Statement of

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Before the

AVIATION SUBCOMMITTEE
Committee on Transportation and Infrastructure
U. S. House of Representatives

Hearing on

NextGen: Area Navigation (RNAV)/Required Navigation Performance (RNP)

Wednesday, July 29, 2009

Mr. Chairman, Members of the Committee, I am Chet Fuller, President – GE Aviation Systems, Civil. Thank you for the opportunity to testify before the Subcommittee today on the issue of Area Navigation (RNAV)/Required Navigation Performance (RNP), an issue central to the discussion on NextGen, the modernization of our nation's air traffic control system.

Today I will share with you four main points:

- *First* – RNP means greater accuracy and precision and RNP enables efficiency. It is through RNP that operators and the flying public derive the value of NextGen Air Traffic Management.
- *Second* – RNP saves time, it saves fuel, it reduces Carbon emissions, and it reduces community noise on both approach and departure.
- *Third* – RNP is fundamental to the transition from the past - ground-based, voice controlled air traffic - to the future – time and space based, digitally controlled management, otherwise known as NextGen's 4 Dimensional Trajectory Based Operations.
- *And Fourth* – The technology is ready today; all we have to do to reap the benefits of RNP is accelerate its implementation.

GE Aviation is a leader in efficient technology

From the turbo supercharger to the world's most powerful commercial jet engine, GE's history of powering the world's aircraft features more than 90 years of innovation. Our innovation is not limited to aircraft engines; GE's Aviation Systems business is a leading global provider of electrical power systems, avionics, actuation and landing gear, aerostructures and propeller systems. GE - Aviation's technological excellence, supported by continuing substantial investments in research and development, has been the foundation for growth, and helps to ensure quality products for customers.

For more than two decades, GE Aviation's navigation systems have guided the world's most successful air transport aircraft, racking up more than 130 million hours of operation on Boeing 737 and Airbus A320 family aircraft, while providing unprecedented levels of safety and efficiency. In fact, every 2.7 seconds an aircraft takes off with GE's Flight Management System (FMS). GE's leadership has resulted in advancements that support NextGen and ATM including:

- First to demonstrate RNP operations at 0.1nm with Alaska Airlines into Juneau, Alaska in the 90s;
- First to extend RNP to 4-Dimensional Trajectory Based Operations (4D TBO) in revenue service with Scandinavian Airlines;
- Playing an integral part in Southwest Airlines' plans to begin RNP operations with our large area displays and FMS.
- Supplying National Airspace capable systems to the US military.

Ecomagination

Ecomagination is a GE business initiative to help meet customers' demand for cleaner and more energy-efficient products and to drive reliable growth. Ecomagination reflects GE's commitment to invest in a future that creates innovative solutions to environmental challenges and delivers valuable products and services to customers while generating profitable growth for the company.

Our efficient product designs alone do not bring benefits to aircraft. The products must be integrated into the aircraft and, important in the context of air traffic management, must be operated efficiently. Our ecomagination certified FMS Optimized Descent provides operational efficiency to our customers in conjunction with the air traffic management system.

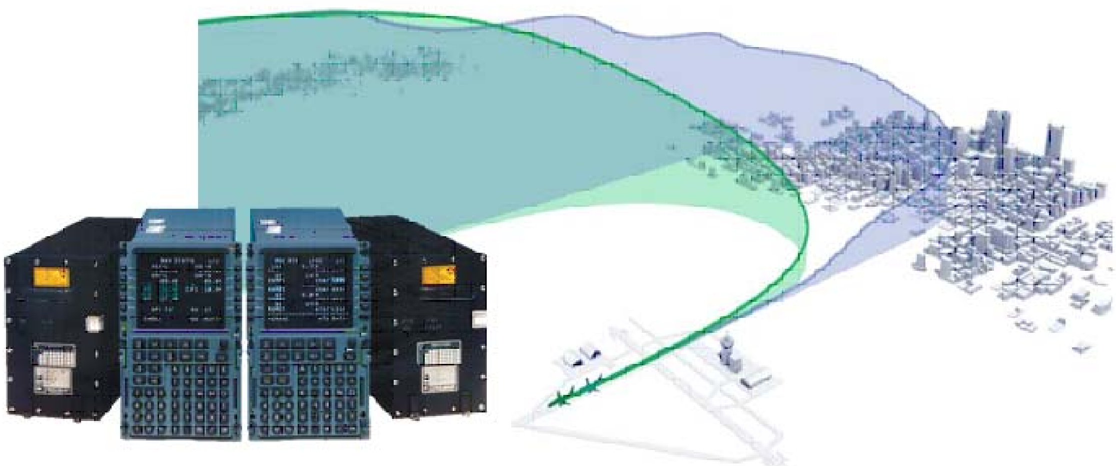

Figure 1. GE Aviation's Flight Management System Optimized Descent is an ecomagination product

The Need for Air Traffic Modernization

Our current Air Traffic Control (ATC) system is outdated, relying on a 1960s era infrastructure. The most efficient airways are constrained by ground-based radar systems and navigational aids, constraining aircraft to a few crowded "highways in the sky" rather than using the full airspace available. As a consequence, today's modern aircraft are forced to fly much farther than necessary due to long, wide turns and radar vectoring when "entering" and "exiting" these highways in the sky.

Moreover, aviation is quickly approaching the capacity limits of our current ATC system. The Congressional Joint Economic Committee calculated air traffic delays to cost the U.S. economy $41 billion in 2007[1]. Despite the current short-term decline in air traffic, the long-term air traffic demand is forecast to continue growing. Our current system of voice-control simply will not be able to keep up with this growth and meet the anticipated demand. The key to achieving growth without further adverse impact on the economy is the ability to accommodate more flights, while maintaining safe distances between aircraft. Improvements in accuracy and integration are critical so our system can keep up with forecasted demand even as we reduce aviation's environmental footprint.

4 Dimensional Trajectory Based Operations - the Solution

Government and industry have reached general agreement that the solution to air traffic management is to build on RNP to achieve 4D Trajectory Based Operations. 4D TBO relies on a few key concepts:

- Navigation: Extend RNP performance to all four dimensions
- Communication: Data link for trajectory negotiation
- Integration: Ground capability to manage and de-conflict the trajectories of various aircraft

4D TBO, often referred to as 4D RNP, truly builds on current RNP technology by extending the performance requirements to the vertical and time dimensions. The most efficient, conflict-free route from take-off to landing is communicated and agreed upon between the aircraft and controller. The aircraft is capable of precisely following this trajectory in all four dimensions, and can meet assigned arrival times with a precision of mere seconds throughout the flight. With 4D TBO the ATC system is capable of managing aircraft by their trajectories, and takes advantage of the precise navigation capabilities of the aircraft to ensure all trajectories are free of conflicts with other aircraft. In this system aircraft are provided access according to a "best equipped, best served" policy.

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[1] Your Flight Has Been Delayed Again – Flight Delays Cost Passengers, Airlines, and the U.S. Economy Billions, Joint Economic Committee Majority Staff, Chairman – Senator Charles E. Schumer, Vice Chairman – Representative Carolyn B. Maloney, May 2008

Needed improvements are already being implemented in other parts of the world, and are close at hand here in the U.S. RNAV/RNP procedures are an important and necessary element of the overall solution to transition from current operations to a 4D TBO system. Rapidly creating RNAV/RNP procedures that address the airlines' needs for efficiency, the air traffic system's need for safety and capacity and the overall need for emission reductions is a critical step. GE recommends that we move forward rapidly and efficiently on the deployment of well designed RNAV/RNP procedures while keeping in mind that the overall solution in NextGen requires all the elements described above to enable 4D TBO.

Next, I will provide an overview of RNAV and RNP and will discuss their benefits.

RNAV/RNP Technology

As stated earlier, our airspace has been allocated and flight routes defined based on a post-WWII infrastructure of ground-based navigation aids (e.g. VOR, DME, NDB, ILS) limiting aircraft to routes and procedures – or "roadways" - defined by the location of these aids and requiring aircraft avionics sensors specific to each. Due to the location and accuracy of these aids, aviation routes and procedures based on this infrastructure are longer and farther apart than necessary with today's technologies. This creates congestion and delays the impact of which goes beyond the obvious environmental impacts to the overall efficiency of the US economy as businesses feel the cost of these delays (for instance through reduced productivity, work stoppages due to late shipments or loss of revenue due to spoiled goods). With today's advanced navigation technologies - RNAV and RNP - aircraft are capable of safely flying along shorter and more efficient routes.

What is RNP/RNAV?

RNAV is navigation using earth coordinates of latitude and longitude to define the aircraft route and position. Because the aircraft is no longer constrained by the limitations of ground-based navigation aids, point-to-point routes can be defined in a more flexible manner. RNP builds on RNAV by adding performance requirements to the system to ensure the aircraft flies the route within a specified accuracy, referred to as containment. Requirements on the integrity of the navigation system and continuity of its operation provide a high-level of predictability and confidence to the air traffic controller that the aircraft will fly the exact RNP route with no system failures. Because RNP-capable aircraft can fly such precise, repeatable flight paths, RNP procedures can be:

- defined anywhere to avoid constraints (e.g. mountains, towers, noise sensitive areas, etc.) where conventional procedures cannot,
- shorter and more direct routes,
- closer together due to the containment to a defined path, increasing airport capacity and also de-conflicting traffic between nearby airports

Rather than requiring a specific set of ground and air equipment, RNP authorization specifies different levels of performance requiring different types of equipment, where the lower the RNP value the more stringent the accuracy requirements. In addition to equipment, RNP procedures with Authorization Required (AR) may also require specific crew training procedures. As a result, airlines can choose the type of equipment and training needed for their particular operations.

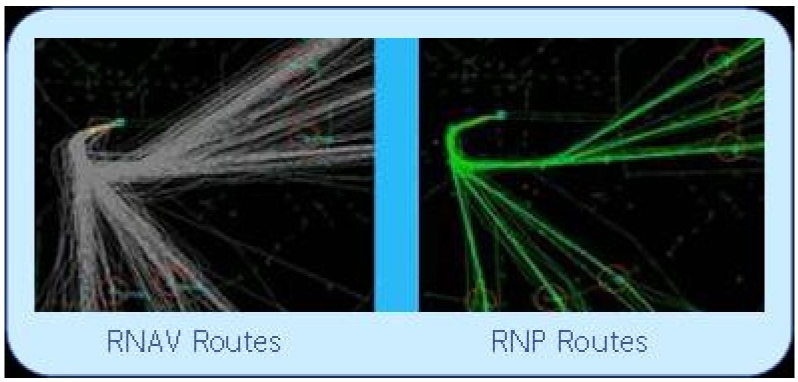

Figure 2. RNP Flight Paths provide even tighter containment, integrity and continuity than RNAV Flight Paths alone

Why is RNP essential for NextGen?

RNP is revolutionary in that it opens the door for varying airspace allocation based on the equipped capability of the aircraft. Expanding the concepts of RNP and defined performance levels to the vertical profile and estimated arrival times is a key component of NextGen's 4D TBO concept. In today's system, ATC has little knowledge of when and where the aircraft will enter a controller's sector, often requiring ATC to intervene with a flight to maintain separation between aircraft, control the flow within the sector or meter aircraft to the final approach. By exchanging the aircraft's 4D Trajectory generated by the FMS periodically throughout the flight, controllers have accurate and timely knowledge of when and where aircraft will enter their airspace and the performance limits of the trajectory.   In NextGen, this improved predictability will move the current air traffic system from one of "control" to one of "management". Implementation of procedures to take advantage of existing RNP technology is a key enabler for this NextGen concept.

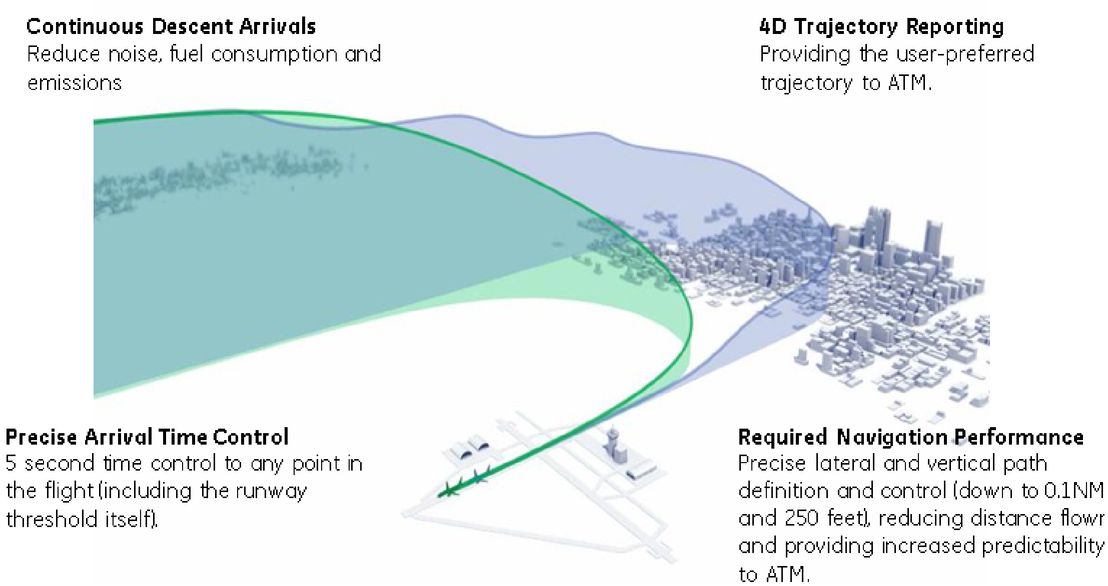

Figure 3. RNP is the Basis for NextGen's 4D Trajectory Based Operations (TBO)

RNP Benefits

There are many benefits of RNAV/RNP to the users of the ATM system, to the air traffic controllers themselves, and to society as a whole. RNP can help aircraft operators reduce flight time and save fuel, and can increase airspace capacity to accommodate the forecasted aviation growth in an environmentally responsible manner. Accelerating RNP implementation also provides economic benefits and will help the U.S. maintain its global lead in the aviation industry.

Environment

RNP is environmentally friendly. By providing flexible routing using satellite navigation, operators are no longer constrained to flying over ground stations. As a result, aircraft are able to fly the most efficient route in the shortest distance, saving both time and fuel and lowering emissions. It is estimated that these shorter routes have the potential to cut global CO2 emissions by about 13 million metric tons per year[2], representing 1.8% of 2008 global aviation CO2 emissions[3]. This includes 2 million tons at the top 10 U.S. airport communities alone[4]. The shorter flight distance and optimized engine settings made possible by RNP also reduce the noise during landing significantly, and the precise, flexible routing can avoid noise-sensitive areas, such as residential communities, altogether. When combined with optimized profile descents RNP facilitates lower, quieter engine thrust levels, further reducing fuel, noise and emissions.

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[2] Meeting Aviation Challenges Through Performance Based Navigation, ICAO/IATA
[3] IATA growth estimates, eia.doe.gov, iea.org, atag.org
[4] Energy & Environmental Benefits, New Procedures Significantly Reduce Noise & Emissions, Honeywell

Use of RNP procedures during the departure phase of flight also yields the opportunity for more reduced thrust operations during takeoff. Reduced thrust takeoffs provide increased engine life due to lower rotational pressure and heat loads. Over the long run this produces an engine with better fuel burn. The flexible and precise routing RNP provides combined with lower thrust levels on takeoff can also significantly reduce the number of people adversely affected by noise from departing aircraft.

There is no reason to wait to develop RNP procedures; RNP is being implemented around the world today, with immediate benefits. In Brisbane, Australia, Qantas has been the lead carrier in the Brisbane Green RNP Project since 2007, a program of particular interest to observers in the U.S. This project has clearly demonstrated that air traffic controllers can integrate RNP capable aircraft and non-RNP capable aircraft in a medium traffic density airport environment to create immediate reductions in CO2, fuel burn and noise. Qantas has already implemented RNP procedures at 15 Australian airports, and AirServices Australia recently announced that it will be working with a third-party RNP procedure designer to produce a nationwide network of public-use RNP procedures at all major Australian airports. This effort is expected to reduce CO2 emissions more than 122,000 metric tons (269 million lbs) per year and reduce fuel consumption by nearly 13 million gallons a year[5].

Figure 4. The Flight Path for the RNP (green) arrival in Brisbane is much shorter than the Traditional (red) arrival, reducing fuel and emissions.

As an initial step here in the U.S., Southwest Airlines is committing $175 million to implement RNP across its fleet of Boeing 737s. A roundtrip demonstration flight earlier

[5] AirServices Australia estimates that are extrapolated from current operations.

this year between Dallas Love Field and Houston Hobby using RNP procedures yielded a 0.41 metric ton (904 lb) CO2 savings for the one flight alone[6].

The extension of RNP to time in 4D TBO is critical to unlocking additional efficiency. In Europe, Scandinavian Airlines has been using time-based operations to significantly reduce their operating costs and help to reduce their carbon footprint. In over 4,000 such approaches into Stockholm, the airline has seen an additional fuel savings of 77,350 gallons (240,000 kg), CO2 reduction of 756 metric tons, NOx (nitrogen oxide) reduction of 2.64 metric tons annually and noise reduction by 50 percent (65db) for the exposed area[7]. The increased predictability of time-based operations and ability to negotiate the optimal trajectory provides significant savings in addition to those available from RNP.

Multiple studies have shown that a typical narrow-body plane utilizing GE's FMS Optimized Descent could save between 32 and 65 gallons of jet fuel per descent compared to a traditional stepped-down approach, reducing fuel, CO2 and NOx emissions an estimated 6-12 percent. In addition, studies have shown that a typical narrow-body plane utilizing GE's FMS Optimized Descent reduces -- by up to 22% -- the land area impacted by noise levels greater than 60 dB. In fact, an average sized fleet of thirty 737 New Generation aircraft flying an optimized descent with an RNP approach only 50% of the time would result in a CO2 reduction equivalent to removing 1,500 cars from U.S. roads, or the amount of CO2 absorbed by over 2,200 acres of southeastern US forest per year.

Capacity and Safety

RNP can also improve safety and capacity by providing a precise lateral and vertical flight path in areas of difficult terrain or congested airspace. Alaska Airlines reportedly chose Juneau for the first RNP flight path in 1996 due, in part, to the operational difficulty of landing or departing the airport during periods of low ceiling and reduced visibility. Building on the success of RNP at Juneau, the airline has gone on to develop additional RNP procedures at other airports which has saved millions of dollars in avoided diversions.

The use of RNP also provides benefits to air traffic controllers. Air traffic controllers in Australia have noted that the predictability and accuracy of aircraft flying RNP have made their jobs easier. Because aircraft flying RNP procedures track the desired course to very tight tolerances, day and night, wind or no wind, rain or shine, controllers have a high degree of confidence that aircraft will perform according to expectations. We expect controllers in the U.S. to have the same positive experiences as those in the rest of the world.

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[6] Figures published by Southwest Airlines.

[7] Figures published by Scandinavian Airlines as part of NUP2+ project.

Economic
We must also consider the economic impact of accelerating the integration of RNP procedures into the National Airspace as opposed to further delays in aviation modernization. The U.S. has historically been the global leader in aviation technology. Last year civil aviation accounted for 11 million jobs and $1.2 trillion in economic activity - 5.6% of the U.S. Gross Domestic Product (GDP). Moreover, the U.S. aerospace industry contributed $61 billion in net exports in 2007[8].

The savings available from use of RNP and 4D TBO could represent 7-12% of an airlines' fuel cost; these types of fuel savings would go a long way in re-establishing the health of the airline industry. Saving these significant amounts of fuel would also contribute an important step in the path to foreign oil dependence. Implementation of these technologies also presents the opportunity for an additional 5-10% savings in maintenance costs, which is one of the top 5 costs for an airline.

RNP is a technology that is ready to be implemented here in the U.S. and can provide significant environmental, fuel efficiency and capacity benefits. The Air Transport Association of America has estimated a cost of only $683 million to equip the entire U.S. air transport fleet for RNP operations[9]. This cost should be offset in a matter of months when potential efficiency gains and reduction in delays become reality. In comparison, to achieve the efficiency gains equivalent to RNP operations via engine and airframe modifications, is estimated to cost well in excess of *$10 billion* in research and development with a much longer time-frame for fleet integration.

With the technology already available, RNP procedure development is the obvious place to begin immediately. We can build on this to implement 4D TBO, where RNP will be extended to the vertical and time dimensions. As the historical leader in aviation, the U.S. is the logical place to create these products and services for our benefit and to be exported around the globe.

Challenges
In implementing RNP in the United States, we have to be aware of some of the potential pitfalls, such as unfocused investments, procedure design issues and the regulatory system. We must also keep in mind that RNP is a step along the road to a greater NextGen system of 4D TBO.

"Stovepipe" investments
For years, the aviation industry has categorized the aviation system's capabilities into three separate bins, or "stovepipes":

- Communication - ability of the aircraft to communicate with the ATC system
- Navigation - ability of the aircraft to progress along the most efficient path

[8] The Economic Impact of Civil Aviation on the Economy, FAA, October 2008
[9] The Case for NowGen: The Right Answer for Our Economy and Our Environment, ATA, April 2009

- Surveillance - ability of ATC to know where the aircraft is now

While this has been useful it has also led to isolation of these functions from each other. The FAA's NextGen Implementation Plan rightly points out the need for an "Integrated Mid-Term Capability" to successfully attain NextGen benefits. However, investment tends to focus on these functions individually and not on their integration.

We are discussing RNP today, which is clearly a "Navigation" capability. RNP produces noteworthy benefits alone as discussed already. However, the most important benefits come when these individual stovepipes are eliminated and integration via 4D Trajectory Based Operations is pursued with vigor.

The NextGen path to 4D Trajectory Based Operations combines the Navigation, Communication and Surveillance capabilities to deliver new levels of predictability and efficiency for controller and pilot alike. The hopes of capacity improvement, benefits of emissions and noise reduction, and increased safety depend on progressing to 4D TBO which, in turn, relies on efficient RNP operations and procedures deployment. The implementation of RNP and the transition to 4D TBO needs to be managed in a focused, integrated manner.

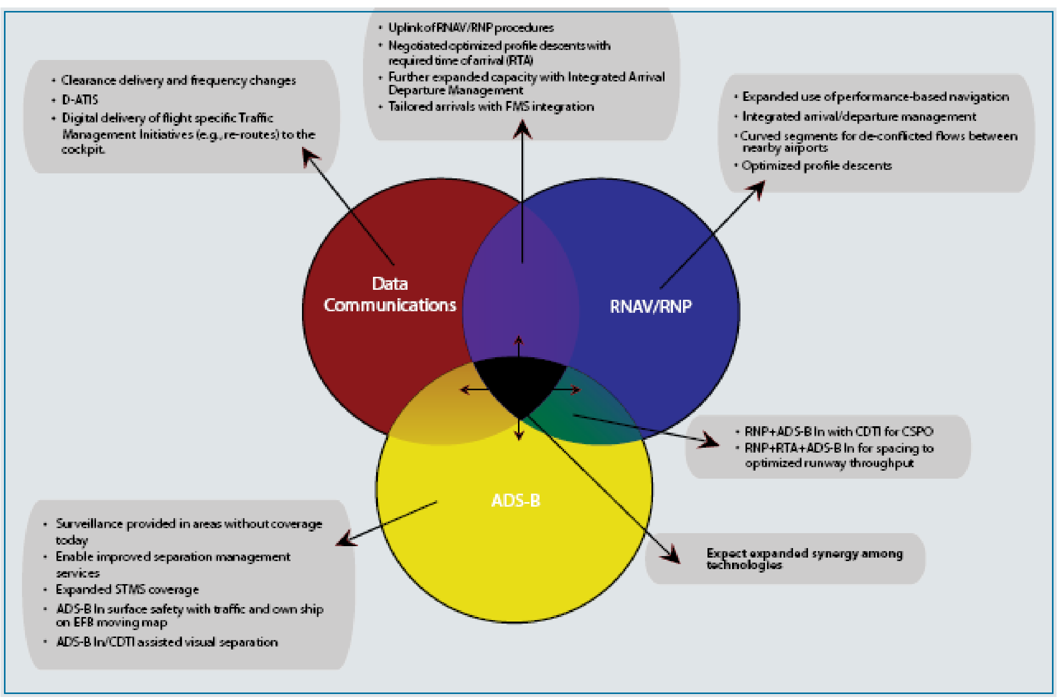

Figure 5. FAA NextGen Implementation Plan for "Integrated Capability[10]"

Procedure Design

All RNP paths are not created equal. It is not enough to mandate a set number of RNP procedures in a given year. Unfortunately, many of the RNP procedures published in

[10] NextGen Implementation Plan, FAA, 2009

the U.S. over the last few years have replicated traditional navigation procedures that are already in place, and in so doing create very little benefit. Although RNP is a powerful tool that can unlock fuel savings, CO2 reductions and noise reductions, merely creating an RNP navigation route is no guarantee of capturing this benefit. To achieve this, the constraints of airspace, aircraft performance, adjacent traffic patterns, air traffic control, geographical features, prevailing weather and noise-sensitive areas around the airport must all be considered in the procedure design. RNP allows all these factors to be taken into consideration by a custom designed three-dimensional path that reduces fuel burn and noise impact while increasing aircraft capacity and safety. We support the emphasis on ensuring operational benefits in new RNP procedure design in the Senate's FAA Reauthorization Bill. To make certain we take full advantage of the benefits of RNP we must quantify the true benefits of new procedures and ensure that the investments are spent in a responsible way that provides real benefits to the stakeholders. It is vital that we create metrics to for success and accurately measure the effectiveness of new procedures by their efficiency gains and their acceptance in use.

Rate of Design

Despite the immediate benefits of RNP and the growing demand from U.S. air carriers for navigation that produces those benefits, the process of approving and deploying RNP navigation procedures in the U.S. remains extremely slow. Moreover, as previously mentioned, many of the published RNP procedures have simply been overlays of existing procedures. FAA review and approval of a given original RNP design often takes years, rather than months. It is our understanding that the FAA is working to develop the processes and procedures under which qualified third-parties can design public-use RNP procedures in the U.S. and that those agreements are either complete or nearly complete. This is a key step to accelerate the introduction of RNP procedures in this country that will reduce fuel, noise and emissions, and we hope that further work can be done to streamline the regulatory process and speed the rate of RNP deployment. We believe that this will be a key recommendation of the RTCA NextGen MidTerm Implementation Task Force next month.

Environmental Assessment

One result of designing more efficient RNP procedures is that the aircraft may take a different route than the less-efficient traditional navigation path. Because the RNP path differs from the previous instrument procedure, there is some question whether an Environmental Impact Statement is required to determine the impact of the new RNP paths. While this is a valid concern that ultimately will need to be resolved, there are immediate ways to design beneficial RNP paths without requiring environmental review. In particular, RNP routes can be designed to replicate the routes taken today by aircraft on clear, good weather days, when controllers clear them for a visual approach.

During periods of good weather and clear visibility, when the pilot has the runway in sight, it is a common and widely accepted practice for the air traffic controller to release the pilot from the instrument approach procedure to land the plane at his discretion. Because a pilot who sees the runway can take the most direct and expeditious route to get there, these visual approaches are generally more efficient than corresponding instrument approaches. By studying the historical radar tracks of aircraft that have been cleared for visual approaches, the procedure design can limit the RNP paths to these areas. In this way, RNP paths can route the aircraft over areas where visual air traffic is already flying, mitigating any potential adverse environmental impact of the new procedure. However, this will require that FAA provide categorical exemptions from environmental review to RNP procedures that overfly existing visual flight paths.

Path forward

Modernization must take place. NextGen will allow the maximum use of the system to keep up with the expected growth in aviation, while also helping aviation reduce its environmental footprint on both noise and emissions. It will significantly contribute to the economic health of the air transport industry, while aiding our path to foreign oil dependence. RNAV/RNP is a critical technology essential for success of NextGen and offers benefits immediately. Moreover, accelerating RNAV/RNP procedure development will pave the way for a larger implementation of 4D Trajectory Based Operations and the associated efficiency and capacity benefits that go along with it.

While there are challenges to achieving this in the U.S., they can be overcome – as is being demonstrated in other areas of the world such as Northern Europe and Australia. To help address these challenges and begin to take full advantage of the benefits RNAV/RNP offers, GE recommends the following:

- *First* – Accelerate the creation of high quality RNP approach and departure procedures immediately.
    - Accelerate the design of RNAV/RNP procedures by utilizing the combined resources of government and industry. There is much RNP work to be done in the U.S. and there are qualified non-governmental third parties with extensive experience who can accelerate the RNP procedures and commercialize the technology so it is available to all airlines and users across the nation.
    - Accelerate the review and approval of RNAV/RNP procedures by streamlining the regulatory process, including providing exemptions from environmental reviews for procedures that overfly existing visual paths. These visual procedures are the prevalent mode of landing at many airports the majority of the time, and there is no reasonable justification for any other treatment.
- *Second* – Create metrics for success. Measure the effectiveness of new procedures by their efficiency gains and their acceptance in use.
    - Require that RNP procedure development focus on delivering procedures with three dimensional paths that minimize fuel burn and noise impact

- *Third* – We need to accelerate movement toward the NextGen vision of 4D TBO, extending RNP to time. This requires a coordinated effort integrating Communications, Navigation and Surveillance.
    - Implement a path toward NextGen's 4D Trajectory Based Operations to address the air traffic modernization need, updating controller's decision support tools, such as Arrival Managers, to facilitate these operations. 4D TBO offers the greatest environmental and economic benefits, with a significant increase in capacity as a result of improved accuracy. In order to achieve the full benefits of NextGen, an integrated approach is required where Communication, Navigation and Surveillance are treated as interdependent pieces of the same system – one strategy, one vision, many enablers.

A key step towards full 4D TBO, advanced RNP technology is "shovel ready", and could begin being implemented today. As discussed, RNP procedures are already being widely implemented in other areas of the world. The acceleration of RNP procedure development carries significant environmental benefits while helping to meet the forecast air traffic demand. Moreover, it has economic impacts in terms of minimizing costly delays and maintaining our world-lead in the aviation industry. Other countries such as Sweden and Australia have demonstrated the feasibility of RNP procedures in an environment with many aircraft of mixed capabilities. The Brisbane airport environment is comparable to US airports such as Dallas Love, Houston Hobby, Portland, St. Louis, Milwaukee, Oakland and literally hundreds of other commercial U.S. airports. This raises the obvious question: What is stopping us from implementing the same efficiency improvements at U.S airports that the Australians are demonstrating at Brisbane? We must act now to provide the public with the near-term economic and environmental benefits available while continuing to push forward on a full implementation of NextGen.