Evaluation of a PRM/SOIA Approach Procedure at São Paulo International Airport

PRM/SOIA (Precision Runway Monitor/Simultaneous Offset Instrument Approach), first implemented at San Francisco International Airport in 2004, is an approach procedure that is specifically designed to allow simultaneous approaches at runway systems spaced as close as 750 feet. Once implemented it is expected to increase airport runway capacity and hence contribute to the mitigation of congestions that arise with air traffic growth. São Paulo International Airport runway system is composed of two parallel runways about 1,250 feet apart, and so is unable to handle simultaneous approaches with the current traditional approach procedures. Using, computer simulation (RAMS Plus), this paper addresses the potential impact of the use of a PRM/SOIA approach procedure at São Paulo International Airport (GRU). The results obtained so far indicate potential reductions of 51% in total airborne flight delays with about 18% increase in arrivals capacity at the airport.

Introduction

IATA’s most recent special report on the state of the aviation infrastructure (IATA, 2011 [1]) says that “the tremendous demand for air transport in the coming decades is adding to the pressure for effective aviation infrastructure”. The report leaves no doubt that airport capacity is recognized as of paramount importance for the economic development anywhere as it states “capacity has to be built in all parts of the network to avoid bottlenecks that could limit potential growth”. Specially addressing Latin America and Brazil, the report adds that “problems with São Paulo have led IATA to warn that the country will never fulfill its potential with the current infrastructure”.

Air transportation demand grew fast in Brazil over the last years (INFRAERO, 2011 [2]). INFRAERO is the Brazilian Airport Authority managing the main airports in the country. INFRAERO’s reports on annual movements shows an overall growth over the last five years of about 3.7% per year in aircraft movements and of about 4.9% per year in passenger movements. São Paulo International Airport (GRU) is one of the major airports within INFRAERO’s system of in total 67 airports. It is responsible for about 9.5% of all aircraft movements and for about 17.3% of all passenger movements in 2010. GRU’s growth figures for the last five years round up to 5.0% per year increase in aircraft movements along with 5.4% per year increase in passenger movements. INFRAERO’s investment over the last years has not been sufficient to ease the congestion caused by the steady annual growth. GRU is known (McKinsey, 2010 [3]) to be already at or over capacity both at the runway system and at the passenger terminal system. Therefore, alternatives to increase GRU capacity are on demand, motivating this evaluation of the potential runway capacity improvement that could be achieved with the use of a PRM/SOIA approach procedure at the airport.

Precision Runway Monitor/Simultaneous Offset Instrument Approach

All over the world, research effort has been directed in recent decades to improve airside capacity, showing the extreme importance of increasing airport capacity. Early studies of multiple runways concentrated on reducing the separation between aircraft during simultaneous parallel approaches. The amount of separation reduction that can be safely achieved is highly dependent upon aircraft navigational accuracy. A simulation conducted in 1984 considered runways spaced 3,000, 3,400, and 4,300 ft apart, employing both standard and modified radar displays, using three levels of radar accuracy and radar update rates (Altschuler and Elsayed, 1989 [4]). The study established...
the importance of navigational accuracy in determining system capacity, and it showed the relationships between a number of system parameters and the controllers’ abilities to cope with unexpected events (FAA, 1992 [5]).

The urge to increase the capacity at parallel runways closely spaced led to the creation in the 80s of a Precision Runway Monitor (PRM) approach procedure. The PRM procedure allowed parallel independent instruments (ILS) approaches to runways spaced as close as 3,000 feet. According to ICAO Annex XIV [6] in Chapter 3 a larger separation would be required since it recommends that “where parallel instrument runways are intended for simultaneous use subject to conditions specified in the PANS-ATM ( Procedures for Air Navigation Services - Air Traffic Management) and the PANS-OPS ( Procedures for Air Navigation Services - Aircraft Operations), Volume I, the minimum distance between their center lines should be 1035 m for independent parallel approaches” (that is about 3,400 ft) and allow only dependent parallel approaches at runways as close as 915 m (that is about 3,000 ft).

PRM procedure is supported with digital color displays with alerting algorithms (sound and visual alerts) associated with a PRM radar (Massimini, 2006 [7]) with a one second update rate and a position predictive software that provides controllers with nearly instantaneous aircraft dynamics with the reduced course separation. The advanced displays and enhanced radar surveillance are required to provide the level of safety that is achieved in a more widely spaced runway system (FAA, 2003 [8] and 2006 [9]).

Figure 1 provides a representation of the PRM approach procedure.

With PRM each final approach course is to be monitored by a dedicated controller on his PRM radar monitor. An aircraft deviating from the NOZ (Normal Operating Zone) toward the NTZ (Non Transgression Zone) would immediately triggers the issuance of flight instructions to return the aircraft to its initial approach course. If required breakout or abort-approach instruction would be issued. Currently, according to FAA [10], PRM approaches are conducted at Minneapolis – St. Paul International Airport and Philadelphia International Airport.

PRM/SOIA procedures are built assigning a straight ILS (Instrument landing system) PRM approach to one of the runways (for instance, as indicated for runway 27R in Figure 2) and a convergent LDA (Localizer Type Directional Aid) PRM approach to the other runway (for instance, as indicated for runway 27L in Figure 2). In the event of a simultaneous approach, the ILS PRM approach is assigned to the leading flight while the trailing flight is assigned to the LDA PRM approach. Simultaneous approaches are conducted and radar monitored up to a point where the approach paths are about 3,000 ft apart (indicated as MAP – Missed Approach Point in Figure 2). At this point it is required that the trailing flight performing the LDA PRM approach assures visual contact with the leading flight performing the ILS PRM approach, and from then on flight separation is ensured by the pilots by visual means.

São Paulo International Airport / GRU

Opened in 1985, São Paulo International Airport (GRU – represented in Figure 3) was originally designed to handle medium and long haul domestic flights as well as international flights within South America (Müller and Santana, 2008 [14]). Since then, INFRAERO has made ad hoc arrangements in the passenger terminals and aprons to cope with the changing aircraft and passenger demand that today includes the majority of the Brazilian international traffic (46% of the international aircraft movement and 65% of the international passenger traffic in 2010). 2010 figures account for a total of 250,493 aircraft movements and of 26,849,185 passengers at GRU.
Despite all INFRAERO’s ad hoc arrangements at GRU over the years, it is well known (McKinsey, 2010 [3]) that the passenger terminal, apron and runway systems are already congested. Terminal and apron congestion is expected to be eased soon as construction of a new third terminal and of a new apron is about to be commissioned by INFRAERO and government authorities. The runway system, on the other hand, has no significant improvement planned and a third runway was rejected on grounds of social and environmental restrictions. Therefore, more efficiency is to be required from the actual close spaced parallel (1,250 ft apart) runway system and the PRM/SOIA is expected to be of some help.

**Simulation**

Simulation was chosen to evaluate PRM/SOIA approach procedure at GRU since it allows the representation of the dynamics of simultaneous approach (leading and trailing flights) as well as that of the taxing on the ground in the way to gates. Simulation also allows the representation of the inflight descent for landing using the standard arrival procedures and it also allows for the consideration of the traffic of nearby airports (especially traffic to/from São Paulo Airport – Congonhas).

RAMS Plus, the Reorganized ATC Mathematical Simulator version 5.29.15 (ISA SOFTWARE, 2003 [16] and 2006 [17]), was used to evaluate a PRM/SOIA procedure at GRU.

Two scenarios were created: a) one with current approach procedures in use at the São Paulo Terminal Area (TMA-SP) and b) another considering the availability of a PRM/SOIA approach procedure at GRU. Both scenarios accounted for the three majors airports in the area: São Paulo International Airport (GRU), São Paulo Airport (Congonhas - CGH), and Campinas Airport (Viracopos - VCP). Traffic related to these three airports was simultaneously considered because of the interference they cause on each other once flying the same TMA-SP.

The current scenario considered the Standard Instrument Departure (SID) and Standard Terminal Arrival Route (STAR) procedures regularly in use at the São Paulo Terminal Area (TMA-SP), as seen in Figure 4.

The PRM/SOIA scenario was designed to closely emulate the procedure long in use at San Francisco International Airport (SFO), taking into account the features of the TMA-SP, such as mountains and elevation of the runways (no such features were identified that prevented the use of PRM/SOIA at GRU). The PRM/SOIA procedure was considered for GRU runways 09 since these are in use most often (more than 80%). Figure 5 shows the geometry of the PRM/SOIA procedure developed so that a LDA PRM approach conducts to RWY 09R and an ILS PRM approach conducts to RWY 09L.

As shown, the design considered the LDA PRM approach convergent with a 3° angle with the ILS PRM approach up to a point 5.4 NMi from threshold 09R, from there on up to 1.5 NMi from threshold 09R the approach converges with a 4° angle. The LDA PRM approach when closer than 1.5 NMi to threshold 09R is parallel to the ILS PRM approach and 381 m apart (that is about 1,250 ft). Both approaches were considered using a regular Glide Path angle of 3°. The stabilized final ILS PRM and LDA PRM approaches were considered to start at about 20 NMi from 09L and 09R thresholds (as is the case at the SFO PRM/SOIA approaches).

**Results**

The evaluation was performed with the simulation of the traffic registered
at TMA-SP on June 3, 2008 considering the current approach procedures as well as the availability of the PRM/SOIA procedure for approaches at GRU. Data for June 3, 2008 was the only data available at the time of this study with detailed report of flight development from TMA-SP entrance up to gate parking. Ten simulations runs, allowing random aircraft in flight performance, runway occupancy time and taxi time, were performed for each scenario. Simulated flying time and delays at TMA-SP were recorded and compared for the traffic of the day. A total of 1,030 movements were generated at each simulation run. Average results are shown in Table 1.

The total simulated airborne flight time represents the summation of the flying time from TMA-SP entrance to touchdown for all flights accounted in the simulation. It shows that the use of a PRM/SOIA approach procedure is expected to reduce total in flight time.

Total airborne flight delay accounts for the summation of the time spent in every maneuver, a flight performs that is not associated with the normal completion of the assigned STAR and final approach procedure (such as airborne holding pattern, vectoring and speed reduction). The results indicate that the airborne delay with PRM/SOIA procedure is expected to decrease by 51%. This reduction is mainly due to holdstack time reduction and it causes total expected airborne flight time to be reduced by 15%, although the total flight distance is expected to be increased by 6% with the PRM/SOIA scenario (due to the enlargement of the approach path it requires).

The average airborne delay per aircraft registered in the simulation with the current procedures is at about 10.5 minutes, while with the PRM/SOIA procedure this value is close to 5 minutes. Further analysis of the results indicated that for the same level of airborne delay observed with the current procedures an 18% increase in aircraft movement is expected at GRU with the use of the PRM/SOIA procedure proposed. Thus, PRM/SOIA availability at GRU is expected to result about 18% increase in runway capacity for the same level of delay the current procedures actually impose.

The simulation of a PRM/SOIA approach procedure at GRU showed that it would allow about 18% increase in runway capacity provided the actual level of delay is accepted. This capacity improvement would come very handy as soon as INFRAERO finishes the expected construction of the new third passenger terminal and apron as passenger demand keep on growing.

The results encourage further research on new procedures to enhance TMA-SP and its airports capacity. It would be certainly necessary to re-evaluate the benefits of a PRM/SOIA approach procedure once GRU third terminal and apron is in place, as it will change the way taxing is performed on ground affecting runway capacity. One major question is related to the taxing of a landing aircraft that requires crossing an active runway to reach the new apron and terminal area. Will it cause any capacity reduction?

Alternatives to allow more departures to take place in between arrivals will also be of need, so to reduce the estimated delay on ground for departing flights. This could be eventually achieved reducing the required separation between arriving and departing flights, using the approach speed of the landing aircrafts as possible. Further study will be required to evaluate the economic impact of this longer waiting for take-off for the airlines and the airport, this study has not addressed this question.

### Conclusions

The results obtained with the simulation indicate that significant reductions in airborne delays (51%) can be achieved at TMA-SP with the implementation of PRM/SOIA approaches at São Paulo International Airport (GRU). However, as expected, the average time on the ground for departing aircraft is expected to increase, due to an increase in the arrivals at GRU, resulting longer queues for takeoff.

The side effect of a PRM/SOIA approach procedure at GRU, as it benefits mainly arriving flights, is that it would cause larger waiting times for departing flights, as can be seen in Table 1 for the total ground departure queue delay, expected to rise by 13%. This rise is mainly due to the need for departing flights to wait longer for a gap in between arrivals that allows for a takeoff to be
guidance. Eventually, one more take-off could be squeezed in between landings when the leading landing aircraft uses a faster approach speed and is trailed by a landing aircraft with a much slower approach speed. The evaluation of the impact of different separation scenarios of this sort will be required.

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**End Note**

i RAMS Plus and ATM Analyzer utilization in this study is in accordance with the Academic Software License Agreement granted by ISA Software Ltd. to ITA.

**References**


**Photo 1:** Precision approach at São Paulo. Photo made by Igorerzen (panoramio.com/photo/14601810). Also page 1.