similarly 'missed approach' airspace is currently dependent on the flight speed as well as turn radius and climb gradient. Since this will have a major influence on the potential siting of heliports / vertiports in the metropolitan areas and on / near airports, these aspects need to be re-addressed and the possibility of airspace restrictions based on performance-based TERPS and RNP (required navigation performance) based lateral navigation (LNAV) systems considered.

VORTEX WAKE INTERACTION

A related issue applicable to siting of facilities on airports, is the influence of the vortex wake shedding by fixed-wing aircraft, particularly large aircraft such as the Boeing 747 and 777, on helicopter and tilt-rotor aircraft landing and takeoff operations. NASA/FAA studies have been primarily focused on rotorcraft interactions with encountered fixed-wing wake vortex turbulence in flight, not on the ground (DOT/FAA/CT-94/117 Flight Test Investigation of Rotorcraft Wake Vortices in Forward Flight and NASA Langley Helicopter Response to an Airplane's Trailing Vortex). Current anecdotal information from operators and controllers indicate that helicopter operations in close proximity to fixed-wing runways and rotation points are not an issue. Aberdeen, Scotland is such an example. To date, in the US, there is little or no data or recorded incidences of a rotorcraft loss of control associated with siting a FATO near a runway.

It is being suggested internationally that the U.S. requirements of a 700 ft separation between a runway and heliport / vertiport should be increased to 2500 feet for vertical flight SNI. If this gains acceptance via ICAO, it could have a major influence on the ability to locate and implement vertical flight SNI operations. Clearly these aspects need to be reviewed by the FAA, and if necessary, appropriate test evaluations conducted. In addition to the airport SNI operations already mentioned, consideration needs to be given to the movement of rotorcraft within the confines of the airfield.

FLIGHT / GROUND SPEED MEASUREMENTS

During approach to the heliport / vertiport FATO (final approach and takeoff area) it is important to know the accurate ground speed (rate of closure) and airspeed. This is difficult to determine. Much of the difficulty will be resolved with the introduction DGPS and/or WAAS/LAAS-based systems. In the meantime this is a critical aspect when making approaches in windy conditions. The development of a low-cost, accurate, 'measuring' system will be required to allow the full advantages of IFR precision GPS approaches to be exploited. Very accurate ground speed can be derived from GPS, but additional research is required to make this a reality. This is, of course, inter-related with the approved approach speeds, where the stability of the helicopter and pilot workload at low speeds (Vmini) is often as or more important. Work directed providing good low speed measurements during descent is therefore required.

ATC / AIRPORT ISSUES

Advanced helicopters and all proposed CTR's/RIA have "wheeled undercarriages" (landing gear) and can easily ground taxi similar to fixed wing aircraft using existing taxiways. Considerable increases in flexibility could be obtained on an airfield if, for the longer distances, hover taxiing could be used by larger skid-equipped helicopters and if required, by wheeled helicopters as well. This requires the use of suitable taxiways. Although a relatively noisy operation, it would normally not create any additional environmental (noise) problems if performed within the constraints of an airport. This would also allow many more facilities to be used. For this to become reality ground/hover taxi-aids would need to be developed by the FAA and at airports separate taxiways for vertical flight aircraft established wherever possible.

FUTURE DEVELOPMENTS

A number of significant developments are still taking place, which will further enhance the capabilities of helicopters and CTR's/RIA. In general they are not directly associated with FAA activities, except as they relate to the need for certification. Some areas however, require continued 'R and D' such as rotorcraft Damage Tolerance. The Technical Oversight Group for Aging Aircraft (TOGAA) is performing a valuable coordinating function and it is recommended that the FAA RE& D Advisory Committee endorse these activities. Similar in the operational area the TOGA [Takeoff-Go Around] Display Committee is conducting work which will be useful to the development of procedures for future rotorcraft/ CTR/RIN operations. The FAA RE&D Advisory Committee should also support this activity. Other related areas include Health and Usage Monitor Systems (HUMS). Although this is not an operational issue, work should be continued to enable the direct and indirect operational cost (reduced maintenance requirements-replacement on demand/when required rather than on timed schedule) as well as the safety benefits (improved trend analysis) to be fully exploited. The EH 101, S92 and BA 609 all incorporate HUMS since it will undoubtedly contribute to safety and benefits in terms of lower direct operating costs (DOC's).

The expansion of this field to include Fatigue Usage Monitoring Systems (FUMS), for the direct measurements of loads and fatigue damage in real time will further enhance safety. A related topic is the increased use of composite materials, where continued work aimed at improvements in design, inspection, maintenance and repair of such structures is warranted. Additional work on the area of Active Vibration Control (AVC) with the various agencies and academic institutions is also supported. It has already been demonstrated that there are considerable benefits in terms of airframe weight and fatigue from controlling vibration by this method. Further improvements will also improve equipment reliability and safety, will and enhance passenger acceptance of rotorcraft in the public transport role.

The influence of electromagnetic fields (EMF) is still an issue and development of avionics and systems that are EMF ‘neutral’ are required. Currently such testing is complex, time consuming and costly. A reduction in this is required to reduce the cost of impact and stimulate the introduction of new systems.

ENVIRONMENTAL IMPACT/NOISE

Noise in many locations, particularly in metropolitan environments, is a burgeoning critical factor, which must be taken into account. The advanced technology helicopters entering service at the current time or being considered are generally quieter than their counterparts of a number of years ago. Even so, helicopters and CTR’s/RIA will generate significant noise levels, particularly during approach mode. Major research is underway within NASA and the manufacturing companies involving rotor blade / proprotor design and operational profiles (e.g., two segment approach profiles that limit the exposure time in the slow-speed “helicopter mode”) that will undoubtedly lead to further source noise reductions over time. However, since ‘retro-fitting’ quiet technology is not generally possible, the noise foot prints of today’s helicopters – and the coming BA 609 – are essentially fixed, and little or no major noise reduction can be expected in the near term. Fortunately many of the most modern helicopters, including the EH 101 and S92 and many smaller Bell and Eurocopter models have been designed with ‘public acceptance’ in mind, and the designs have been tailored to minimize the annoying source of blade-vortex interaction (BVI) and tail rotor noise. Also on CTR aircraft, such as the BA 609, adjustments of the nacelle angle can be used to minimize the BVI noise so that in practice such vehicles will not generate high levels of impulsive noise. In the medium term harmonic blade control and other advance solutions are anticipated to lead to significant noise reductions.

Noise abatement procedures are available for all modern rotorcraft. These considerably lower the noise level and improves the characteristic of the sound heard on the ground during landing. However, there is evidence that public acceptance is more related to the ‘perceived noise’ and interrelated with concerns over safety and the need for such operations, etc., than the actual noise impact created. This can be addressed by education on the utility and public service provided by the helicopter and should be addressed on a public-private partnership level. A demonstration of operations in appropriate locations would be helpful in this respect to provide a ‘show case’ and indicate public acceptance of passenger-carrying advanced rotorcraft and CTR’s/RIA.

From the FAA perspective it is also extremely important that in the development of unique helicopter routes, in terms of the path and height chosen, and the establishment of approach / departure procedures, the environmental aspects are taken into account. Unfortunately, up until the present time, many of these aspects appear to have been ignored or given little emphasis. The Helicopter Association International (HAI) recommends that ‘flight routes’ for small and large helicopters should be 1000 ft. to 4000-ft. above the ground (AGL), with the higher altitudes (up to 6000 ft.) being desirable. Recently, to take into account the height of buildings and variation in the ground level, it has been suggested that the minimum height to be considered should be 2000 ft. AGL. It is also desirable to avoid as far as possible noise sensitive locations such as schools, hospitals and residential areas. These aspects should be taken into account when developing and selecting flight paths (routes).

During landing, the maximum BVI on a helicopter occurs at or around a 6-degree descent angle. It will be similar for a CTR/RIA. Yet much of the initial focus on Non-precision GPS and Precision approaches is based on the use of a 6-degree approach angle. This is clearly illogical. Some helicopters can use high descent angles (between 6 degrees and 12 degrees). It has been suggested that the final descent angle for the BA 609 should be 9 degrees. V-22 simulation (1 - 1999 NRTC/RITA Project: Helicopter Operations/ Approach – Tiltrotor Steep PA/NPA Terminal Approach Procedures, 2 - 1995 NASA/Boeing Advanced Tiltrotor Transport Technology (ATTT) and 3 - 1994 FAA/Bell*Boeing Vertical Flight Terminal Area Procedures - VERTAPS), which in this respect can be considered represented of other CTRs, has indicated that tiltrotors (with no demonstrable Vmini) can safely perform low IMC instrument approaches (ceilings lower than 200 feet AGL and visibility's lower than ¼ mile or RVR of 1200) at descent angles up to 15 degrees when the flight director and autopilot are coupled. IMC approach angles of 9-12 degrees can safely and expeditiously be flown with an uncoupled flight directed-only. This is likely to be applied to the BA 609 and future CTRs/RIA. These profiles dramatically reduce noise footprints as well as limit exposure to the highest noise levels.

On some helicopters, when descent paths above 6 degrees are not acceptable, angles of 3 or 4 degrees must be considered, but flown at moderate airspeeds (50-60 knots), thereby reducing BVI noise. Even though this results in increased noise levels as a result of the decrease in distance between the over-flown observer and the helicopter, it is offset by the reduction, or practically the elimination, of the 'annoying' impulsive BVI component.

Procedures and performance-based airspace requirements need to be developed taking these aspects into account. While both advanced helicopters and tiltrotor aircraft need to be able to use 'noise abatement decelerating approaches' to reduce the noise impact, much of the current FAA work is focused on constant speed / constant angle approaches. Some difference will exist for CTR's, but during final approach and landing in 'helicopter mode' the same general trends will apply.

It is essential that the FAA take into the account the environmental issues when developing any route structure or TERPS for such operations.

DEMONSTRATION

Although the features of advanced helicopters, the V-22 and the proposed BA 609 are well known, it is appreciated that in many quarters these vehicles are viewed in a less than favorable light. This is true even though in the Gulf of Mexico, UK / North Sea and corporate operations all over the United States, as well as scheduled operations in Canada, Northern Europe, Greenland and the UK etc., where helicopters provide a safe and reliable service. There are also a large number of military helicopter operations in the vicinity of many urban areas (e.g., MCAS Miramar, CA). The U.S. Coast Guard also provides coastal services that are in general very similar to their civil counterparts. These operations are in general conducted with little or no adverse public reaction. It is against this background that, to 'prove' the reliability, safety, etc. and establish pubic acceptance, that it may be necessary and expedient for industry and FAA / NASA to consider a partnership to demonstrate such operations with advanced technology rotorcraft and CTRs/RIA. This could initially be conducted as a freight operation to avoid the additional issues associated with carrying passengers. Passenger demonstrations could be conducted as a follow-on program. Such demonstrations could be conducted in any metropolitan environment, but preferably the flights should be made under demanding conditions such as found in the Northeast during the winter months.

SUMMARY

Rotorcraft and CTRs/RIA, by design, possess and demonstrate unique capabilities that must be utilized during the design of flight paths, flight corridors, terminal operations and the development of applicable FAA (and ICAO) operational rules and TERPS procedures. Such “performance-based” TERPS and rules will provide increased access to constrained metropolitan terminal areas as well as minimize the noise impact on the communities. Rotorcraft low altitude (<6000 feet AGL) IFR infrastructure must be developed, at least on a par with that existing for fixed-wing aircraft operations. Rotorcraft and CTR/RIA performance capabilities must be fully exploited in development of vertical flight performance-based TERPS and operational procedures and regulations.

Full all-weather capability remains a driving requirement. Some integration of anti-/deicing equipment and regulatory relief from restrictions on flight into very conservative forecast icing must be accomplished. Additionally, improvement in the reduction in filing and alternate weather criteria should be developed below that already gained through the good offices of the HAI, AHS and FAA.

The industry, with the FAA and other applicable agencies, must design, evaluate and implement not only improved noise abatement/ noise control techniques and designs, but also improve the comprehensive public awareness of actual noise levels, through actual measurements of noise and dissemination of that data.

RECOMMENDATIONS:

1) A detailed study of icing conditions and their impact on helicopter and CTR operation should be conducted with a view toward establishing operational procedures to permit rotorcraft with ‘limit icing clearance’ to operate under all weather conditions.

2) A detailed review of the current certification procedures for approval for operating in various level of icing conditions should be conducted by the FAA to see if the cost and complexity can be reduced and procedures for limited or intermediate icing approvals can be developed without adversely affecting safety.

3) Research and Development should be carried out by NASA, NRTC / RITA and the manufacturers, to develop low cost, high reliability rotor blade and prop-rotor anti/de-icing solutions. This is urgently required if true all weather operations IMC capable operations are to become a reality.

4) A study with the view of exploiting GPS, DGPS, and other systems, to give good measurements of ground speed and airspeed, should be conducted. The aim should be to stimulate the development of a good low (less than 40 Knot) airspeed/ground speed system.

5) A set of vertical flight performance-based terminal procedures should be developed and a demonstration performed at a suitable site, preferably first at the FAA Technical Center – Atlantic City, followed by a demonstration at a suitable constrained terminal facility such as Boston Logan.

6) A comprehensive industry/DoD/NASA/FAA noise data analysis must be performed to determine actual noise footprint data for representative helicopters and tiltrotors, including noise abatement profiles, with the

results being explained to the public.

Section 2

Operational Considerations – The Next Generation National Airspace System Requirements

Summary Abstract

It has long been recognized by the rotorcraft (now vertical flight) community that instrument standards and procedures used in the current national airspace system do not support efficient vertical flight operations.

Concerns to be addressed are divided between procedural and technological issues. Procedural obstacles prohibiting rotorcraft from realizing their full economic potential and restricting their efficient operation are circuitous routing by air traffic control around constrained airspace, excessive non-precision and precision approach minimums, a lack of GPS precision approach procedures, overly restrictive requirements for building heliports and vertiports, and an absence of procedures to minimize rotorcraft interference with fixed-wing operations in both enroute and terminal constrained airspace.

Technology issues include weather data unavailability for alternates and destinations, and widespread limited communications and surveillance at lower altitudes (<6000 feet AGL).

Before any system can be amended, or necessary improvements developed, evaluated and implemented, the operational requirements must be defined and validated. This document provides as nearly complete

a list of the operational considerations and requirements for vertical flight as can be developed for the Federal Aviation Administration and applicable service providers. It has been developed, evaluated *and validated* through and with the assistance of the vertical flight industry, the civil commercial and military participants as service users.

This document delineates the operational considerations and requirements for the communications, navigation and surveillance capabilities requisite for vertical flight access to and operations in the current and any future National Airspace System. A time line is provided and proposed to implement these critical requirements.

Vertical Flight Satellite Navigation Operational Considerations

Introduction

Forward

This document addresses vertical flight operational considerations supporting current and future potential operations concepts for satellite operational implementation for vertical flight, including both military, civil and commercial vertical flight aircraft, current and advanced helicopter and tiltrotor (powered-lift) aircraft, operated in the next generation US National Airspace System (NGNAS) into the 21st century. It is based on and derived from the NASA/Boeing Advanced Air Transportation Technology studies and the White Paper, VIP21 – Vertical Flight Infrastructure Plan 21st Century, prepare and delivered in 1998 to the Administrator of the Federal Aviation Administration by the AHS/HAI/Industry Infrastructure Working Group.

Tiltrotor operations should not be constrained to either helicopter or fixed wing only procedures. The tiltrotor aircraft are capable of operating as either fixed wing or helicopters within existing FAA operating procedures or TERPS criteria. However, tiltrotors also possess yet to be fully developed unique aeroperformance capabilities that may enable them to operate at potentially slower speeds and steeper approach/departure gradients than current helicopter criteria.

Definitions:

AIM – Aeronautical Information Manual published by the Department of Transportation Federal Aviation Administration to provide basic flight information and non-regulatory air traffic control information

ATM – Air Traffic Management. The governmental and/or civil groups that are responsible for design, development, implementation, management and safety of the US Air Traffic System.

AWOS / ASOS– FAA Automated Weather Observation System or Automated Surface Observation System. Automatically collects, records and transmits local/surface weather data.

CFIT – Controlled Flight into Terrain.

CPDL – Controller - Pilot Cockpit Datalink

CPTR – Copter or helicopter only procedures

CTAS – Center TRACON Automation System - the NASA-developed automated air traffic management system made up of several interrelated systems such as FAST – Final Approach Spacing Tool, SMA – Surface Movement Advisor and URET – User Request Evaluation Tool.

FAST – Final Approach Spacing Tool; air traffic management tool enabling automated spacing (sequencing) on the final approach path.

FATO – Final Approach and TakeOff area

IFR – Instrument Flight Rules

IMC – Instrument Meteorological Conditions – weather conditions with ceilings (cloud bases) less than one thousand feet above ground level (<1000 AGL) and/or visibility less than three statute mile (< 3 mile). Normally written as ceiling and visibility <1000/3)

METAR – Aviation routine weather report

NWS- National Weather Service

TAF – Terminal Area Forecast

TLOF – vertical flight aircraft Touchdown - Liftoff area

VFR – Visual Flight Rules. Operational flight rules requiring flight by visual reference to the ground with a defined horizon, ceilings (cloud bases) greater than or equal to one thousand feet (1000 ft) above the ground (AGL) and inflight visibility equal to or better than 3 nautical miles (≥1000/3)

VMC – Visual Meteorological Conditions – weather conditions with ceilings greater than or equal to one thousand feet above ground level (≥1000 AGL) and visibility equal to or greater than three statute mile (≥3 mile).

LNAV – Lateral Navigation – navigation using specified and depicted lateral course guidance derived from either an internal or external navigation reference.

NPA – Non-Precision Approach, any approach aid providing only lateral guidance (localizer data) and no vertical path guidance (glide slope data), e.g., Localizer-only Landing System - LOC, VHF Omnidirectional Range – VOR, ASR – Airport Surveillance Radar, GPS - Global Positioning System.

PA – Precision Approach, any approach aid providing both lateral guidance (localizer data) and vertical path guidance (glide slope data), e.g., Instrument Landing System - ILS, MLS – Microwave Landing System, PAR - Precision Approach Radar, DGPS - Differential Global Positioning System.

Powered lift vehicles – any air vehicles (aerodyne) deriving vertical lift and inflight propulsion / lift from variable-geometry rotors or engines/propulsive devices attached to or contained with the fuselage or wings.

RNAV – Area Navigation – navigation using specified and depicted lateral course guidance derived from either an internal or external navigation reference from which a series of geopositions (waypoints) are built and either connected within a flight plan or used separately. RNAV may be based on an electronic reference such as a Rho-Theta signal (bearing and range) or inertial earth-referenced (geopositional) locations.

RNP – Required Navigation Performance; maximum permissible cross-track error, e.g., RNP .1 means ± 0.1 nautical miles from track centerline

Rotorcraft – an aircraft (aerodyne) deriving vertical lift and forward propulsion solely from rotors.

SCIA – Simultaneous Converging Instrument Approach(s), any approach system wherein two approach paths, used for concurrent, simultaneous instrument approaches, converge.

SPIA – Simultaneous Parallel Instrument Approach(s), any approach system wherein two approach paths, used for concurrent, simultaneous instrument approaches, remain parallel to each other.

Vertical Flight-capable – embodying the capability to perform vertical/short takeoff and landing (V/STOL) operations, including steep (>6 degree) approaches and climb-outs at airspeeds less than 70 knots. This includes rotorcraft-helicopters, rotorcraft-gyroplanes, and powered lift vehicles.

SNI – Simultaneous and Non-Interfering. SNI (including low-altitude terminal and en route IFR operations). A system of operational criteria and procedures forming a complementary and integrated IFR operating environment, based on the unique performance capabilities of aircraft (conventional, STOL and V/STOL-vertical flight-capable). This capability minimizes interference with fixed-wing operations in the terminal area by eliminating competition for limited resources (runway occupancy time) by sequencing aircraft to separate final approach and take-off (FATO) areas, utilizing separate but complementary discrete approach/departure procedures.

SNI operations combine aircraft-specific flight characteristics with applicable regulations and air traffic procedures, permitting operation in simultaneous but non-interfering, non-competing but complementary, IFR streams, designed around the user aircraft performance capabilities and the requirement to operate at lower altitudes, primarily free of icing influences. SNI embodies the Free Flight concept of IFR direct routing wherever possible.

SNI procedures ***can and do apply to all categories of aircraft***, and are site-specific. SNI potential applications at Newark, NJ (EWR) have been examined and indicate increases in capacity (arrivals/departures) with reduced delay.

Performance-based – based on the aeroperformance and dynamic flight characteristics of the aircraft.

TERPS – Terminal Instrument Procedures. Developed and implemented by the FAA Flight Standards branch to insure uniform applications of common standards and equivalent performance.

Tiltrotor – an air vehicle (aerodyne) deriving vertical lift and inflight propulsion from engine-driven variable-geometry proprotors embedded in engine nacelles attached to the wings. Cruise lift is provided by fixed-incidence wings with variable-geometry flaperons (flight control structure combining the functions of a flap and aileron).

Purpose

Develop a comprehensive description of operations conducted in the current and future U.S. vertical flight ground and air infrastructure.

Background

Operating Environments

Weather

IMC Data. Vertical Flight aircraft operate throughout the year in all meteorological conditions, normally operating at altitudes significantly lower than large commercial aircraft (e.g., >2000 feet AGL <10,000 feet AGL). The predominant occurrence of instrument meteorological conditions (IMC) is in the Southeastern, Northeast and Eastern areas.

The worst weather months are predominately during the traditional solar winter months (Dec-Mar). Exceptions appear to be the Southern US (GOMEX) due to late winter/early spring conditions on the Gulf of Mexico, and in both the Eastern US and Western US, where IMC conditions are encountered in the summer due to smoke, haze and/or smog.

Data indicate that IMC conditions (ceilings less than 1000 feet AGL and/or visibility less than 3 statute miles) occur, or can be accurately predicted to occur, 11.03% per year or 40.25 days of the year[1]. Considering the percentage of the year when conditions less than four hundred feet and one mile (<400-1) occur, the national average is 2.33% or 8.5 days per year. Conditions below CAT 1 precision minima (≈200-«), occur only 1.2% or 4.4 days of the year. Given the projection that GPS with the Wide Area Augmentation System - WAAS will provide CAT 1 instrument minima, a Local Area Augmentation System

(LAAS) may not be required. Only operations all 365 days per year would require the additional capability, and associated expense, provided by a LAAS. Operational capabilities to less than 200-1/2 (Cat I) should be based on user requirements.

Icing Data. Data indicates that the average freezing level for the areas indicated, not including Alaska, is at three thousand (3000) AGL for 109.5 days of the year (30%), and at five thousand (5000) feet AGL for 165 days of the year (45.3%).

The worst icing areas, areas within which any aircraft will require de-icing/anti-icing capability are Far Northwest (Alaska) (81%), the Northeast US, North Central and Northwest, all at or above 50% recorded icing at 5000 feet.

Data indicate the probability of the ceiling being at 3000 and the freeze level being the same as approximately **.0891** or **8.9%.** The probability of the ceiling being at 5000 and the freeze level being the same as approximately **.708** or **70.8%**. Rotorcraft - helicopters/vertical flight-capable aircraft, filing year round at 5000 MSL (AGL), will require icing equipment for all areas with an icing incidence of 40% or greater, e.g. Northeast and Mid-Atlantic, North Central and Northwest US.

National Airspace Utilization

It is evident, that vertical flight-capable aircraft, including tiltrotors, will continue to share all available airspace for IFR operations with the fixed-wing community.

In the case of the tiltrotors, as that of the helicopter, potentially slower approach speeds allow for flexible routing, both for arrivals and departures in shared airspace. The only airspace that helicopters do not normally use currently is that of the Class A (above FL 180) high altitude controlled airspace and Class E upper altitudes (10,000 to FL 180) controlled airspace. Helicopters perform best, and therefore normally fly, below ten thousand (10,000) feet MSL, flight planning six thousand (6,000) MSL and below. This airspace is also used/shared by the fixed-wing community for low altitude enroute or transitioning into and out of terminal facilities. This shared airspace includes all IFR departure and arrival routes, instrument approach procedures airspace and runway landing facilities.

Vertical flight-capable aircraft (rotorcraft-helicopters and powered lift), being able to decelerate and accelerate more rapidly than fixed-wing, are thereby capable of turning in a tighter radius. Through their ability to decelerate in a stabilized manner to much slower airspeeds ($\approx$1/5 V_S of a normal category fixed wing aircraft), vertical flight-capable aircraft are uniquely qualified for lower minima instrument approaches. Speed incompatibility is the primary reason to establish separate and distinct VF airways (for helicopters) and departure/arrival routes. Powered lift aircraft (tiltrotors) can use existing or future enroute structure.

NAS Rotorcraft and/or Tiltrotor Infrastructure Availability and Requirements

Vertical flight IFR operations require the same handling priorities and considerations as fixed-wing aircraft. Vertical flight aircraft, while capable of operating in the existing airspace management infrastructure, possess unique flight characteristics that enable some unique but complementary air traffic handling procedures and TERPS criteria, that further enable safer and more efficient operation of constrained airspace (reduce delay and increase access and capacity) in the National Airspace System.

Rotorcraft Helicopter/vertical flight-capable Applicable Infrastructure	Required	Available
Standard Instrument Departures (SIDs)	Yes	Only From Airport
Surface to Cruise Altitude Surveillance	Yes	No
Surface to Cruise Altitude Communications	Yes	No
Direct Routing Clearance	Yes	Limited
Low Altitude Victor (VOR) Airways Routing	Yes	Yes
Discrete (or Rotorcraft - helicopter/vertical flight-capable-only) RNAV Airways Clearance	Yes	<50%
Standard Terminal Arrival Routes (STARs) (Fixed-wing Performance Procedures Only)	Yes	Only To Airport
Rotorcraft - helicopter/vertical flight-capable-specific Instrument Approach (CPTR)	Yes	Limited
Rotorcraft - helicopter/vertical flight-capable-specific TERPs/AT Procedures	Yes	*No
Rotorcraft - Helicopter/vertical flight-capable applicable ATM Tools (CTAS/ FAST)	Yes	**No

Helicopter/vertical flight-capable IFR Infrastructure Requirements - Available or Not

* Currently have only RW GPS NPA and MLS TERPS
** ATM Software Not Designed for Decelerating Approaches

The rotorcraft and tiltrotor infrastructure requirements and current availability are listed below. Note that most infrastructure (communications, navigation and surveillance facilities) is placed to accommodate airports/air facilities, not remote sites/heliports.

Heliport/Vertiports.

Civil, commercial and to some extent, military vertical flight aircraft operate from remote heliports/

vertiports, though operations from air facilities such as airports are more common. Helicopters (and soon the first commercial small tiltrotor) do and will continue to operate from small, often minimally improved or unimproved sites, some with unprepared surfaces.

Airport.

Airport operations are becoming more congested and prohibitive to helicopters and vertical flight aircraft. Access in an airspace system designed and operated for conventional fixed-wing aircraft is decreasing. Surface movement is inhibited. IFR access to the primary runway surface is decreasing as airport capacity and delay reaches its saturation point.

Special use airspace

Many of the direct routings preferred by helicopters and vertical flight machines lie through controlled or special use airspace such as the Aberdeen, MD or Patuxent River Restricted Areas.

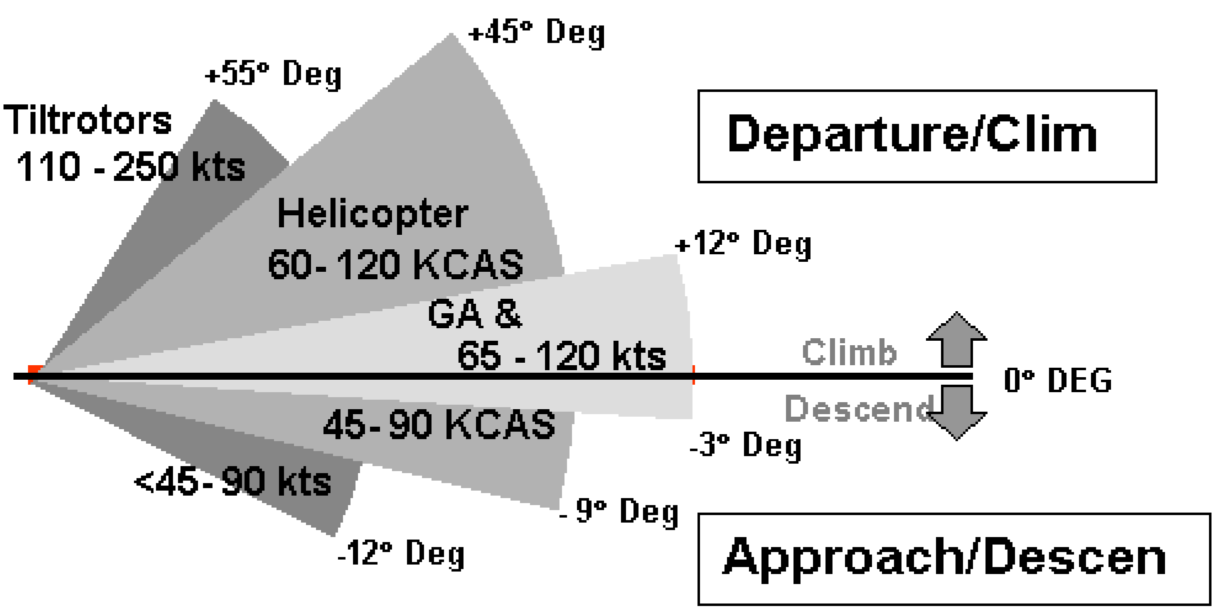
Preponderance for VFR

The majority of operations are under visual meteorological conditions (VMC) and visual flight rules (VFR). However, the current trend is for increased use of IFR operations for the attendant safety margins afforded and the potential increased mission completion rate.

Aircraft operating requirements and limitations

Vertical Flight

In order to fully exercise the unique capabilities of rotorcraft, both helicopters and tiltrotors, precision and non-precision TERPS must be developed around their unique performance characteristics.



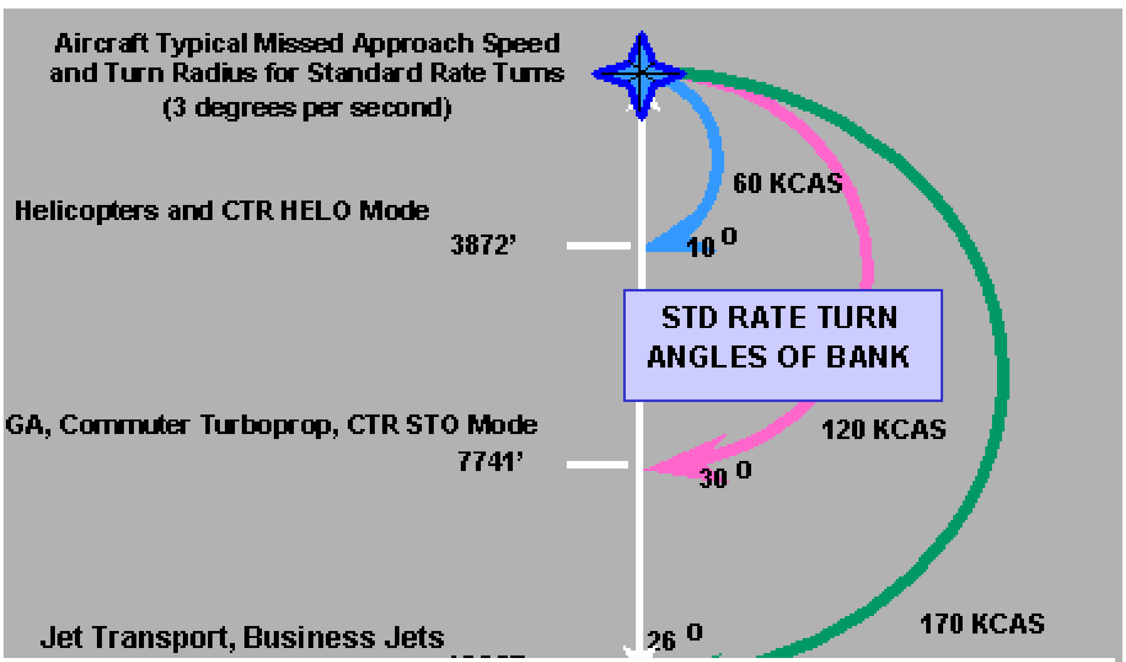
Vertical Flight vs Conventional Fixed Wing IFR Approach/Departure Gradient

The helicopter and tiltrotor flight performance envelopes are quite distinct from that of the conventional aircraft, in that they have a very slow to zero speed capability at the low end of their performance curves. These capabilities must be used in procedural development and regulations to enable air traffic managers to make best use of the aircraft in traffic management. The figure below illustrates a comparison of capabilities.

NOTE: The depicted approach/climb angles and airspeeds are under evaluation and are not prescriptive at this date. Flight evaluation is required to fully define safe approach gradients as a function of airspeeds and rates of descent.

Vertical flight aircraft may offer the opportunity to safely execute approaches at steep angles. Helicopters can approach at angles up to six or even to nine degrees while tiltrotors may be capable of safe approaches up to 15-deg. Steep approach angles offer several advantages over conventional approaches. The distances are compressed for the approach.

Vertical flight aircraft can turn comfortably and with complete control at nominal approach speeds of 60 to 70 knots. Turns at such speeds result in dramatically reduced turning radii. See illustration in following figure.



Vertical Flight vs Conventional Fixed Wing Slow-speed Turning Radii

Additionally, rotorcraft and tiltrotors do not need to operate from conventional runways, but may operate safely from smaller final approach and take-off areas (FATO's) separate from airport runways.

The environmental impact on the community is diminished, as the noise footprint is smaller. In a robust TERPS development activity, aircraft performance would be defined for a range of approach angles and speeds. The aircraft configurations and equipage required to safely execute those approaches would be identified.

It is assumed that a statistical database of procedure execution could be created in piloted flight simulation.

This would significantly reduce the number of flight test hours required. Flight testing of the aircraft would still be conducted in order to verify the simulation results with a much smaller sample. The proposed tasks for tiltrotor TERPS development include definition of the flight characteristics, approach concept development, simulated approaches, a flight program and correlation/validation.

Operating Community

Civil Use Rotorcraft

Mission Types and Applications

The FAA's mission categories include corporate executive, business, personal, instructional, aerial applications, aerial observation, external load, other work, sight-seeing, air taxi and air tours, and other. The piston helicopter fleet is used primarily for flight instruction and personal and business (owner/operator) flying, while the turbine fleet serves the broadest applications as discussed above.

The following are brief descriptions of the FAA civil mission categories:

Scheduled Air Carrier. Transportation of passengers and cargo on a scheduled basis (FAR Part 135).

Non-Scheduled Air Carrier or Air Taxi-Commercial Operations. Transportation of passengers and cargo on a non-scheduled basis (FAR Part 135).

Corporate Executive. Transportation of corporate executives, management and company-associated passengers and cargo. The company employs a paid professional crew.

Business. Owner-pilot or rental-pilot conducting business including transportation, cargo, and passenger transport. Individual use for business transportation without a paid, professional crew (FAR Part 91).

Personal. Owner-pilot or rental-pilot flying for personal reasons (excludes business transportation).

Instructional. Flying under the supervision of a flight instructor (excludes proficiency flight).

Aerial Applications. Application of pesticides, fertilizer, seed, fire retardant, cloud seeding, etc.

Electronic News Gathering (ENG). Use of vertical flight aircraft to transport news reporters/correspondents, use as an on-scene-reporting platform and/or transmission of video/audio signals.

Emergency Medical Services. Transportation of emergency medical/trauma cases or inter-medical facility patient transfer.

Aerial Observation. Aerial mapping/photography, patrol, search and rescue, hunting, highway traffic advisory, ranching, surveillance, oil and mineral exploration, criminal pursuit, fish spotting, etc.

External Load. Fire fighting, logging, construction, wildlife management and/or movement and movement of heavy objects.

Other work. Construction work (not FAR Part 135 operations), parachuting, aerial advertising, towing gliders, etc.

Sightseeing. Commercial sightseeing conducted under FAR Part 91.

Air Tours. Commercial sightseeing conducted under FAR Part 135.

Other. Experimentation, R&D, testing, government demonstration, air show, air racing, proficiency flight, etc.

Public Service/Public Use Rotorcraft

The following describes the public-service missions and agencies that use helicopters in their everyday operations, and their helicopter fleets.

Public-service applications include EMS, law enforcement, public safety, disaster relief, search and rescue, wildlife management, environmental surveys, environmental transport, water management, and energy management. Subsets of each mission further define the role of helicopters in serving the general public.

Law Enforcement. This area includes drug enforcement, security and surveillance, search, patrol, observation, apprehension, pursuit, command post, crowd control, pollution control, and transportation.

Public Safety. The government oversees the safety of the general public through fire rescue and fighting, search and rescue, marine patrol, traffic control, and aviation test and evaluation.

Disaster Relief. Usually, the first respondents to a disaster or mass-casualty incident will be public-service helicopters, especially when local infrastructure (roads, rail and/or air facilities) is damaged/interrupted or irreparable. These helicopters assess the damage, bring in and carry out teams and supplies, and monitor and survey activities on a continuous basis. Tasking includes but is not limited to passenger/cargo transport, food dispersal, damage assessment, etc.

Search and Rescue. When people are lost, severely injured, killed, or in distress in remote areas, public-service helicopters will be launched to search for, locate, provide medical assistance, and/or rescue them in any terrain or over water.

Wildlife Management. Airlifting or herding animals and wildlife from areas where there are natural disasters, overpopulation, or the need to move an animal to a different location are the major uses of helicopters in wildlife management.

Environmental Management. Conducting geological, environmental, wildlife, land use, and water quality and management surveys; monitoring and counting species in various habitats are also part of the public-service responsibility.

Utility Support and Environmental Transportation. Public-service helicopters transport people, supplies, and major components for electrical, telegraphic, pipeline, and construction projects.

Agriculture/Forestry. Forestry observation, seeding, spraying against pests and diseases, logging, and aerial surveys are conducted by the Department of Interior and many state governments.

Military

Missions and Applications

This section summarizes the major missions and applications for each military service. Normal military IFR operations in the National Airspace System (NAS) include flight crew instrument training, interbase transport of personnel and/or logistics (transport and utility), and search and rescue (civilian public use): they do not include tactical operations. The U.S. Coast Guard is normally an integral part of the Department of Transportation; however, during war, it is assumed under the control of the Department of Defense. For that reason, Coast Guard data are listed under Public Service/Public Use above.

U.S. Army. The Army's helicopter fleet contains several types of aircraft that have been designed or modified to be used primarily for combat missions (reconnaissance and attack) or transport missions (combat support and medium lift). In addition, peacetime operations include counter-drug operations.

IFR percentage of total flight-hours for the Army is 10%.

U.S. Air Force. The Air Force has four principle roles: aerospace control, force application, force enhancement, and force support. Air Force rotorcraft have been modified to be used for executive support, missile site support and combat support (Combat Search and Rescue and Special Operations). In addition, peacetime operations include counter-drug operations. The CV-22 Osprey tiltrotor will be added in the near future.

The IFR percentage of total flight-hours for the Air Force is 10%.

Naval Aviation. U.S. Navy and U.S. Marine Corps aircraft, though having separate and distinct missions, are included under the same branch of the Department of Defense (Navy Department), and are combined as ***Naval Aviation***.

The IFR percentage of total flight-hours for Naval Aviation is approximately 14%. Individual service branch mission-applicable data are listed below.

U.S. Navy. The individual segments of the Navy employing helicopter assets include Anti-Submarine Warfare, Anti-Surface Warfare, Anti-Air Warfare, Naval Surface Fire Support, Mine Countermeasures, Theater Ballistic Missile Defense (TBMD), Special Warfare Support, Fleet Logistics Support Vertical Replenishment (VERTREP), and Naval Aviator (Navy and Marine) Flight Training. In addition, peacetime operations include counter-drug operations and assistance to the Coast Guard for search and rescue.

U.S. Marine Corps. The Marine Corps' missions can be divided into Operating Force assets U.S. Marine Forces Atlantic (MARFORLANT) and U.S. Marine Forces Pacific (MARFORPAC) and Executive Support.

Operating Forces. The Marine Corps' vertical flight assets are used for assault support, including attack and reconnaissance, amphibious assault, command and control, utility and logistics resupply, as well as non-tactical administrative support, training and base support or Marine Corps Air Station search and rescue.

The IFR percentage of total FMF aviation flight-hours, both shore- and sea-based, is approximately 14%.

Executive Transport. An additional mission of the Marine Corps is National Command Authority (NCA) Executive Transport, assigned to Marine Helicopter Experimental Squadron One (HMX-1), Presidential Flight Detachment, based at Marine Corps Air Station Quantico, VA. HMX-1 also is tasked with development of new engineering design and operational evaluations (OPEVAL).

The IFR percentage of total flight-hours for Presidential/NCA and/or OPEVAL support is approximately

10%.

Additionally, the US Air Force also operates H-1 aircraft from Andrews AFB, Camp Springs, MD on Special Air Missions (SAM) executive support as may be directed.

Disaster Relief

Both active duty and reserve/national guard assets can and are called on to provide disaster relief support (passenger/cargo carriage, food dispersal, damage assessment, etc.) when supporting either the Federal Emergency Management Administration (FEMA) or local state EMA organizations. This is especially important when local infrastructure (roads, rail and/or air facilities) have been rendered inoperable.

Operational Considerations

Design Requirements and Objectives

Prior to developing any system of operational considerations, a set of prime requirements must be established. These are at the highest level, and from these will fall all further design and implementation requirements.

Design Requirements- Near Term

DR 1 Provide Simultaneous and Non-interfering IFR Operations

DR 2 Provide Positive Communications and Surveillance to the Ground (where needed or required)

Provide Communications/Navigation/Surveillance (C/N/S) coverage to enable low altitude enroute IFR operations and to the surface where required.

DR 3 Provide Increased Availability of Weather Data.

Provide en route and destination real-time and forecast weather data available as required to support vertical flight requirements

- Expand/Improve Weather Data Availability to Support Vertical Flight Operations.
- Insure improved accuracy and reliability of weather information, e.g. improved local area weather models.
- Improve fidelity of weather information, e.g. NWS (or other) availability & provide in correct format, e.g., adding ceiling to NWS data..
- Determine access requirements – e.g., data link (CPDL) or voice transmission.
- Ensure weather information available on-board, e.g. datalink, sensor fusion, data available in real-time.

Realtime weather data is required in support of the NASA Small Aircraft Transportation System (SATS) design efforts. In addition to METAR and forecast data, SATS-capable aircraft anticipate having the capability to access and display weather data, including current/active radar summary data, as well as local current conditions.

- Improve reporting frequency of weather information, e.g. interpolation of area weather, data available in real-time, provide AWOS/ASOS where required based on frequency of operations.
- Develop and Implement predictive weather models.
- Increase area weather availability.

Departure / Destination / Alternate Weather. Weather data, either departure, destination and/or alternate weather is required, and, for the most part, available when filing to major facilities and metropolitan areas. Qualified weather observers, either FAA or non-federal control tower personnel or qualified fixed-base operators/air carrier operations personnel, are present at all major facilities. Automated Weather Observation Systems (AWOS) or Automated Surface Observation Systems (ASOS) are placed to accommodate those air facilities where observers are not present.

Filing to or from a remote area is a problem. Data available from operator surveys indicates a paucity of weather information in areas with few air-capable facilities (e.g., airports, AWOS/ASOS or Flight Service Stations). In particular, alternate weather may not be available, since the alternate facility may be only a small, non-full service, air facility minimally within the IFR endurance range of helicopters or other vertical flight-capable aircraft.

Filing weather requirements and data should be appropriate to the aircraft and capabilities. Aircraft having short legs (minimal fuel tankage capability) should be able to use existing local area data provided by the National Weather Service, NOAA, the FAA's AWOS/ASOS or other yet-to-be-approved but extremely reliable source such as "The Weather Channel" which can and does provide ceiling and visibility, dew point spreads and surface winds for localities with no aviation facility. Where point/ landing site data is not available, localized area weather can be appropriate with a corresponding increase in minima.

<u>DR 4 Any new infrastructure design for the NAS will provide an *Increased Capacity of the NAS* in terms of number of aircraft to be handled and passenger throughput.</u>

Provide vertical flight TERPS and operational procedures that will maximize NASA/FAA metrics for safety, capacity, delay reduction, NAS system flexibility and efficiency.

- Provide equal access for vertical flight aircraft without competing for resources.
- Provide the capability for modeling & simulation of capacity with vertical flight aircraft inclusion and/or replacement.
- Update or develop airspace-modeling tool(s), e.g. TAAM, SIMMOD, ADSIM, RAMS, etc. to incorporate vertical flight-capable aircraft aeroperformance and capabilities.
- Update or develop airport/vertiport/heliport approach modeling tool(s).
- Update or develop airport/vertiport/heliport surface modeling tool(s).

Select separate, <u>on-airport facilities</u> dedicated to vertical flight-capable aircraft

- Develop mixed-fleet concepts of operations (SNI).
- Develop facility designs, determine shared facilities.
- Design vertical flight-capable approaches.
- Design vertical flight-capable on-airport ground-side facilities and access requirements/impacts.
- Identify environmental impacts.

Provide fully capable <u>off-airport facilities</u> for vertical flight-capable aircraft

- Design vertical flight-capable ground-side facilities.
- Design vertical flight-capable approaches.
- Design vertical flight-capable off-airport ground-side facilities and access requirements/impacts.
- Identify environmental impacts.

<u>**DR 5 Any new infrastructure design for the NAS will** provide *Expand Access* to air facilities **above current level in any future NAS.**</u>

Increase Available Vertical Flight Origins & Destinations

Improve methodology for IFR Approach Development/Approval

- Qualify simulation to develop and approve IFR Approach TERPS Criteria.
- Qualify simulation to approve IFR Approaches.

Minimize Incurred Airspace

- Quantify and categorize all vertical flight-capable aircraft performance characteristics.
- Improve vehicle performance characteristics.
- Provide narrow LNAV-based GPS route widths based on required navigation performance (RNP).
- Minimize TERPS obstruction clearance planes.

Enable/Improve IFR Approaches

- Develop/deploy precision GPS approaches.
- Develop/deploy steep approaches, e.g., Flight Displays, FMS interface, noise reduction capabilities.

DR 6 Any new infrastructure design for the NAS will *Minimize Restrictions* t**o all user class IFR and VFR operations in any future NAS**

Minimize Restrictions to Direct Flight operations.

- Design and implement Communications/navigation/Surveillance capabilities to support low altitude vertical flight operations
- Increase development and fielding of Automatic Dependent Surveillance – Broadcast (ADS) equipment and ATM capability.
- Develop and implement pre-determined non-interfering, low altitude direct routes (rotorcraft/vertical flight-capable discrete airways – ROMEO Airways) patterned after the Ransome Airlines and Northeast Corridor Helicopter Routes.
- Provide on-demand, direct flight routing.
- Develop 4D based flight planning/management system including time.

Minimize Restrictions to Terminal operations.

- Design Simultaneous and Non-Interfering FATO Facilities
- Design vertical flight aircraft departure procedures, arrival routes and approaches

Rotorcraft/Vertical Flight Discrete Routes. In the 1980's, the FAA working with the New England region Helicopter Association developed the low altitude (less than six thousand feet) Northeast Corridor Helicopter routes. After design, several VORs were re-sited, necessitating the redesign and re-approval of several waypoints. In addition, during the trial periods, local controllers were not fully trained on the routes. As a result, the route was never implemented.

In 1979, Ransome Airlines, operating STOL aircraft between Philadelphia International, Washington DC national and New York airports, instituted two Rho-Theta-based RNAV routes, capped at six thousand feet MSL, that ended in RNAV approaches to PHL, DCA and JFK.

Data indicate that GPS precision and accuracy would permit reduction of that enroute width to approximately ± ½ nautical mile or less (RNP 0.5), and RNP 0.1 in terminal areas. This would permit development and placement of many more "air corridors" (4:1) in places where there is now only one Victor airway or arrival/departure route.

Both of these route structures should be redesigned using GPS waypoints, reduced RNP criteria, and evaluated for reinstatement.

- Design vertical flight aircraft groundside facilities design guidance to improve capability for VFR- and IFR-useable FATO/TLOF siting.
- Insure vertical flight aeroperformance integrated into CTAS tools.
- Insure vertical flight are integrated into conflict probe tool(s).
- Insure vertical flight are integrated into conflict alert tool(s).
- Insure vertical flight aeroperformance capabilities/algorithms are integrated into TCAS/CDTI.
- Develop and Implement separate vertical flight-capable FATOs.
- Design Vertical Flight instrument flight rule (IFR) operations to avoid, whenever and wherever possible, the primary flow of conventional IFR fixed-wing traffic.
- Determine and develop rotorcraft/vertical flight aircraft downwash –related turbulence aircraft separation criteria.
- Develop and Implement separate vertical flight-only RNP LNAV-based dGPS DPs (old VSIDS), vertical flight-only terminal area procedures (VTAPs – includes VSTAR and dGPS PA/NPA approach).
- Develop and implement powered lift-specific terminal area (low-high-low) transitions.
- Develop and Implement separate vertical flight steep RNP LNAV-based dGPS PA/NPA IFR approaches including approach gradients between three (3) degrees and twelve (12) degrees.
- Develop and Implement a separate vertical flight-capable only low speed PA/NPA IFR approach category including approach speeds between ninety (90) knots and fifty (50) knots.
- Develop and Implement separate vertical flight-specific procedures such as RNP LNAV-based dGPS Simultaneous Converging/Parallel Instrument Approaches (SCIA/SPIA).
- Research, develop and implement rotor/wake turbulence interactions and develop and implement restrictions and procedures.
- Develop and Implement vertical flight-integrated final approach spacing (FAST) tools.
- Develop and Integrate vertical flight capability into Surface Movement Advisor (SMA).
- Design Heliport/Vertiport Lighting requirements and certification to maximize FATO acquisition and identification ***based on operational suitability***.

Heliport/Vertiport Lighting. Lighting for the FATO must include the immediate landing surface as well as FATO recognition/identification such as the current heliport rotating beacon and runway end identification lights. Lighting should be sufficiently bright as to illuminate all required obstacles and surfaces, but no so bright as to present a sight impediment to the approaching crew. Lighting must be controllable, in operation and intensity, by the approaching aircraft crew.

Heliport/Vertiport lighting has the potential to play a significant role in improving operational safety in both visual and instrument approach conditions, and for minimizing crew workload related to navigation and approach execution. Several issues related to heliport lighting need to be addressed in order to determine the heliport lighting requirements that facilitate safe and effective precision instrument approaches when using a Differential Global Positioning System. Currently, the only lighting systems developed and approved by the FAA to support instrument approaches to heliports are the Helicopter Instrument Lighting System (HILS) and the Helicopter Approach Lighting System (HALS). HALS, which is 1,000 ft in length, is a scaled down version of airport approach lighting systems. These lighting systems are not suitable for installation at many heliports due to space limitations. A proposed configuration change, NAS Change Proposal (NCP) 12485, recognizes that "some heliports, due to their location, may not have enough available real estate to provide 1,000 ft of lights." In particular, rooftop and city center heliports are very constrained and 1,000 ft of approach lighting is not feasible. In those cases, it is recommended that a waiver of the 1,000-ft requirement be obtained. The proposed change does not, however, give any guidance on how HALS should be changed, or how much it can be shortened in order to fit at various heliport sites. Clearly, HILS and HALS do not meet many heliport requirements and an alternative system is needed.

Existing systems such as HALS are not appropriate for higher approach angles, e.g., greater than 4 degrees, since either all or the majority of the lighting system will be behind the arriving aircraft when the visual segment is attained (assuming a breakout at minimums). Lighting certification and approval requirements should be based on operational considerations and practical acceptance.

Lighting for vertiports is critical for night operations, for credit toward lower minimums in IMC conditions, and for identifying the vertiport landing surface in an obstacle-rich environment. A simple system such as the DoD-used "box and 1" lighting configuration may be appropriate.

Minimize interference with fixed-wing operations

- Design Simultaneous and Non-Interfering route structures.
- Design and implement Communications/navigation/Surveillance capabilities to support low altitude vertical flight operations.
- Increase development and fielding of Automatic Dependent Surveillance – Broadcast (ADS) equipment and ATM capability.
- Develop and implement pre-determined non-interfering, low altitude direct routes (vertical flight-capable discrete airways – ROMEO Airways) patterned after the Ransome Airlines and Northeast Corridor Helicopter Routes.
- Provide Vertical flight aircraft deconfliction from conventional fixed-wing traffic.

Increase Availability of previously Unused / Not-In-Current-Use Airspace

- Provide dynamic special-use airspace (SUA) access capability relative to one hour prior to requested/ required use. The current USAF Military Airspace Management System (MAMS) is not capable of providing dynamic airspace scheduling.
- Provide redefinition of use/availability of Class B, C, D airspace, e.g., non-circular Class B (formerly TCA).
- Provide arrival/departure-segment-avoiding VFR/IFR route segments through Class B/C airspace directly over terminal areas.

DR 7 Provide a reduction of Pilot and Controller/Air Traffic Manager workload **through Human-Centered Automation.**

Provide improved tools to limit risks to mission/flight planning

- Define requirements and operational concepts for use of Controller-Pilot Data Link Communications (CPDLC) for low altitude vertical flight enroute and terminal operations.
- Develop capability to provide and use electronic PIREPS enabling flight into potential but not actual (nor currently reported) icing conditions.

- Provide certified, low-cost de-icing capability.
- Provide a mission planning system, interactive with ATC.

Interactive Flight Planning. The flight planning process, using a computer-based system similar to DUATS should provide the pilot and controller with the same information in real time. Conflict probe and resolution should also be included. The pilot should be able to access weather date, route data including NOTAMS, and file a preferred route flight plan. The system should use conflict probe and resolution to determine the suitability of the flight plan, sending the pilot notice of acceptance, or rejection indicating alternate routing or timing (earlier departure) or alternate altitude. The pilot can decide which option is best, select that option, and get confirmation of ATC acceptance.

This will reduce the potential conflicts and uncertainties and increase the flexibility of the system, and the controller and pilot workload, eliminating most of the clearance changes after departure.

- Provide an on-board mission planner, interactive with uplinked data.
- Design Air Traffic Control/Air Traffic management rules and procedures to utilize aircraft type and aircraft-specific aeroperformance characteristics to design applicable TERPS criteria.
- Develop a slow speed approach category for aircraft able to execute/perform instrument approaches between 50 and 70 knots.

NOTE: Currently, the MV/CV-22 aircraft fly instrument approaches at 115 KCAS based on the standard 3-4° ILS glide slope. Steeper approach gradients are possible and feasible.

Performance-based TERPS. Terminal Instrument Procedures (TERPS) must be performance-based. In order to maximize the benefits gained in reductions in protected airspace from the increased performance of the vertical flight aircraft, the aeroperformance of each type of vertical flight aircraft be considered in the development of a set of TERPS criteria and air traffic control/air traffic management operational procedures.

DR 8- Any new infrastructure design for the NAS will *Improve Efficiency & Flexibility* of any future NAS

DR 9 Provide increased System Safety **through application of appropriate technology and/or procedural changes**

Reduce the susceptibility to and occurrence of controlled flight into terrain (CFIT) mishaps.

- Provide level 2-3 terrain mapping for database(s).

DR 10 Any new infrastructure design for the NAS will provide *Increase Operational Safety* **with an associated reduced mishap rate, including hull loss rate, below current levels.**

Ensure that proposed changes to the NAS infrastructure shall be evaluated to understand and quantify impacts.

Current FAA Programs that Support Some VF Operational Considerations -

CTAS – Center-TRACON Advisory Tool(s)

FAST – Final Approach Spacing Tool(s) – Upgrades must provide capability to incorporate decelerating approach profiles.

SMA – Surface Movement Advisor – Upgrades must provide coordination of all filed/active flight plans.

URET – User Requested Evaluation Tool(s)

CDTI – Coordinated Display of Traffic Information

CPDL – Controller – Pilot Data Link

Schedule Planning for Vertical Flight Satellite Operations Operational Considerations

3 Year Requirements

DR 1 Provide Positive Communications and Surveillance to the Ground (where needed or required)

Update NAS CIP and architecture to reflect/add CNS support for low altitude vertical flight

5 Year Requirements

DR 2 Provide **Simultaneous and Non-interfering IFR Operations**

Update vertical flight TERPS and operational procedures to maximize NASA/FAA metrics for safety, capacity, delay reduction, NAS system flexibility and efficiency.

Provide Rotorcraft/Vertical Flight Discrete Routes.

DR 3 Provide **Increased Availability of Weather Data.**

Provide en route and destination real-time and forecast weather data available as required to support vertical flight requirements

DR 4 Any new infrastructure design for the NAS will provide an ***Increased Capacity of the NAS*** in terms of number of aircraft to be handled and passenger throughput.

Select separate, on-airport facilities dedicated to vertical flight-capable aircraft.

Provide fully capable off-airport facilities for vertical flight-capable aircraft.

7 Year Requirements

DR 5 Any new infrastructure design for the NAS will provide ***Expanded Access*** to air facilities above current level in any future NAS**.**

Increase Available Vertical Flight Origins & Destinations.

Improve methodology for IFR Approach Development/Approval.

Minimize Incurred Airspace.

Enable/Improve IFR Approaches.

DR 6 Any new infrastructure design for the NAS will ***Minimize Restrictions*** to all user class IFR and VFR operations in any future NAS.

Minimize Restrictions to Direct Flight operations.

Minimize Restrictions to Terminal operations.

Minimize interference with fixed-wing operations.

Increase Availability of previously Unused / Not-In-Current-Use Airspace.

DR 7 Provide a **reduction of Pilot and Controller/Air Traffic Manager workload** through Human-Centered Automation**.**

Provide improved tools to limit risks to mission/flight planning

Provide Interactive Flight Planning

DR 8- Any new infrastructure design for the NAS will *Improve Efficiency & Flexibility* of any future NAS.

DR 9 Provide *Increased System Safety* through application of appropriate technology and/or procedural changes.

Reduce the susceptibility to and occurrence of controlled flight into terrain (CFIT) mishaps.

DR 10 Any new infrastructure design for the NAS will provide *Increased Operational Safety* with an associated reduced mishap rate, including hull loss rate, below current levels.

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IN REPLY REFER TO
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APC
07 NOV 2000

Mr. Robert R. Wilkins, Jr.

Chairman
FAA REDAC Vertical Flight Subcommittee
TARTNAS Operational Considerations Working Group
Boeing Company
P.O. Box 16858 MS P24-63
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Dear Mr. Wilkins,

Thank you for including the Marine Corps in the study commission addressing "Tiltrotor and Advanced Rotorcraft Technology in the National Airspace System." Marine aviation has been at the forefront of tiltrotor technology and appreciates the opportunity to be involved with the development of the Vertical Flight Operational Considerations document.

The Marine Corps wants to assist in the advancement of tiltrotor technology into the twenty-first century for both military and civil aviation. It is advantageous to the entire aviation community to use the innovative advanced technology of the tiltrotor to operate more efficiently in the National Airspace System.

The subcommittee's dedication and support of aviation is to be applauded. Thank you for seeking Marine aviation participation in this effort.

Sincerely,

Fred MCorkle

F. MCCORKLE
Lieutenant General, U.S. Marine Corps
Deputy Commandant for Aviation

Thank you for inviting the Air Force participate in and comment on the development of the Vertical Flight Operational Considerations document. As advanced helicopters and tiltrotor aircraft mature and enter our nation's aircraft inventory, they will unquestionably reshape the way we view and operate within our National Airspace System (NAS).

We share your view that it is important that our NAS keeps pace with new aircraft capabilities and smoothly integrate them into the system. We commend your committee's efforts and would like to thank-you in advance for incorporating our comments into the attached document.

Sincerely,

ROBERT D. BISHOP JR., Brig Gen, USAF
Deputy Director of Operations and Training
DCS, Air and Space Operations

HEADQUARTERS
UNITED STATES AIR FORCE
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14 SEP 2000

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Dear Mr. Wilkins

Section 3
Air Traffic Control / Air Traffic Management

Air Traffic Control (ATC) Program Issues

Forward:

The purpose of this section is to identify the RDT&E initiatives necessary to support Vertical Flight under a new paradigm. The level of support must be at a level where vertical flight aircraft can access the National Airspace System (NAS) as safely and conveniently as fixed wing aircraft. The current limitations imposed by current procedures on vertical flight aircraft operating both VFR and IFR must be removed by the initiation of new procedures supported by updated ATC system technology. By virtue of new innovation this new access should be at or better than current safety standards.

It should be noted that some of the current problems of congestion in the air and on the ground could be favorably affected by an efficient and convenient vertical flight network that off loads demand for runway access at major metro air centers. Trips of 300 nautical miles or less serviced by vertical flight aircraft can accomplish the desirable effect of removing some of the fixed flights that are now accessing the finite runway capacity.

Background:

The current NAS configuration provides support to vertical flight operations based upon a paradigm developed for maximum safety and optimization of fixed wing air traffic flow. The legacy of this approach has produced a NAS that while it remains safe; it is experiencing stress due to the shear numbers of fixed wing commercial operations. The sub-optimization of vertical flight operations continues to be an attribute of the overall system. There is a perception within the public and private sector that vertical flight is an insignificant player in the very large NAS arena dominated by the wide-body air transports. However the trend is going in the opposite direction. For instance, the situation at San Francisco where the air port is trying to persuade United Air Lines to change the equipment they are using to depopulate the airspace by using larger aircraft is an example of the thinking to remove aircraft from the airspace to deal with the problem. There are several initiatives to develop a more efficient and accessible NAS for smaller General Aviation aircraft. The NAS Architecture in relation to the Small Aircraft Transportation System (SATS) program is seeking developments that increase the accessibility of aircraft to the NAS. All the while, the Air Traffic Management goals remain the same and are briefly outlined as follows:

- Greater operating efficiencies through more direct routing and user route selection
- Change in airspace design & structure to capitalize on emerging SATS capabilities
- Optimize advanced technology decision support tools
- Minimized delays and congestion
- Accommodate mixed equipage aircraft
- In-flight-planning capability

ATC Union Influence

It is recognized that the NAS of the future will still have the same necessary presence of the air traffic controllers. Air traffic controllers prioritize the task of dealing with vertical flight aircraft as less important than handling the wide body fixed wing traffic. It seems this practice stems from a long held perspective that safety is better served by handling the fixed wing traffic on a priority basis. This build up of experience has lead to a syndrome in the ATC community that vertical flight aircraft cannot operate to the levels where they can be integrated into the flows of air transports into and out of major air centers. However with the advent of satellite navigation systems such as the U.S.'s Global Positioning System (GPS), the Russian GLONASS and the proposes European GPS/LORAN C hybrid, and the emergence of new technology vertical flight aircraft, there is a burgeoning perception that providing separation for mixed traffic of vertical flight and conventional fixed-wing air carriers severely restricts the efficient use of airspace. The speed performance of helicopters in the past gave credence to the perspective that helicopters should be considered marginalized during the rapid growth era of air-traffic in the NAS. A culture developed in the air traffic controller community that helicopters could and should not be mixed with fixed wing air traffic flows.

It is essential that the Air Traffic Control Union support any change of paradigm in the handling of air traffic. They should be involved in discussion early on as to how to best develop a system that can efficiently handle the mix of helicopter and fixed wing traffic. Under some existing scenarios, ad-hoc procedures are able to create temporary operating environments that work well. The prospects of making these types of systems work on a permanent basis is difficult to envision due to the potential workload increase at the ATC consoles and inconsistent application of some procedures e. g. SNI approaches. Innovation and a change in the perspective of what the NAS is as a public transportation asset will take time. Now is the time to take the first steps toward causing a change as far as the critical step of bringing the Air Traffic Control personnel into the integrated team that will work together in developing and managing the new NAS.

Standards and Procedures

As new technology is prepared for air and ground systems, preparation of certification standards for equipment that will go into the aircraft and into console equipment must be made ready. The new standards and procedures must be conceived with the same devotion to safety, as has been the hallmark of the achievements in making the NAS into the marvelous system that it is today. As will be discussed in the following observations, the development period is where the considerations of standards and procedures must come forth to insure that the resulting system is not sub-optimized for handling vertical flight aircraft as an integral part of the overall system. If the motivation is to consider vertical flight requirements after the core R&D is done, the NAS will be unable to support a mode of transportation that holds great potential to assist in resolving some of the congestion problems.

Terminal Areas/Enroute Phase

A major R&D task for enabling the ATC system to handle vertical flight along with other traffic is the development/integration of new terminal area and enroute procedures. More will be described about a new perspective for total trajectory management perspective. This is complicated by the fact that a helicopter or vertical flight aircraft must be able to access heliports that are not always associated with large airport facilities. Single aircraft requiring separation guidance as it executes an approach to a heliport remote to a major airport represents a major service availability issue to be resolved. The Enroute phase for vertical flight aircraft is also problematic in that the surveillance airspace is low altitude—in some instances down to ground level. The development of approaches for Emergency Medical Service (EMS) helicopters has broken ground in the ATC procedures development indicating progress is being made. There can be new developments that enable the ATC monitoring of low altitude targets (vertical flight aircraft) in the en route phase of flight utilizing Communication, Navigation, and Surveillance (CNS) technology. The programs being conducted are now in the evaluation stage. They are being studied in an operational environment. Before decisions are made on the respective sites, criteria should be added to the data collection requirements to include vertical flight as a portion of the flight operations activity at one or more of the evaluation sites.

The final phase of the new NAS for vertical flight is the integration of the terminal area procedures and the enroute procedures. There are numerous programs being worked on to develop a tool for sequencing traffic into the Terminal Radar Approach Control (TRACON). Vertical flight aircraft are not currently being studied in the proper context of a new operational paradigm that provides access to heliports for both precision and non-precision approaches—on and off airports.

Overview of ATC R&D Initiatives in Need of Vertical Flight Integration

The following is a brief overview of the relevant ATC R&D programs where vertical flight requirements should be integrated into the program R&D phase.

En route Descent Advisor (EDA)

NASA's Advanced Air Transportation Technology (A^2T^2) project is pursuing the development/validation of Air Traffic Management (ATM) Decision Support Tool (DST) technologies and procedures in support of NASA's Distributed Air Ground Traffic Management (DAG-TM) Concept. The A^2T^2 project has selected four DAG-TM Concept Elements for concept exploration. Two of those concept elements (CE-5: En route Free Maneuvering; and CE-6 En route Trajectory Negotiation) focus on enabling user-preferred trajectories and maximizing user flexibility in flow constrained en route airspace. The most challenging form of flow-constrained airspace is the transition to/from high-density terminal airspace. This is of vital interest to the vertical flight community for future access to the central business district of major metropolitan centers that have one or more major airports in their vicinity.

The approach for both CE-5 and 6 is to develop and evaluate decision support technology, and supporting procedures, for both the flight deck and air traffic service provider (ATSP). A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a "trajectory orientation" rather than the current-day procedures which are "sector oriented". A trajectory orientation leverages strategic planning to minimize downstream deviations. Such procedures will require advanced decision support capabilities. The ATSP automation will be developed from the Center TRACON Automation System (CTAS) baseline.

The en-route element of CTAS is the En-route / Descent Advisor (EDA). EDA assists the controller in planning fuel-efficient, conflict-free trajectories with the goal of reducing deviations from the user's, preferred trajectory. Accurate 4D-trajectory prediction is the foundation of EDA algorithms, which generate advisories for conflict detection/resolution and conformance with traffic-management restrictions such as crossing attitude/speed, and flow-rate (i.e., metering or miles-in-trail (MIT) spacing). Efficient conformance with flow-rate restrictions is important because these restrictions are a major cause of user deviations that are often required to reduce dynamic overloads of airspace/airport capacity. Flow-conformance planning also provides conflict detection/resolution (CD/R) functions with accurate models of intent, thus reducing the false-alarm and missed-alert rates associated with flow-constrained operations. A fundamental contribution of the EDA concept is the integration of flow-rate conformance and CD/R to deliver total system performance that is greater than the sum of the contributions from each part.

EDA will service en-route airspace including aircraft in the climb, cruise, and descent phases of flight. It is imperative that the capability of EDA encompass the dynamic trajectory characteristics of vertical flight aircraft of all types. By providing decision support to enable controllers to operate with a trajectory orientation, EDA establishes a foundation for the following:

- Reduction in route and crossing restrictions.
- More favorable distribution and reduction in sector workload
- Reduction in ATC "interruptions" due to corrective clearances
- Efficient "Path-independent" flow-rate conformance when necessary
- User preferred trajectories and flexibility through:
  - Distributed decision making (e.g., trajectory negotiation);
  - Distributed responsibility (e.g., separation and flow-conformance assurance) maybe explored.

EDA Research and Development

Initial EDA research (I 98 8-1995) focused on the development and evaluation of a tool for the "R-side" (radar) controller using an integrated R-side graphical user interface (GUI). The GUI combined radar track, airspace, and flight plan information with EDA advisories for conflict detection/resolution and metering/spacing. Controller simulation evaluations (1988-1992) were complemented by extensive field testing of EDA trajectory-prediction accuracy using NASA and commercial aircraft (1992-1995). The controller evaluations focused on concept exploration including the integration of EDA with flight management systems (FMS) via data link to enable the users and controllers to negotiate conflict-free user-preferred trajectories. Development of the full-up EDA concept (i.e., integrated R-side tool) was then put on hold due to the downfall of the Advanced Automation System (AAS) program (which limited the interface options in the field) and limitations in field testing (the FAA Host patch did not support real-time track data for all flights).

Since 1996, when "all-flight" track data has become available, EDA research has focused on several spin-off capabilities that may be possible to implement in the near term with minimal changes to FAA systems or controller procedures. The Conflict Probe and Trial Planner (CPTP), a "D-side" tool was tested in the field on an auxiliary display/interface in 1997/98. The newest en-route application is a "Direct-To" advisory that leverages conflict-probe technology to actively advise controllers if a "user-preferred" direct-to clearance (i.e., one that would shorten doglegs in the current clearance) is conflict free.

While the near-term en-route capabilities will provide early benefits from en-route DST technology, the A2T2 project has the goal of developing longer-term technologies that will support user flexibility and distributed air-ground traffic management. The long term challenge is the management of the transition to/ from high-density terminal areas. Economically, it does not make sense for the user/ATM community to heavily invest for en route savings only to loose the benefit upon transition to a congested airport. Also it may not make sense to develop traffic management systems that are not evaluated in handling vertical flight trajectories. The likelihood of helicopter and tiltrotor flight activity in the high density terminal airspace must be addressed during the development phase of the ATC technology.

A focused effort to develop and evaluate EDA, in support of DAG CE-5/6, has begun. EDA development is planned along a transition of 5 builds within the CTAS baseline. Build I and 2 will introduce basic flow-conformance and CD/R integration capability to support near-term part-task assessments without automation for inter-sector coordination. To date there are no indications that the new builds will be evaluated against vertical flight trajectories that are representative of procedures such as SNI approaches and curved trajectory on airport IFR approaches. Build- I will focus on en route spacing and Build-2 will focus on arrival metering (a la CAST). Build-3 represents a methodical top-down design of EDA resulting in an experimental system to support high-fidelity controller-in-the-loop simulations of high-density arrival metering airspace. Build-3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities. Build-4 will enhance EDA's automated advisory capability and interface, and emphasize specific development of integrated CNS capabilities and advisory functions to support the distributed air-ground aspects of CE-5/6. Build-5 will incorporate enhancements, representing the final culmination of lessons learned from CE- 5/6 assessments, for final technical transfer and demonstration to industry at the end of the A2T2 project. It is important that in the culmination of these investigations those tiltrotor/tiltwing and helicopter trajectories have been fully evaluated and portrayed in the simulations and industry demonstrations.

Refined Benefits Assessment of Expedite Departure Path (EDP)AA TT Decision Support Tool

Background

The Advanced Air Transportation Technologies (A2T2) Project is part of NASA's Aviation System Capacity (ASC) Program. A2T2's objective is to improve the overall performance of the National Airspace System (NAS) as a whole. In order to meet this objective, A2T2 is developing decision support technologies and procedures to aid NAS stakeholders in the near- term, mid-term, and far-term. The near- and mid-term Decision Support Tools (DSTS) are grouped under the category of Arrival / Surface / Departure tools which are focused on the terminal airspace surrounding airports, as well as surface movement. A/S/D tools are initially created as standalone DSTs which will be integrated to perform seamlessly with other software aids as their designs mature.

EDP is currently at Technical Readiness Level (TRL) 2, with an initial benefits assessment performed in Fiscal Year 1999, the purpose of which is to define the requirements for a refined benefits assessment of EDP across the NAS, for current and future air traffic demand scenarios. Results of the FY99 benefits assessment were based upon one day's air traffic demand at two sites in the NAS, which were then extrapolated for annualized benefits in 1997. Successful completion of this task will use a larger set of data, including weather data to increase the fidelity of the FY99 study. The description of DST functionality and resulting benefit mechanisms will be verified, and possibly expanded, in conjunction with the Technical Monitor (TM) and the NASA Level IV manager for EDP.

EDP Description

The high level concept for EDP is to produce advisories and generated displays to controllers in the Terminal Radar Approach Control (TRACON) and Air Route Traffic Control Center (ARTCC). These advisories assist the controllers in dealing with certain departure-related situations. Specifically, EDP is designed to address the complexities of unrestricted climbs into the en route system, and the merging of multiple aircraft over a common fix or through a departure gate. EDP also generates timelines showing sequencing and scheduling information for departure fixes/gates. These timelines will be available in the Traffic Management Units (TW's) in the TRACON and ARTCC. The operational uses of these timelines are still being researched by members of the A2T2 Terminal and Surface Sub element.

EDP is most likely to produce the greatest benefits in regions where today pilots are requesting low altitude departures (or 'tunneling') trading higher fuel burn for schedule integrity. Another area in the NAS where benefits for EDP show potential is airspace where TRACON's must coordinate departures of short flights from -smaller satellite airports (usually General Aviation aircraft) while simultaneously delivering service to regularly scheduled airlines at major airports. The Los Angeles area serviced by the Southern California TRACON is an example of such an airspace.

Benefits Assessment Requirements and Dependencies

Results from this EDP benefits assessment task will serve at least two functions: to better understand the effect of EDP on the efficiency of the NAS (and possibly assist in the design of this DST) and feed calculations for the annual A^2T^2 technical metrics for EDP. Information resulting from this task will also feed the A^2T^2 Milestone 6.5 (Integrated Life-cycle Cost / Benefit Assessment of A/S/D). In order to create benefits assessments which are comparable through the life of the A^2T^2 Project and the development of DSTS, certain criteria have been established for studies funded by the Benefits and Safety Assessments Sub element. A table must be created consisting of the DST functions, benefit mechanisms associated with each function, proposed metrics (including units) by which to quantify each function's benefit and finally whether the resultant quantification will be based upon field data, subject matter expertise, computer modeling or some combination thereof. Economic conversions for airline fuel and crew costs shall be based upon documentation from the FAA's APO office (information available via the Internet). The vertical flight community must be represented by information that indicates how impacts are assessed for integration of vertical flight aircraft into the automated ATC equipment suit. If evaluation of vertical flight is left to later case-by-case consideration, a accurate representation of the benefit of ATC automation will be missed

Benefits can be calculated for air traffic demand in 1999 and 2015 using the FAA's Terminal Area Forecast data. Several intensive airports and associated airspace can be selected for modeling. This task will consider the deployment of EDP across the NAS (U.S. continental airspace), as represented by 42 airports selected for use in previous A^2T^2 benefit assessments, and their associated airspace, as appropriate (not all locations in the NAS may benefit from the functionality of a departure tool such as EDP).

A^2T^2 technical metrics are comprised of the following categories: capacity, predictability, flexibility, access, safety and environment. See A^2T^2 Metrics Description document for definitions of each metrics category. An economic metric is also calculated for each DST on an annualized basis. Economic benefits are either cost avoidance by an airline (i.e., fuel savings) or increased potential revenue (i.e., increased number of flights). In order to create benefits which are comparable to assessments from previous years, economic results shall be stated in terms of 1997 dollars, for both the current and 2015 benefits. There may be other categories of benefits derived from the implementation of EDP across the NAS, such as reduced Air Traffic Controller (ATC) workload. Any such additional categories and quantifications of benefits in addition to those listed above shall also be included in the results of this task.

RECOMMENDATIONS:

1. Develop a set of flight trajectory data as representative preferred operating profiles for vertical flight operating in terminal airspace. This data should be integrated into A^2T^2 simulations and demonstrations for all ATC tools being developed for Center TRACON automation.

2. Develop multi faceted criteria for benefit assessment related specifically to vertical flight operation.

3. Develop off-air port IFR approach procedures for vertical flight operation inside major airport terminal areas.

4. Coordinate with DOD for obtaining flight trajectory information for tiltrotor aircraft performing arrival and departure procedures.

Section 4

Public Acceptance / Public Perception

Public Acceptance – The "Marketing" of Vertical Flight

In order to fully realize the utility and benefits afforded by vertical flight applications, both the private and public sectors must be appraised of the benefits. These benefits include the minimal environmental effects required to realize those benefits, the small potential for errors associated with those benefits, and the excellent (and improving) safety record of vertical flight operations.

Travel delays, and associated costs, have become an ever increasing problem across the U.S. and throughout the world. More and more pressure is being applied through the press and the passenger associations to have Congress do something - ***NOW***. Up until the last ten years, weather has historically been the cause of most flight delays. But now, due to the increase in passenger demand, airspace congestion, overcrowded terminal space, and lack of sufficient numbers or runways or runway occupancy time, are the main problems. These are problems that are not easily fixed without the infusion of money and political will. Vertical flight aircraft can, according to a number of studies funded by both the government and industry, provide congestion and delay relief by off-loading some of the short-haul travel passengers that use smaller aircraft ($\leq$50 seats) into the larger hub airports. These studies are discussed in greater detail later.

The traveling and non-traveling public alike understand and accept the utility of vertical flight when they see the emergency medical services (EMS) helicopters airlifting a time-critical injury to a shock/trauma center, thus saving an otherwise fatality. They see and understand the operations of law enforcement agencies and the Coast Guard. What they do not understand or accept is the need for vertical flight operations to be based “in my backyard” or the need to accept certain levels of environmental impact to realize those benefits. That is the imperative mission requirement of both the FAA and the vertical flight industry – manufacturers, service providers/operators and those that benefit alike.

It has been difficult for both aviation agencies and local community leaders around the world to make people feel comfortable with heliports. Issues of noise and safety contribute to this public acceptance challenge. Most heliports have had the aura of something temporary and transient. Now, when the public hears that a vertiport is really a mini-airport it sounds like a permanent facility and it evokes visions of overwhelming noise and pollution, not to mention ground congestion and larger numbers of aircraft. In reality, if a region develops a system of heliports and vertiports properly, it would be just the opposite. A vertical flight system is just like a series of train stations or subway stops but is spread out over greater distances. It is high frequency, relatively low numbers of people traveling in a much more efficient way from point to point, avoiding ground traffic and contributing to the reduction of airport congestion.

Low noise impact through current and planned improvements to existing and new helicopter and tiltrotor designs such as HUMS and noise-reducing rotor system designs must be emphasized. Helicopter and tiltrotor noise must be compared with existing ambient noise levels to demonstrate that vertical flight operations result in lower noise pollution. The improved safety record of vertical operations, especially those of Corporate Part 91 and Part 135 must be emphasized. Like the impact of private automobiles and the commercial trucking industry, and the commercial air transportation industry, the vertical flight applications can be shown to provide a much used and needed benefit.

This vertical flight system education and marketing effort must explain the costs (environmental and dollars), the benefits (lives saved, laws enforced, business returns on investment), and the rationale and methodology (the infrastructure) required to build the system.

The Development of Vertical Flight Infrastructure

When we talk about the need for vertical flight infrastructure development we are really talking about two different areas: airside and groundside. The airside of the issue, although very technical, it is usually straightforward and non-emotional. The groundside becomes much more complex. As we work with the Federal and local government, and the general public as well, the issues can and have become very emotional.

Heliports versus Vertiports

On the groundside there is some terminology, e.g., heliports and vertiports, to explain before discussing it from a marketing and public acceptance point-of-view. Heliports and vertiports differ primarily in their physical size and capability. Heliports have existed for a long time. However, vertiports are relatively new and seem to elicit different reactions. The official definition of a vertiport put forth in the FAA’s Vertiport Design Advisory Circular (150/5390-3, dated 5/31/91) is “an identifiable ground or elevated area, including any building or facilities thereon, used for the takeoff and landing of tiltrotor aircraft and rotorcraft.” In reality, a vertiport, by industry standards, is a “full-service heliport” that is capable of all-weather passenger service. Many existing heliports are nothing more than level, open spaces with a windsock and an address. A modern vertiport is a mini-airport for vertical flight aircraft that provides lighted landing areas, taxiways, parking areas, terminal, weather information (automated or via radio), and perhaps even baggage handling and rental car facilities on a reduced scale. Rather than the traditional heliport landing pad, it may utilize a rollway (short runway much like an airport but shorter in overall length) to accommodate rolling takeoffs and landings. The rollway, based on early flight simulations of commercial tiltrotors could be 600-1000 feet in length. The vertiport offers all the basic services air travelers expect without the need to occupy excessive real estate. A vertiport will still handle all aircraft that take off and land vertically, helicopters and tiltrotors, and that is where our perception problems begin.

Current Vertical Flight Service Doesn't Benefit Enough People

Introducing new rotorcraft into the transportation system will benefit many groups but none more than the traveling public, something that the general public doesn't understand. Helicopters, and by association tiltrotors, still evoke images of high-priced executives traveling first-class. Additionally, other air travelers, facing increasing congestion and delay at large hub airports, don't seem to realize what impact vertical flight facilities could have on their travel needs. Vertical flight aircraft and a convenient vertical flight system will make a dramatic difference. The public must be made aware of the benefits of vertical flight and become enlisted to put a system in place. The public must also be enlightened to the benefits that such a vertical flight system would bring, not only to those who would use it for regional to/from hub airport transportation (feeder airlines), but also to those who would benefit from faster mail/package delivery. Origination and destination (O&D) travel would also be greatly enhanced through congestion relief that tiltrotors can afford.

Time is money… The economics of helicopter and tiltrotor travel are misunderstood. When looking at the cost of travel, the ticket ***price*** is the first consideration. If traveling by private auto, the only visible costs for a given trip are the cost of fuel, meals, and overnight accommodations. If one is taking the train, the only expenses considered are the rail ticket price plus the cost of meals. For air travel usually only the airline ticket price is included in the cost of the trip. However, there are always other less obvious costs that should be included in the expense of any trip in order to accurately evaluate trip value. For example, air travel must include total trip expense or the cost (in time and monetary expense) of getting to and from the airport, the travel time expended at the facility, enroute to the airport serving the destination, and from the airport to the destination. The total trip should be assigned a total cost before the mode of travel is selected. An economic value can also be associated with the travel time. A qualitative assessment cannot be made as to the overall effectiveness of one mode over another without assigning a total cost to the trip.

Although a tiltrotor ticket will probably be more expensive than an airplane, it can still be more affordable from an overall trip cost standpoint. Studies performed over the past fifteen years by Bell Helicopter, Boeing, NASA and the FAA address the economics of a tiltrotor system. NASA and the FAA published a comprehensive analysis of a commercial tiltrotors in scheduled passenger service in a 1991 study entitled "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market". The study concluded that "A commercial tiltrotor system is not only technically feasible but economically competitive" with existing air transportation modes of travel. The report, which was delivered to the U.S. Congress via a congressional staff briefing, also concluded that "Commercial tiltrotors can extend the useful life of existing airports and preserve service from small airports to congested hub airports." In other words, this NASA/FAA study documented the benefits that communities could realize with the establishment of a commercial vertical flight system. One of the major recommendations coming from the study suggested that a "public/private partnership be formed to pursue a national commercial tiltrotor plan" which included the development of an infrastructure that would accommodate all vertical flight aircraft in an all-weather capable system. Participants in this study recognized nearly a decade ago what long-term benefits could accrue to the public at large with the implementation of an expanded national transportation system that includes helicopters and tiltrotors.

Can Public Perception and Acceptance be Improved with new Helicopter and Tiltrotor Technology?

Public perception of vertical flight aircraft is a key factor in vertical flight system success. Noise, ***perceived noise***, has become a critical factor in the location and operation of heliports and vertiports. Helicopter noise stands out in a community because it is different. It is a complex noise that seems to disturb people more than car traffic noise or construction sounds probably because they are not used to hearing it. New helicopters are getting quieter.

The aviation industry is finding new and innovative ways to reduce engine noise, make quieter main and tail rotor systems (NOTAR) and generally reduce the overall noise signature of rotary wing aircraft. Although a tiltrotor sounds like a helicopter when it takes off and lands vertically, once it moves its rotors into forward fixed-wing flight the noise signature drops to very low levels compared to any other aircraft in the sky today. NASA has also done exhaustive noise studies over the last eight years on advanced rotorcraft and industry has worked closely with them. Noise data has been collected on a variety of helicopters and tiltrotors. NASA is developing a computer simulation that will be able to predict noise footprints on the ground surrounding a heliport or vertiport site. Planners, local communities, and environmentalists, must do the impact and cost/benefit studies on the surrounding communities to design both the facility and operational requirements before a facility is actually constructed and approved for operation.

We also know that developing specific routes around and through populated areas can positively impact the public noise perception. By containing the noise in discrete corridors, over already noisy highways and rail lines, the impact to the community can be significantly reduced. Operators have also learned that flying at higher altitudes, especially with heavier aircraft, is an effective way to reduce noise signatures and improve public perception/acceptance.

Industry has worked vigorously to come up with mathematical methodologies to measure and classify noise from helicopters. Now we have very sophisticated measures related to time of day, number of occurrences, peak level impact, and other metrics. However, the point with the public on the issue of virtual noise must be addressed and solved. This is a very subjective measure of annoyance that is related to all the other issues that have just been discussed. It must also be realized that no matter how complex the equations become to show people the noise levels of these aircraft, it is a proven fact that the annoyance level of any noise increases dramatically once you exceed 4-5 occurrences per day, whether it is near a residence or a business office. People do not want to continually hear noises that they find offensive and intrusive, no matter how quiet the helicopter noise averages turn out to be. Even if the noise signature of vertical flight aircraft is lowered significantly through the use of technology and flying techniques, that fact alone will have little impact on the fear of the aircraft crashing. The issue of virtual noise is the new frontier to conquer for the vertical flight industry if it is to succeed in the arena of public perception.

The following noise chart (Fig. 1) puts helicopter and tiltrotor noise in perspective with other common daily noises. It clearly shows that vertical flight aircraft are quieter than other forms of transportation and public services. The difference is in the perception of the aircraft and the unique sound it makes. The entire vertical flight industry must contribute financially to efforts that not only minimize noise signatures but also educate communities on the social value and cost of having vertical flight aircraft available to their community for quality of life improvements and in times of natural disaster.

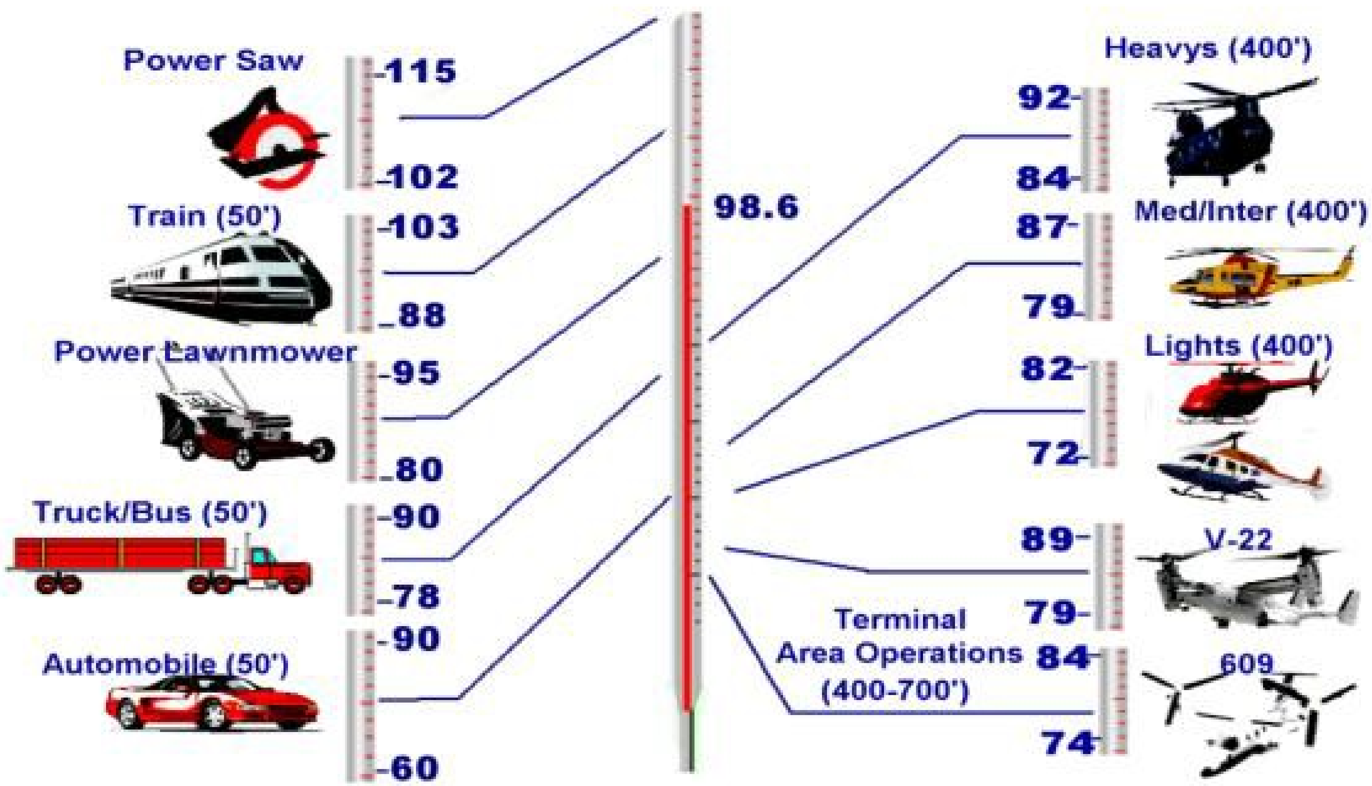

Figure 1. Common Noise Sources

The industry must be aware of the impact that military aircraft have on noise and the public's perception of helicopters and tiltrotors. There are many military helicopters flying today in and around communities. They make a lot of noise and are not as sensitive to public perceptions as communities would like them to be. With the coming of V-22 Ospreys, this problem may become worse. Now they will be dealing with a new, different sound coming from something that still looks a lot like a helicopter and at times sounds a lot like a helicopter, even though the noise should be less intrusive. The military establishment must be part of the solution.

SAFETY is an Issue but Noise is the focus of attention ……

But the issue is not just noise. Since the New York Airways' helicopter mishaps at Newark International and atop the PanAm Building in New York, there is definitive data to show that another real issue is perceived SAFETY, or the protection of the "third party", the person on the ground. JARs and ICAO mandate the safety of the third party. The noise signature seems to trigger the safety fear that a helicopter will crash if its engine quits. The sounds emitted from the helicopter vary significantly during various maneuvers and at different speeds and this also contributes to the concerns that the helicopter may be having mechanical problems, reinforcing the fears to the non-aviation person on the ground. There is also an underlying concern about invasion of privacy since vertical flight aircraft can and do fly much closer to the ground than fixed-wing aircraft. The combination of all these concerns, most of which are perceived and not real, has come to be called "virtual noise". It is this virtual noise that tends to work against the public acceptance of the helicopters and tiltrotors.

Since tiltrotors can take off and land like a helicopter, they will also have to prove themselves more neighborly if they are to be successful. One advantage that tiltrotor has is that it looks like an airplane with large propellers. It has wings and a long, thin body with a tail similar to fixed wing aircraft. The public should perceive them as airplanes rather than as helicopters. Even thought they look somewhat different than an airplane, they operate just like an airplane throughout most of their trip. Tiltrotors will be marketed and advertised as aircraft with very unique operating capabilities, with conventional airplane-like systems and the associated conventional airplane safety. Larger tiltrotors in the 40+ passenger size can easily become the commuter aircraft of choice by the traveling public. The perception of the people on the ground watching them fly as well as the passengers should be positive because of the obvious differences from helicopters. Major efforts are going to have to be made to show people what a tiltrotor is and how it can improve their lifestyle without being a nuisance to the environment or the community.

A Vertical Flight System Will Provide Community Benefits

There are community benefits that accrue from vertical flight aircraft in the area of new airport construction and airport expansion. Where commuter helicopters and tiltrotors are available, additional runway construction, where possible, can be delayed if not deleted from future plans. FAA data used in a recent NASA study of the National Airspace System, "Advanced Air Transportation Technologies (AATT)" showed that approximately 40 percent of the takeoffs and landings at New York cities three major airports carry only 20 percent of the total passengers, and they travel an average of less than 300 miles.

Helicopters can provide the short-range commuter service (less than 100 nautical miles) and tiltrotors can displace many of the small airplane commuter/regional flights that travel short distances today (less than 300 nautical miles or 90 minutes). These aircraft do not require runways thereby freeing up those runway slots for larger aircraft. The cost of airport expansion in most countries of the world is borne primarily by local funding and/or by the government. The remainder is funded by local airport authorities and by the traveling public through higher user fees and airport service costs. If only a fraction of this money were used to develop a vertical flight system, it would not only cost less in terms of total travel expense (as discussed earlier), but it would alleviate many of today's problems (increased delay ($) and reduced capacity) caused by airports needing more land and causing more noise over existing communities near the airports.

Both the ground and air congestion around airports can be spread out more equitably over a much larger area, and would give passengers more options for departure and arrival locations, thereby reducing the pressure on the road infrastructure leading to the hub airport. This in turn can delay or negate the need to continually upgrade and expand the roadway (automobile surface transportation infrastructure) capacity around airports, further saving valuable taxpayer assets.

Other public benefits of an improved vertical flight system include improvements in both emergency medical services (EMS) transportation as well as law enforcement (LE) activities. There are now more than 300 EMS operations in the USA, two-thirds of them based at hospitals, operating 350 helicopters that average 823 flight hours and 847 transported patients annually per aircraft. They carry more than 250,000 patients per year of which more than 20% are children. There have been more than 600 law enforcement helicopters purchased by communities over the past 6 years (1994-1999). The market projection is for an additional 85-130 helicopters per year for the next ten years. That will bring the overall law enforcement population of helicopters to nearly 2000 by the year 2010. The benefits of having helicopters in the air during apprehension of criminals is that the chase is much shorter, the ground officers have a significant advantage and the high-speed chases are minimized. Reducing the number of high-speed chase accidents alone saves an average of $1.5 million per incident.

Communities can use heliports and vertiports to do what airports have historically done by creating new economic and business centers. Almost every new airport built in the last forty years has resulted in a business community growing up around it e.g., White Plains/West Chester County, Dulles Airport, Hartsfield International, Dallas- Fort Worth International, Denver, Chicago O'Hare. After the airport is built the business community begins to develop, creating the need for more residential communities and the support functions needed to sustain them. In other words, airports become the focal point of new cities, cities within cities, and economic centers that have a life and character of their own.

If an efficient and affordable vertical flight system is to be put in place, planners, community leaders, airport managers, federal officials, operators, and citizens must all work together for the good of all. Each player can recognize the benefits that will accrue and what the cost savings might be (more than just money). City leaders can plan properly for future rotorcraft if they are to realize the full potential of these aircraft in helping relieve congestion.

The economic success of a competitive vertical flight system will probably be difficult to achieve because it will be competing with somewhat less expensive modes of traditional transportation. Because of the higher costs of operation, ticket prices for rotorcraft transportation can be higher than equivalent air service, unless subsidized as the railroads are today. Convenience, reduced access time and access cost are the discriminators that will make people choose vertical flight transportation over the other available modes. If convenience is important to the traveler then a vertical flight system will succeed, even if ticket prices may be higher than competing modes of transportation.

Heliports and vertiports can do the same thing for communities on a smaller scale. They can be demographic shifters, letting community leaders decide where they want the population to shift. Air service has an appeal that draws business development because it has become a core need for commerce in the next century. Businesses in today's world recognize the need to move their goods and services quickly and conveniently, and air is the best/fastest way to get it done. A vertical flight system will be the next new wave in community initiatives because it makes sense, both financially and environmentally.

An Improved Air Transportation System Through the Use of Vertical Flight

A new system of heliports and vertiports will take time to develop. Development of a vertical flight transportation system will involve many key players from varied backgrounds who must pull together to accomplish the task. A heliport/vertiport system can be developed with a sense of community spirit. The city of Dallas, Texas saw the economic benefit of vertical flight aircraft facilities and decided to act on the need. Today, the Dallas Vertiport is atop one of the country's largest convention centers. This world-class vertiport is designed to be expanded in the future to become a full service reliever airport, capable of handling thousands of travelers daily.

Infrastructure development is essential to the success of both helicopters and tiltrotors. Without the landing facilities and the needed airspace changes, IFR rotorcraft will be used by only a small number of users and will have little impact on the transportation system. Vertical flight aircraft can prove themselves to be cost effective and reliable. Operating in all weather conditions, they can provide dispatch reliability equal to other transportation modes, especially fixed wing aircraft. Ongoing commercial and military rotorcraft development programs will provide an important database and history of this technology. The responsibility to make a good commercial product rests squarely on the shoulders of the manufacturers and federal regulators. The technologies available today make these goals achievable and affordable. Industry will do its part when it is prudent to do so from a business opportunity standpoint. The amount of investment necessary to launch a program to produce commercial quality aircraft is high. It will be done as the time is right, and the economic conditions are favorable.

What steps should be taken?

One immediate issue is simply informing and educating the public on the safety and utility of vertical flight aircraft. Many individuals only pay attention to helicopters when they notice the unique noise they make as they fly by. Others only tolerate helicopters when there is a disaster or someone is lost. Still others can only accept helicopters that are affiliated with moving critically injured people to the hospital. The average citizen does not assimilate all of those factors into a mode of transportation that improves their lifestyle and will have an even more impressive impact on ground and air congestion as they mature into all-weather commuter aircraft.

It is recommended that the FAA with HAI and each state's Transportation Departments initiate and support an education program at the local, state and national level that would make people aware of the benefits of a vertical flight system. The helicopter industry, along with the FAA and NASA, sponsored a number of intermodal transportation conferences in the mid-1980's and they were successful in generating considerable interest in vertical flight aircraft. Industry experts conducted these conferences and the audience included land-use planners, local politicians, aviation facility managers, and managers from all modes of transportation from bus lines to airlines. It is time to re-institute these conferences but add disaster relief and congestion reduction into the main message of the conference. If the FAA were to include vertical flight in their discussions and plans for congestion relief it would help the cause of the industry when they talk to airlines about congestion relief potential of vertical flight aircraft.

The FAA can initiate a change in their culture that includes mentioning vertical flight aircraft and their benefits in all of their public statements related to the national transportation system. It is recommended that the FAA include helicopters when they talk about the extraordinary safety record of aircraft in the U. S. when compared to other modes of transportation. The reality is that, according to NTSB records, helicopters in a controlled environment such as the national transportation system have an outstanding safety record. Only when all the applications of helicopters, including crop dusting, law enforcement, and training are included does the safety data look less attractive.

Additionally, it would be a significant act of cooperation to have the Department of Transportation initiate a partnership with the vertical flight industry to begin planning for a future intermodal system that includes vertical flight in a way that will improve air service for everyone.

The issue of reducing congestion at major airports and on the ground infrastructure system feeding those airports needs further analysis. There were several studies conducted in the early 1990's in support of the Congressionally mandated Civil Tiltrotor Development Advisory Committee (CTRDAC) which was released to Congress in December 1995. The data gathered to support the CTRDAC's final report addressed the benefits of reduced congestion at airports by opening up takeoff and landing slots and putting those passengers into vertical flight aircraft. It is suggested that an update those of studies be conducted in order to ascertain what changes have occurred over the last 5-10 years that have had an impact on congestion. Take another look at how all-weather vertical flight aircraft might reduce congestion at major hub airports. This data can be used to justify the need to begin integrating vertical flight aircraft into the system.

Another concept that has been offered as a solution to inter-city heliports is to develop a system of emergency preparedness facilities near major city centers that can be used by police and public service providers as well as helicopter operators during normal operations. In times of emergency, these facilities will be converted into disaster control centers and be capable of handling large vertical flight aircraft including S-92's, CH-47 Chinooks and V-22's. With a system of large, permanent landing facilities in place for emergency service in key locations around major cities the vertical flight system described above will have a core around which to build smaller landing sites. This will make the entire system not only viable but very successful in being able to offer convenient air service to locations where people want to go.

The potential for vertical flight in the next century is tremendous. There are public perception hurdles to overcome. There will be resistance but the rewards are worth the effort, especially since there are very few alternative options available for transportation improvements. Now is the time to start and with the FAA and industry working together. A great new transportation system can be put in place that will be truly intermodal and both economically and environmentally sound.

Summary

Vertical flight infrastructure is going to be critical to the success of helicopters and tiltrotors for the future. This includes not only airspace control issues that are the domain of the FAA but more importantly the development of ground facilities from where these aircraft will operate. There are major social, economic and environmental issues that must be addressed by the manufacturers, the regulators and the communities in which these facilities are located. Noise, both measurable and virtual, is an issue that can not be overlooked. It is an environmental problem in most communities and can cause the demise of the vertical flight industry's goal of integrating helicopters and tiltrotors into the transportation system.

Public perception of vertical flight aircraft is something that can, and must, be improved if helicopters and tiltrotors are going to fit into the air transportation system and be effective in efficiently moving people. Perhaps the biggest misconception is that helicopters don't benefit the public at large. Only natural disasters, emergencies, or law enforcement actions bring out the public cry for helicopters. It is imperative that helicopters and tiltrotors become accepted, like airplanes, if they are to become an integral part of the transportation system.

Showing communities the public benefits of both aircraft and air facilities is the key to public acceptance. Economic growth potential around airports, heliports, and vertiports can sway public opinion and make a win-win scenario for many communities. Developing the facilities in a manner that minimizes the environmental impact while maintaining the convenience of access to air travel is the challenge facing all of us. It can and must be done to have an optimum air transportation system in place to help share the load of the increased demand for travel in the future.

Recommendations

1. **FAA commit the resources to continue development of GPS-based non-precision and precision IFR flight procedures to maximize the efficiency and safety of helicopters and tiltrotors in the national airspace system so that the full benefits of vertical flight will be used to reduce airport and airway congestion.**

2. **FAA, working in conjunction with industry and other agencies, lead the effort to measure and document the acceptable noise and safety impact to communities of implementing a vertical flight system.**

3. **DOT and FAA update earlier studies on the impact to airspace and airport congestion of having a vertical flight system that includes scheduled helicopter and tiltrotor service to both hub and non-hub airports from heliports and vertiports.**

4. **DOT and FAA work with industry to get communities involved in the development of socially and environmentally acceptable ground facilities that will help improve their transportation systems and economic development.**

5. **DOT and FAA include the public benefits of vertical flight aircraft in any public speeches they make related to air transportation program initiatives.**

6. **DOT and FAA publicly praise the safety record of helicopters as they do airline operations for similar types of operations.**

7. **DOT and FAA work with the vertical flight industry to set up venues for public education on the operation and public benefits of helicopters and tiltrotors.**

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