GREENER SKIES FOR BRAZIL:

CONSIDERATION FOR EFFICIENT SIMULTANEOUS APPROACHES USING THE RNP ESTABLISHED CONCEPT

José Alexandre Tavares Guerreiro Fregnani, MSc
Boeing Research & Technology, Brazil
e-mail: jose.a.fregnani@boeing.com

Michael Ulrey, PhD
Boeing Research & Technology, Seattle
e-mail: michael.l.ulrey@boeing.com

Sheila R. Conway, PhD
Boeing Commercial Airplanes, Seattle
e-mail: sheila.r.conway@boeing.com

Jeffery D. Musiak, PhD
Boeing Research & Technology, Seattle
e-mail: jefery.d.musiak@boeing.com

Av. Dr. Altino Bondensan, 500 Distrito de Eugenio de Melo,
12247-016 São José dos Campos (SP), Brazil.

ABSTRACT

There is tremendous potential growth in the demand for instrument approaches at Brazilian airports. Expansion of operations, especially simultaneous approaches, at many of these airports is complicated by terrain constraints. Highly accurate, curved approach procedures to airports within busy and complex airspace are being introduced worldwide to improve operational efficiency and reduce noise and emissions. These same procedures may also improve efficiency and capacity at Brazilian airports when used in new approach operations. This paper describes Required Navigation Performance-Established (RNPe) operations and suggests how RNPe and related concepts might enable new efficient instrument approach procedures in Brazil while addressing the demands of challenging terrain and significant demand growth. A quick review of possibilities on the three main international airports in the country is also presented.

Keywords: Performance Based Navigation, Required Navigation Performance, RNPe, EoR, Simultaneous Approaches, Curved Approaches, Air Traffic Management.

1. INTRODUCTION

According to Boeing's current market outlook (Boeing, 2015) the number of airplanes worldwide will grow on average 5.1% per year, reaching the mark of 43,560 aircraft in the year 2034. Growth in demand for air travel in Brazil continues to outpace much of the industry. The volume of passengers in the ten major Brazilian airports in 2015 is expected to be about 39% higher in 2015 than they were in 2005 (Marazzo et al., 2010). According to (ABEAR 2014), domestic traffic in Brazil is projected to grow at an average rate of 7% per year in the next five years, despite uncertainties in the world economic situation. This growing demand at the airports is accompanied by increased usage of the Brazilian air traffic network. Furthermore, higher traffic demand generally causes operations to become less efficient and create more noise and emissions for the communities near the airports. In addition, profitability of the top four Brazilian airlines has fallen short of goals, resulting in significant losses in the last two years. This situation has been exacerbated by high fuel costs and currency fluctuations. Therefore any improvements in operational efficiency of the system (aircraft, airspace or airports) are welcome.

The problems of poor efficiency, community noise, environmental concerns, and to a certain extent, insufficient capacity can be mitigated by simultaneous parallel approaches with downwind that are shorter than traditional approaches. However, approaches to some airports in Brazil are constrained by obstructions such as high terrain, making traditional multi-approach operations difficult at best. RNPe (Required Navigation Performance Established) procedures can be designed to alleviate all of these problems in most cases.

Fortunately, the top four Brazilian airlines have made significant investments in their fleets, achieving a 95% level of RNP-capable aircraft out of the 526 combined total aircraft (average age 6.7 years). Thus, since this capability is already in place for the most part, very little additional investment in the airspace/airplane/airport infrastructure is needed. Of course rules may have to be modified, procedures will have to be designed, safety and business cases made, and pilots and controllers trained, but this is relatively inexpensive compared to traditional hardware capital investment.

The Brazilian air navigation service provider (DECEA) has a well-established roadmap for ATM technology implementation aligned to International Civil Aviation Organization (ICAO) recommendations (ICAO, 2014). In addition, Boeing Research and Technology Brazil (BR&TB) is developing partnerships and collaborations with local academic institutions and industry for doing state-of-the-art ATM technology research in Brazil.

The effort to design and implement these procedures in Brazil will benefit from a recent success in Seattle. Based on a safety case developed by Boeing, the Federal Aviation Administration (FAA) approved RNPe operations under waiver at Seattle International Airport (KSEA) in April 2015. These approaches have already garnered praise by the dominant carrier, Alaska Airlines, for the reduction in track miles on approach, thus reducing fuel burn, noise, and emissions dramatically.

2. CURRENT RULES ON SIMULTANEOUS APPROACHES

In the United States, simultaneous dependent approaches may be conducted under the provisions of the FAA Order 7110.65[1], which governs air traffic control (ATC). ATC application of current provisions is achieved by means of tactical radar vectoring of aircraft to parallel runway centerlines separated by less than 4,300 ft and not less than 2,500 ft. To ensure separation standards are respected, ATC applies 1,000 ft of vertical separation between aircraft during turn-on to adjacent final approach courses until both paired aircraft are "turned on"[2] and "established on their respective final approach courses"[3]. As presently defined, this demands final runway alignment, though extension of curved approach definition of "course" in the

[1] FAA Order JO 7110.65V, effective April 2014

[2] FAA Order 7110.65V 5-9-6 a.2

[3] FAA Order 7110.65V 5-9-6 b.2.4.

Controller-Pilot handbook may in the future clarify this statement's applicability to RNP Radius-to-Fix (RF) segments[4]. Consequently, during moderate to heavy arrival traffic, aircraft are required to fly extended downwind legs to be sequenced onto final approach courses for glide slope interception. This can add 4 to 8 minutes of level flight to each operation resulting in excessive fuel burn, carbon emissions, and noise exposure to surrounding communities.

In Brazil, the local Air Navigation Service Provider (DECEA) follows ICAO guidelines (Doc. 9643 - Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways, SOIR) on final approaches on parallel runways operations. This means vertical separations of at least 1000ft on parallel approach traffic for runways separated by 760m (2500ft) minimum.

3. ESTABLISHED RNP DEFINITION AND CONCEPT OF OPERATIONS

The RNPe concept stipulates that standard radar separation, lateral or vertical, will be maintained with the aircraft conducting an adjacent parallel RNAV (Global Positioning System, GPS), RNAV (RNP), or precision approach, i.e., Instrument Landing System (ILS) approach until both aircraft are established on their respective instrument approach procedures (IAP). Once established on their procedures, alternate RNPe separation can be maintained by ensuring compliance to the required performance in the defined procedures.

The RNPe concept is based on Performance-Based Navigation (PBN) elements for operational approval, and on the capability of PBN-equipped aircraft navigation systems to achieve a specific level of position accuracy, integrity, and continuity supporting a defined operation in terminal airspace. This assures that the aircraft will be within plus/minus two times the RNP value (for example, 0.15 RNP provides +/- 0.30 NM containment) to achieve an acceptable level of risk. "Established" is defined by (FAA 2014) to be stable or fixed on a route, route segment, altitude, heading etc." In keeping with this definition, for separation assurance purposes, the aircraft is "established on RNP" when stable on a published RNAV (RNP) instrument approach route segment within specified lateral deviation tolerances, on a defined altitude profile.

There is still a minimum radar separation authorized between participating aircraft following on the same procedure, and potentially on the procedure to the adjacent runway, for wake protection. This latter constraint is influenced by the "mode" of operation: either dependent or independent. If the runway spacing is less than required for safe wake separation between landing streams per International Civil Aviation Organization (ICAO) or local authority, a required diagonal spacing will be defined between aircraft on the adjacent procedures.

Figure 1 below shows an example of the RNPe design concept in dependent mode, where the minimum required diagonal spacing during the approach is 1.5NM. This shows an RNP approach against a traditional ILS approach. The new feature which requires a rule change is that the RNP aircraft is considered "established" beginning at the RNP initial approach fix (IAF), and therefore, when the ILS aircraft turns onto its approach the usual minimum vertical separation of 1000FT is no longer required.

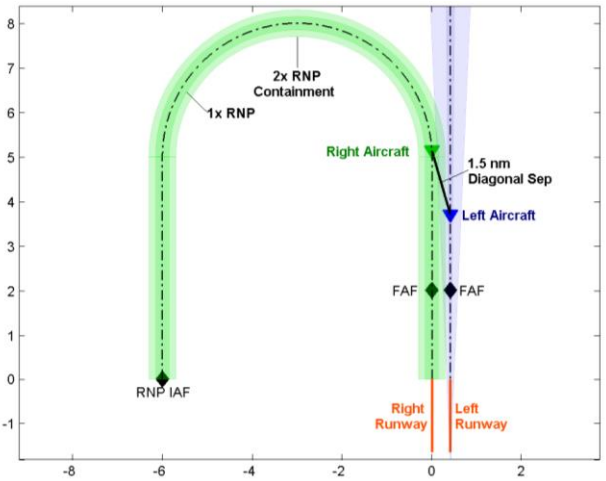

Figure 1: Example of RNPe design for parallel runways

[4] From Pilot/Controller Glossary 7/26/12: COURSE- a. The intended direction of flight in the horizontal plane measured in degrees from north. b. The ILS localizer signal pattern usually specified as the front course or the back course. c. The intended track along a straight, curved, or segmented MLS path.

While current simultaneous operations based on ILS are limited by existing ICAO guidance, RNPe benefits include potential for reduced track miles and flexibility of track position. In turn, this can reduce fuel burn, associated carbon emissions, and noise exposure to local communities that would otherwise underlie aircraft tracks of radar-vectored arrivals. Authorization to conduct RNPe operations will require additions and amendments to Air Traffic Control Orders and Notices related to simultaneous dependent approaches in accordance with this operational concept. In Brazil similar additions and revisions to the current regulations would be necessary.

Of course, the details of RNPe implementation are key to a safe and efficient operation. Normal performance requirements, defined by coded RNP values in the procedures, must be sufficiently precise to eliminate interplay between the parallel traffic as well as any required alerting tools for controllers, such as a Non-Transgression Zone[5] (NTZ). Additionally, using RNPe inherently mitigates many of the causal factors which have historically led to parallel runway operations developing a non-normal condition, such as overshoot into the parallel track. Therefore, RNPe procedure definition should play into analyses of both normal and non-normal operations, which in turn should be considered in operational authorization.

4. THE FAA'S GREENER SKIES PROJECT

RNP procedures can be used to reduce fuel burn, emissions, and noise, but currently they are not authorized for use during simultaneous operations. To enable these operations, a consortium consisting of Alaska Airlines, the Seattle FAA Terminal Area Control, Boeing, and the FAA NextGen office have been exploring new dependent operations with focus on effective RNPe implementation for simultaneous approaches. They were motivated mainly by the desire for operational and environmental benefits. In the first quarter of 2015 under the NextGen "Greener Skies Program", RNPe became operational under waiver at Seattle International Airport (KSEA). This airport operates under a parallel approach runway configuration. Under regular operations (prior to RNPe) ILS approaches on both runways were available if 1,000 ft minimum vertical separation was maintained prior to localizer intercept.

Figure 2 shows the marked contrast between the accuracy of the RNPe approaches (in green) and the traditionally-managed traffic with longer, more variable approaches (yellow). Note that the number of RNPe approaches (green) is approximately the same as the number of traditional approaches (yellow), even though it is hard to tell because there is so little variability in them.

Figure 2: Flight paths with RNPe (green) and without RNPe (yellow)

[5] NTZ is defined by ICAO SOIR DOC 9643 as a required surveillance alert for air traffic controllers between independent parallel approaches to trigger controller intervention if encroachment is imminent.

The 'Greener Skies over Seattle' initiative allowed aircraft approaching from the west to fly an environmentally friendly RNP-Authorization Required (RNP-AR) track over Elliott Bay in south flow (Figure 3, in green) vs over central Seattle. Similarly, the new north flow procedure over Commencement Bay also reduces noise exposure. Aircraft are able to fly the approaches concurrently with an aircraft on an instrument approach to the east runway in instrument meteorological conditions (IMC). The operation requires no specified vertical separation, though still under some level of dependent spacing for wake avoidance.

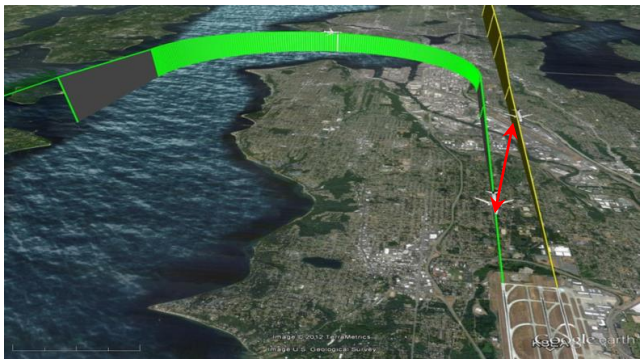

Figure 3: Flight path over the Elliot Bay after RNPe implementation

All of the stakeholders reported very optimistic initial results. According to an Alaska Airlines press release (Alaska Airlines press release 6/30/2015):

"Alaska Airlines is on track to save 87 gallons of fuel, shorten flight times by about nine minutes and reduce carbon emissions by nearly 1 metric ton, every time one of its planes lands at Seattle-Tacoma International Airport using new, operations-enhancing Federal Aviation Administration (FAA) procedures. That's the equivalent to the amount of carbon dioxide produced from driving about 1,800 miles in a passenger car, according to a new Boeing Company report. The benefits are about 28 percent greater than what was initially projected in 2010."

The operator estimated the new operational configuration is saving the airline about US$200 in fuel per flight. Also according to FAA's estimate, if all equipped airlines at this airport used the Greener Skies procedures on all flights from the southwest landing south, it would reduce fuel consumption by 2.7 million gallons a year and reduce carbon emissions by 25,600 metric tons, the equivalent of taking 5,400 cars of the road each year. As the use of the procedures increase, so do the environmental benefits: The new tracks over inhabited areas result in 100% noise mitigation for approximately 187,000 inhabitants. Other portions of the community will benefit from lower noise exposure from higher, Constant Angle Descents (CDAs) at idle thrust.

In addition, as part of the same Alaska Airlines press release (Alaska Airlines press release 6/30/2015), the local airport authority issued the following statement:

'The Port of Seattle is glad to be a partner in this effort to reduce the environmental footprint of our airport and create increased efficiencies for current flight corridors that benefit operations and surrounding communities. Whenever we consider airport improvements our goal is to be the most energy efficient we can be. The procedures implemented in Seattle can also be used at certain U.S. airports that have comparable runway configurations, including Portland International Airport."

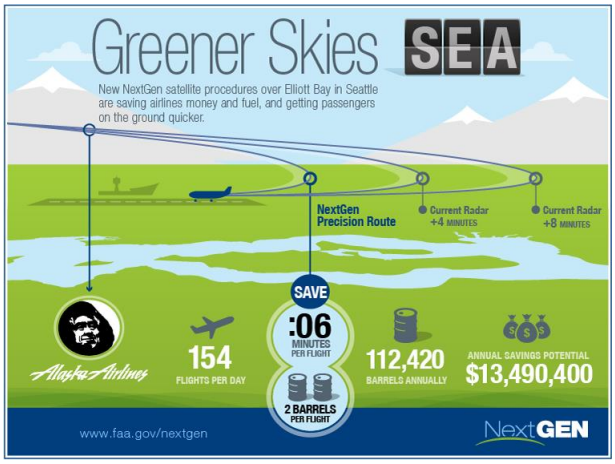

Figure 4: FAA Greener Skies: Initial Benefits of RNPe at Seattle International Airport

One important additional outcome of the "Greener Skies" project was a safety analysis methodology that demonstrated these operations to be safe. Greener Skies studies found that the overall safety risk was influenced more by system integrity issues (rare, faulted conditions) than by approach "accuracy". This does not mean that highly accurate approach systems are not necessary; only that establishing accuracy is not itself sufficient to determine risk. A decline was noted in some quarters of a proper emphasis on system integrity and even an occasional confusion between the concepts of system integrity and system performance. The Greener Skies safety assessment leveraged compliance with the RNP Authorization Required (RNP-AR) integrity, availability, and accuracy requirements as a suitable way to demonstrate the desired level of safety and achieve authorization for use.

Motivated by the growing demand from many airlines for more efficient approaches based partially on the success at Seattle, the ICAO Separation and Safety Panel (SASP) is drafting changes to international guidance on air traffic management to include the use of RNPe. ICAO PANS ATM (Doc.4444) and Simultaneous Operations on Parallel or Near Parallel Instrument Runways (SOIR, DOC Doc. 9643) are expected to be revised accordingly.

5. OPPORTUNITIES IN BRAZIL

The developing ICAO simultaneous approach criteria will afford the use of RNP approaches, without affecting existing infrastructure. This will bring operational efficiency and environmental benefits and may provide a means to better meet the growing demand.

Below we discuss the RNP procedures and safety methodology that could support their use in simultaneous approach operations at major airports in Brazil. Generally, efficiency gains and potential capacity gains due to RNP operations are expected because of the following factors:

1. ILS critical area is unnecessary (reliant on GPS instead of ILS).
2. Controller workload may be reduced due to fewer required instructions to pilot on each approach (from 8 instructions down to 3, approximately).
3. Simultaneous operations may be achievable in terrain-challenged areas that make ICAO-SOIR compliant parallel ILS procedures otherwise unavailable.

Additionally, RNPe transitions to the runways may be safer at airports like Sao Paulo International Airport (Guarulhos, SBGR), for example, where the initial descent is almost circular, and depends on a mix of previous technologies, such as VORs and NDBs, some of them in obsolescence. RNP operations can provide closed-loop guidance in both vertical and lateral dimensions in almost any flyable geometry compatible with local terrain, airspace, and community noise constraints.

However, one of the potential issues with RNP procedures in Brazil may be the presence of ionospheric disturbances near the equator, which play havoc with GPS availability and continuity. The loss of GPS availability in the middle of an RNP approach

may lead to significant disturbances to the continuation of the approach. According to recent studies (Aguiar, 2005) scintillation events can last for many days during the peak periods, mainly determined by sunspot cycles (approximately every 11 years).

As elsewhere, regulations in Brazil generally require different longitudinal separations between parallel approach traffic streams depending on runway configuration (e.g., lateral separation and stagger) and aircraft wake turbulence categories. This, in turn, impacts the system's capacity. The regulatory constraint needed to address the wake turbulence interference between the aircraft on adjacent trajectories is not unique to Brazil. Based on this discussion, potential applications at three different Brazilian airports are suggested:

5.1 BRASILIA INTERNATIONAL AIRPORT / JUCELINO KUBICZCHEK (SBBR)

This airport has two parallel runways (11L/29R and 11R/29L) separated by 1200m laterally, currently allowing simultaneous parallel operations (recently adopted). Under this scenario system capacity is around 80 movements per hour using IFR operations. Similar to the operation in Seattle, RNPe at Brasilia (SBBR) airport could exploit RNPe to allow simultaneous operations. But, compared to Seattle, the greater runway spacing at SBBR affords either independent or dependent simultaneous approaches based on ICAO rules related to potential wake interactions between approach flows. Again, the use of RNPe would require little additional investment.

By contrast, other currently available options in compliance with ICAO guidance would require a significant infrastructure investment. For example, a Precision Runway Monitor (PRM) system would require installation of a PRM system, implementation and staffing for a Non-Transgression Zone (NTZ) monitor. Perhaps more importantly, guidance for traditional ILS use requires extending the final course-aligned course segments sufficiently to provide vertical separation prior to both aircraft being stabilized on their approach guidance. This typically extends the final out to 15-20NM from the airport. Often, airspace or community concerns make such an extension difficult.

5.2 SÃO PAULO INTERNATIONAL AIRPORT / ANDRE FRANCO MONTORO (SBGR)

This airport has very closely-spaced parallel runways (375m lateral and 580m stagger) operating in segregated mode (mode 4 by ICAO definition) leading to a system capacity of approximately 50 movements per hour: one runway is dedicated to landings and the other takeoffs. There are conventional ILS approaches provided for all thresholds, and an RNP-AR approach published for the most used runway for landing (09R). According to the Brazilian Air Navigation Services Provider (DECEA), the published RNP-AR procedure for runway 09R is designed with the focus on fuel conservation, presenting a lateral path using radius-to-fix concept shorter than the conventional ILS and associated vectoring (the RNP-AR minimums are designed according to RNP 0.3 standards). The airport operations due to this design are not yet evaluated in the field since no airlines at the moment have the operational certification to conduct operations on this approach.

Other strategies to increase the runway system capacity of an airport may offer a way to manage increasing traffic demand in Brazil, for example, PRM/SOIA procedures (Precision Runway Monitor/ Simultaneous Offset Instrument Approaches)[6]. Matsuyama

[6] SOIA (Simultaneous Offset Instrument Approaches) allow airports with parallel runways that are 750 to 3000 feet apart to conduct (almost) simultaneous approaches to the two runways. At an airport, one runway uses the ILS PRM approach, while the other runway uses an offset LDA PRM approach (with glideslope). SOIA refers to the LDA PRM approach, where another aircraft is flying the ILS PRM approach ahead. PRM stands for Precision Runway Monitor, which is a high-update radar system allowing for "equivalent" safety with

(2011) formulated a risk assessment model based on Monte-Carlo simulations applicable to PRM/SOIA. For example, with low runway separation, (ICAO 2004) recommends the adoption of special controlled procedures supported by robust risk assessment scenarios in order to mitigate the probability of inadvertent lateral overshoots during the approaches.

Nevertheless, with small runway separations, regulations require the operations to be conducted under visual meteorological conditions (VMC) in order to mitigate this risk. Innovative procedures such as staggered approaches and steep approaches were investigated by (Janic 2008) and (Burnham, Hallock e Greene 2001) of this kind of scenario pointing to potential improvements. Under this line of research (Almeida and Muller, C. 2014) investigated parallel approach scenarios at Sao Paulo International Airport (Guarulhos, SBGR) showing that the capacity on the two runways, separated laterally by 580m, could be potentially increased up to 33%, if separations less than 3NM between parallel paths were adopted under visual meteorological conditions (VMC). This of course required reduction in spacing margins, and relies on visual acquisition of traffic targets to mitigate residual risk for both collision and wake encounters. In early studies (Murayama and Cugnasca 2008) discuss the adoption of Closely Special Parallel Approaches (CSPA), such as the PRM/SOIA used at San Francisco International Airport, at the main Brazilian airports during IFR operations as a feasible solution to absorb the traffic demand growth in Brazil. (Fraga 2009) evaluates PRM/SOIA procedures at SBGR and concludes that a potential increase of 18% in capacity for arrivals may be achieved. Despite such potential, no initiatives for effective implementation of CSPAs have been started at this airport. There are also no additional studies considering different types for approach procedures on both runways (09L and 09R) under simultaneous approach scenarios in instrument meteorological conditions (IMC). With minor redesign changes, the RNPe procedures could be used as the transitions to a SOIA-like operation. Providing guidance for final course alignment as a reference may reduce the likelihood of overshooting the final course line and interfering with traffic on the other approach (a prime concern for SOIA), and reduce pilot and controller workload.

5.3 RIO DE JANEIRO INTERNATIONAL / TOM JOBIM (SBGL)

This airport has two converging runways (50 degree angle), both equipped with ILS and one of them approved for a RNP-AR 0.3 approach, under dependent operations. Airports with this configuration must consider missed approach operations, and how they may interfere with operations to the other runway. The current go around tracks, as defined by the RNAV (GPS) procedures, are crossed over while operating under the converging runways configuration (runways 28 and 33 in Figure 5). However, it may be possible to design RNPe procedures with appropriately-defined missed approach points and tracks such that they can be used in either a dependent or perhaps even an independent mode. It is also worth mentioning that the surrounding traffic to and from Santos Dumont Airport (SBRJ) may make this redesign even more challenging and must be considered in the final solution.

reduced margins. A localizer type directional aid (LDA) is a type of localizer-based instrument approach to an airport. It is used in places where, due to terrain and other factors, the localizer antenna array is not aligned with the runway it serves.

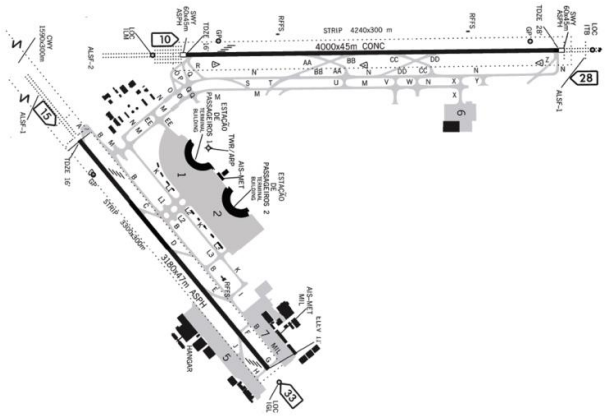

Figure 5: SBGL converging runways configuration

6. CONCLUSIONS

In early 2015, the FAA's NextGen program successfully implemented the RNP established ("RNPe", also referred to as "EoR") operation at Seattle Tacoma International Airport (KSEA) for simultaneous approach operations. The new procedure demonstrated significant potential environmental benefits to local communities, and substantial fuel savings to airlines. In parallel, the International Civil Aviation Organization (ICAO) has begun the process of publishing ATM guidance to make RNP established procedures globally available.

In Brazil, some studies of parallel approach operations (dependent or not) have been conducted with focus on airport capacity only. However, no initiatives using such approaches have been started with a focus on efficiency, capacity increase and environmental benefits. On the other hand, current RNP-AR procedures for some major airports have actually been designed with this objective in mind (assuming only one runway is being used for landings).

RNPe implementations at Sao Paulo, Rio de Janeiro and Brasilia International Airports, combining RNP and ILS operations, may bring environmental and possible capacity benefits to multiple runway configurations. Similarly, the challenging runway configuration at Sao Paulo International Airport (SBGR) may also benefit from a mix of RNPe and PRM/SOIA operations. Finally, although environmental and workload benefits have been demonstrated for simultaneous RNPe operations, the capacity benefits still need further research.

In order to adopt RNPe as a solution for Brazilian airports it is first necessary to collaborate with local industry stakeholders (airlines, airports, regulatory agency ANAC and DECEA) to determine the benefits and establish a roadmap for implementation. The regular RNP-AR certification and approval process should be improved with a new and more detailed risk assessment analysis, which is suggested to be similar to FAA guidelines (FAA, 2011). In order to allow this kind of operation to be conducted in Brazil, new rules need to be developed in addition to the current regulations. Boeing's experience in Seattle assisting the FAA in a similar implementation could be replicated in Brazil with local stakeholders.

7. REFERENCES

Aguiar,C.R. (2005). Modelo Regional da Ionosfera: implementação em tempo real. Dissertação de Mestrado, UNESP. Presidente Prudente, Brazil.

Alaska Airlines press release, 6/30/2105, 10:17 AM http://splash.alaskasworld.com/Newsroom/ASNews/ASstories/AS_20150630_101440.asp

Almeida, R.A., Muller, C. (2014). Aumento da capacidade de Pistas Paralelas e Proximas: um estudo de caso do Aeroporto Internacional de Guarulhos. XIII SITRAER – Air Transportation Symposium, November 17-19,2014. Sao Paulo, Brazil.

Associação Brasileira das Empresas Aéreas, ABEAR (2013). Panorama 2013. Sao Paulo, Brazil.

The Boeing Company (2015). Long Term Market Outlook. Seattle, United Stated, 2015. http://www.boeing.com/commercial/market/long-term-market/ (09/21/2015)

Burnham, D. C., Hallock, J. N., & Greene, G. C. (2001). Increasing Airport Capacity with Modified IFR Approach Procedure for Close-Spaced Parallel Runways. Air Traffic Quarterly, 9(1), 45-58.

Federal Aviation Administration, FAA (2011). “PARC RNP Benefits Sub-Team - RNP Established-Parallel Approach.” Report dated January 10, 2011. Washington, United States.
Federal Aviation Administration, FAA (2014). “ORDER JO 7110.65V – Air Traffic Organization Policy. April 3rd 2014”. Washington, United States.
Fraga, R. T. (2009). Analysis of criteria for closely-spaced parallel runway approaches applied to multiple airport system. Dissertação de Mestrado. Instituto Tecnologico de Aeronautica. Sao Jose dos Campos, Brazil.

M. Marazzo, R. Scherre, and E. Fernandes (2010), “Air transport demand and economic growth in brazil: A time series analysis,” Transportation Research Part E: Logistics and Transportation Review, vol. 46, no. 2, pp. 261–269, 2010.

ICAO, International Civil Aviation Organization. (2004). Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR) - doc 9643 (First ed.).
Janic, M. (2008). Modelling the capacity of closely-spaced parallel runways using innovative approach procedures. Transportation Research Part C, 16, pp. 704-730.

Matsuyama, R. T. (2011). Avaliação de rsico em operações de pouso de aeronaves em pistas paralelas utilizando procedimentos e técnicas CSPA. Dissertação de Mestrado. Escola Politécnica da Univesridade de São Paulo. Sao Paulo, Brazil.

Matsuyama, R. T., Cugnasca, P. S. (2008). Analise comparativa de tecnicas de pouso em psitas paralelas e suas aplicações para o cenário brasileiro. VII SITRAER – Air Transportation Symposium, 380-381,2008 Tr 222. Sao Paulo, Brazil.