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Safety Study Report on Final Approach Fix (FAF) Compression

Flight Systems Laboratory
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Safety Study Report on Final Approach Fix (FAF) Compression

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Technical Report

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12. Abstract

This report is in response to a request for analysis work by the Strategic Operations Group, AJT-28, proposing reduced in-trail separation between arrivals once aircraft have reached the Final Approach Fix (FAF). This proposal is aimed at minimizing the decrease in capacity that occurs when poor atmospheric conditions require a change from Visual Flight Rules (VFR), where aircraft on final approach can compress with visual separation, to Instrument Fight Rules (IFR), where Air Traffic Controllers (ATC) must maintain radar separation. The purpose of this report is to determine the impact of allowing in-trail separation to decrease once the lead aircraft reaches the FAF during Instrument Meteorological Conditions (IMC).

Results from the analysis showed that the proposal to allow decreased separation between arrival aircraft once the lead aircraft is inside the FAF does decrease the RVT as operations are currently run. At the same time, the proposal would increase the missed approach/go-around rate of a given runway. The results showed that the proposal would produce missed approach/go-around rates of 16.6% and 6.67% for ATL and ORD Runway 27L, respectively. In conclusion, this increased missed approach/go-around rate would introduce more inefficiencies to the flow of traffic than could be gained from the decreased RVTs. Until there can be some assurance that a lead aircraft will maintain or exceed a minimum speed (dependent on the speed of the trailing aircraft) inside the FAF, a buffer distance at the FAF will be necessary.

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Executive Summary

This report is in response to a request for analysis work by the Strategic Operations Group, AJT-28, proposing reduced in-trail separation between arrivals once aircraft have reached the Final Approach Fix (FAF). This proposal is aimed at minimizing the decrease in capacity that occurs when poor atmospheric conditions require a change from Visual Flight Rules (VFR), where aircraft on final approach can compress with visual separation, to Instrument Fight Rules (IFR), where Air Traffic Controllers (ATC) must maintain radar separation. The purpose of this report is to determine the impact of allowing in-trail separation to decrease once the lead aircraft reaches the FAF during Instrument Meteorological Conditions (IMC).

Through analysis of Airport Surface Detection Equipment System (ASDE-X) data from all arrival runways at Hartsfield-Jackson Atlanta International Airport (ATL) and Runway 27L at Chicago O'Hare International Airport (ORD), the impact of reducing in-trail separation inside the FAF was calculated. The amount of Runway Vacancy Time (RVT) was measured between arrivals at each runway. The ideal result for this proposal would be RVTs that are near, but not less than zero. A negative value for RVT would result in either a runway incursion or missed approach/go-around.

Results from the analysis showed that the proposal to allow decreased separation between arrival aircraft once the lead aircraft is inside the FAF does decrease the RVT as operations are currently run. At the same time, the proposal would increase the missed approach/go-around rate of a given runway. The results showed that the proposal would produce missed approach/go-around rates of 16.6% and 11.2% for ATL and ORD Runway 27L, respectively.

In conclusion, this increased missed approach/go-around rate would introduce more inefficiencies to the flow of traffic than could be gained from the decreased RVTs. Additionally, Terminal Procedures (TERPS) 8260 series orders pertaining to missed approach obstacle protection are based, in part, on the missed approach/go-around nominal rate of 1%. As such, there would be at least a ten-fold risk increase based upon the missed approach/go-around portion of the Collision Risk Model (CRM) used for TERPS. Until there can be some assurance that a lead aircraft will maintain or exceed a minimum speed (dependent on the speed of the trailing aircraft) inside the FAF, a buffer distance at the FAF will be necessary.

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1.0. Introduction

In September 2009, the Flight Systems Laboratory, AFS-450, began receiving Airport Surface Detection Equipment System (ASDE-X) data to analyze the in-trail compression of arrival aircraft inside the Final Approach Fix (FAF). The request for analysis work by the Strategic Operations Group, AJT-28, proposed that allowing the in-trail separation between arrivals to decrease once aircraft had reached the FAF would optimize the use of each runway and therefore increase the capacity of the airport. This proposal is aimed at minimizing the decrease in capacity that occurs when poor atmospheric conditions require a change from Visual Flight Rules (VFR), where pilots can compress with visual separation, to Instrument Fight Rules (IFR), where Air Traffic Controllers (ATC) must maintain radar separation. The current radar separation rules in FAA Order 7110.65T, Air Traffic Control, (Reference 1) paragraph 5-9-7c.3, requires that the in-trail separation never decrease below 3 nautical miles (NM) until visual separation is applied, the lead aircraft reports the approach lights or runway is in sight, or the lead aircraft is within 1 NM of the runway threshold. According to the Strategic Operations Group’s proposal, this standard unnecessarily leads to extended time periods where the runways are vacant between arrivals. The purpose of this report is to determine the impact of allowing in-trail separation to decrease once the lead aircraft reaches the FAF during Instrument Meteorological Conditions (IMC).

2.0. Proposal Description

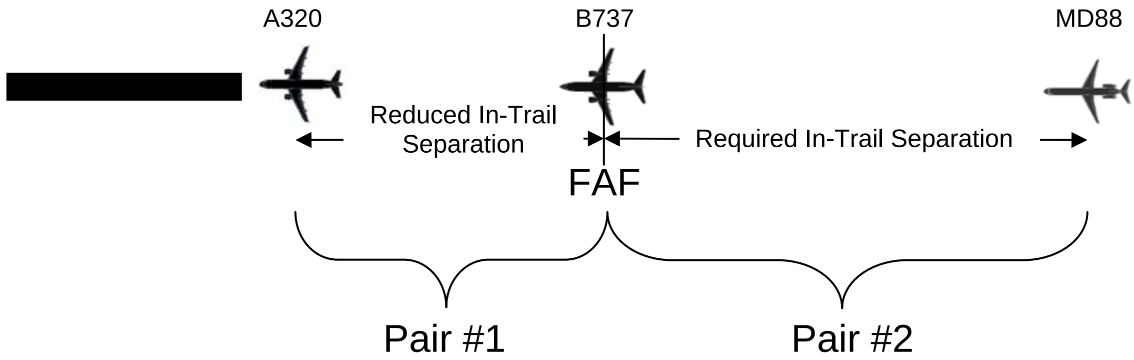

Figure 1: Proposal Diagram

In Figure 1, an example stream of traffic on approach to the same runway is shown. Simplifying the stream into pairs of aircraft, Pair #1 consists of an A320 as the lead aircraft in the pair and a B737 as the trailing aircraft. Pair #2 consists of a B737 as the lead aircraft and an MD88 as the trailing aircraft of that pair. After the A320 in Pair #1 exits the runway, the runway is vacant or unoccupied until the trailing aircraft, B737, crosses the runway threshold. This represents a positive Runway Vacancy Time (RVT). For the most efficient use of the runway, the RVT should be minimized to zero. This means that the trailing aircraft would cross the runway threshold at the same time that the leading aircraft has cleared the runway surface. Assuming traffic is awaiting arrival to the runway, i.e., during peak traffic periods, and there are no additional safety factors such as weather conditions or wake turbulence to consider, excessive values for runway vacancy time represent unnecessary flight time that adds to time delays and fuel costs. On the other hand, if the B737 reaches the runway threshold before the A320 has sufficient time to clear the runway then Air Traffic must direct the B737 to perform a go-around if a runway incursion (two aircraft on the same runway at the same time) is to be avoided. As a result, a negative RVT value of -5 seconds would have a greater detrimental effect on operational efficiency than a positive RVT value of 50 seconds. As an example, a go-around that lasts 5 minutes caused by a -5 second RVT would be much worse than a 50 second positive RVT.

While a zero RVT value would mean maximum efficient runway use, the ATC must work with some limitations that hinder consistent efficiency. One of the limitations is the varying speeds of aircraft inside the FAF. Due to different reference landing speeds, V_{ref}, that can be unique among each aircraft, FAA Order 7110.65, paragraph 5-7-1 states that the ATC cannot provide speed control once aircraft are inside of the final approach fixes. This introduces an unknown parameter to the ATC trying to maintain required separation distances. Based upon aircraft type and previous experience, an ATC may decide a buffer distance in addition to the required separation distance is necessary to guarantee that minimum separation is exceeded or maintained until either visual separation is applied, the lead aircraft reports the approach lights or runway is in sight, or the lead aircraft is within 1 NM of the runway threshold. This buffer distance is based on ATC's experience and best estimator for the decelerations and speeds of two separate aircraft as they approach the FAF. Among the questions that this analysis seeks to answer: Are these buffer distances for the purpose of maintaining required separation inside the FAF really necessary and what capacity effect could be expected if they were not required?

Since the basis for the FAF Compression analysis request is rooted in the capacity drop from VFR to IFR, a comparison of RVT values during both meteorological conditions is beneficial for quantifying potential gains in capacity. Figure 2 provides an IFR to VFR comparison for current RVT values from every arrival runway at Hartsfield-Jackson Atlanta International (ATL) airport from December 6th to 20th, 2009. IFR arrivals were determined by METAR reports where IMC was defined to be visibility less than 3 NM or ceiling less than 1000 feet. This conservative definition of IMC helps to ensure that the arrivals within the analyzed IFR data set are not compressing due to visual separation. As the analysis is interested in periods of high traffic, the shown data is filtered to only include aircraft pairs where a trailing aircraft was within 120 seconds of the lead aircraft at the runway threshold. Additionally, aircraft pairs where a Heavy/B757 is the lead aircraft were also omitted from consideration in this analysis due to wake turbulence separation requirements. Decreases in runway efficiency are evident in Figure 2 as poor weather conditions lead to IFR arrivals. The average runway vacancy time increases from 44.1 seconds for VFR arrivals to 56.2 seconds for those arrivals during IFR.

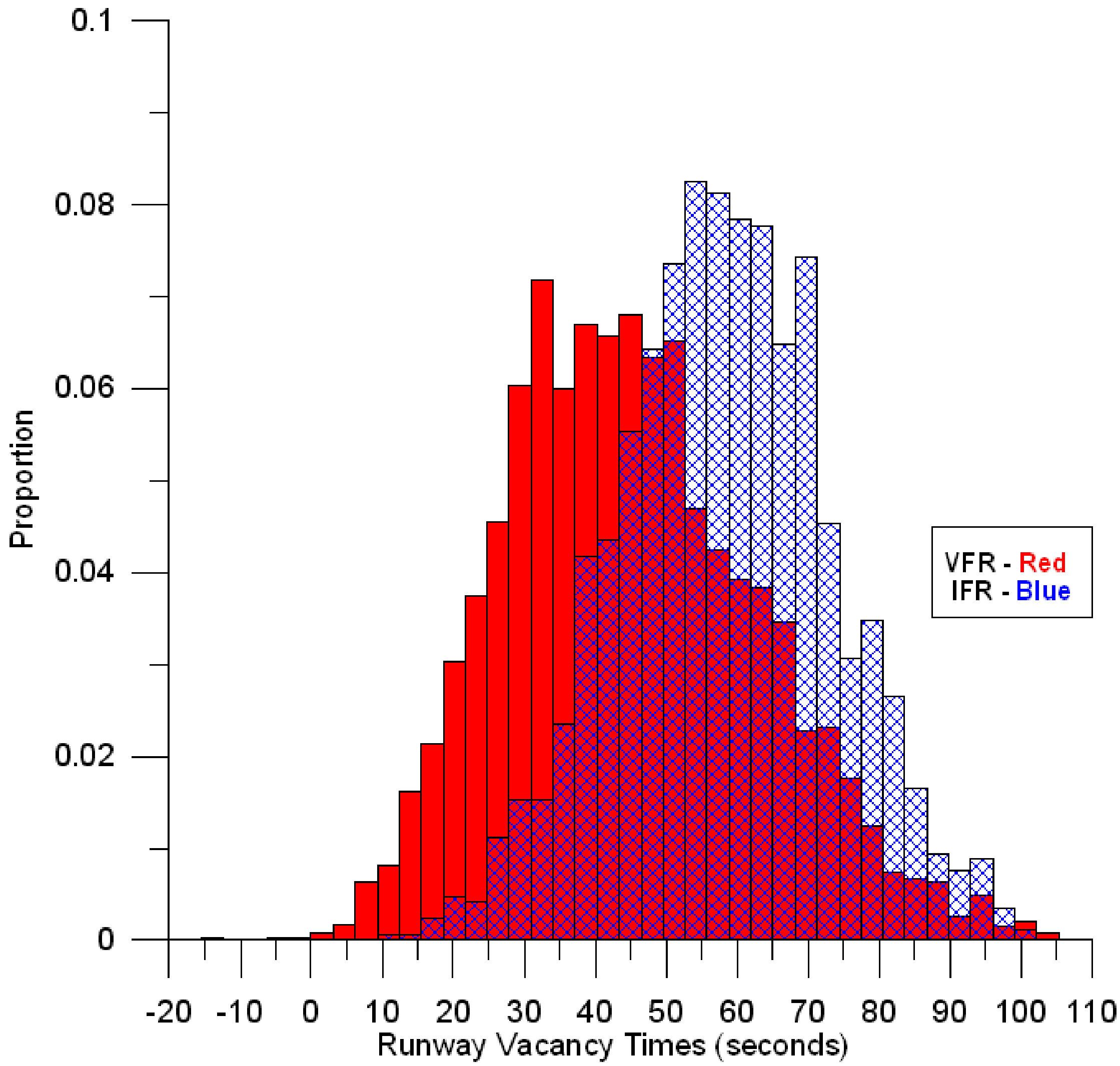

Figure 2: ATL Vacant Runway Times

3.0. Analysis Methodology

Having established potential gains in capacity during IFR arrivals as suggested by the AJT-28 analysis proposal, does the proposed solution of allowing reduced separation inside the FAF duplicate the type of runway vacant times that have been recorded during VFR arrivals? To answer this question, the ASDE-X data is processed to extract the time required by each aircraft to complete two different segments of their arrival. Figure 4 shows the specific segments that are extracted in the analysis. The first segment of interest is the time for each aircraft to travel from 3NM outside the FAF to the runway threshold, defined in Figure 3 as t_{Trailing}. The second recorded segment starts from the FAF and ends as the ASDE-X target location leaves the runway, defined as t_{Leading}. This is to say that there could still be a portion of the aircraft over the runway surface depending on the transponder location within the airframe. Future analyses could include a more conservative approach to runway exit time by moving the recording boundary to some distance outside the runway surface boundary to provide greater confidence that the aircraft has vacated the runway entirely.

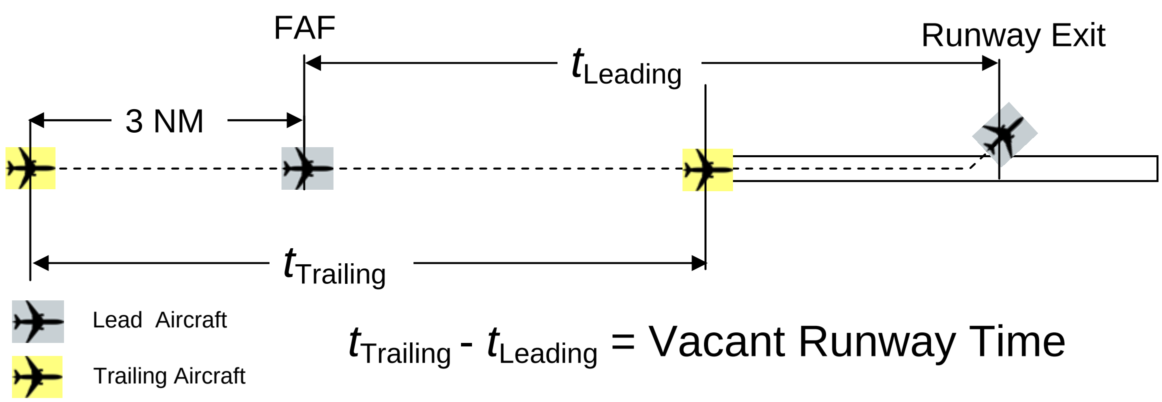

Figure 3: Methodology

The next step is comparing the recorded arrival time segments by using the ASDE-X data of the traffic as it arrived to each runway. For example, if XAL123 arrived to runway 27L and then was followed by YAL1321 on December 6th, 2009 at 6:08AM to the same runway 27L then a comparison can be made between t_{Trailing} of YAL1321 to t_{Leading} of XAL123, and it can then be determined how the runway vacancy time of Runway 27L would have been affected if the two aircraft were separated by 3NM as XAL123 crossed the FAF. The data was filtered to exclude aircraft pairs where the lead aircraft was a Heavy/B757 or where the trailing aircraft was more than 120 seconds behind the leading aircraft as the leading aircraft reached a distance of 3NM from the runway threshold. The second condition eliminates time periods when the runway is vacant due to breaks in traffic. In total, 11,280 ATL arrivals and 256 ORD Rwy 27L arrivals were captured from the ASDE-X data. After filtering the conditions listed above, the IFR data included 1,700 ATL and 89 ORD Rwy 27L arrivals, while the VFR data included 3,468 ATL and 80 ORD Rwy 27L arrivals.

It should be noted that if all aircraft were being separated at exactly 3 NM as this analysis assumes rather than the varying distances between 3.5 to 5 NM that occurred in the ASDE-X data then it is safe to assume that ATC would exercise stricter speed control farther out from the FAF. The ATL traffic analysis results should be considered as very conservative since stricter speed control would probably have been used if the FAF separations were reduced. The Chicago O'Hare International Airport (ORD) Runway 27L traffic results are still conservative as all aircraft pairs were not at 2.5 NM as was assumed, but most separation was closer to 3 NM and represent a less conservative result as compared to the ATL analysis.

4.0. Analysis Results

4.1. ATL with 3 NM Initial FAF Separation

The results of the analysis are shown in Figure 4 with comparisons to current RVT values for VFR and IFR arrivals. The implementation of FAF Compression reduces the runway vacancy time between aircraft pairs; however, it comes at the expense of a 16.6% (282 out of 1700 arrivals) negative RVT rate. This may be significantly detrimental to IFR arrival operations, outweighing any benefit from reduced runway vacancy times.

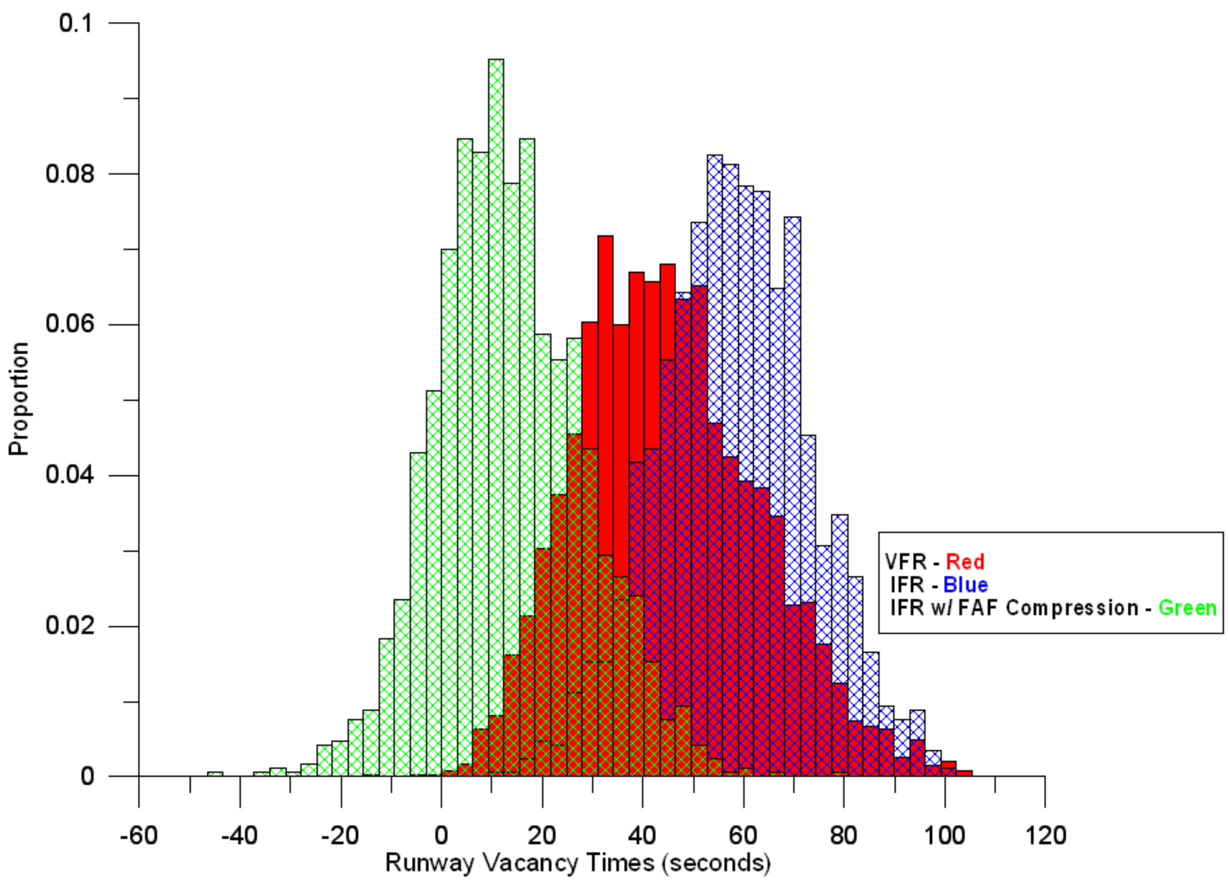

Figure 4: ATL Vacant Runway Time with FAF Compression

4.2. ORD Runway 27L with 2.5 NM Initial FAF Separation

In an effort to further test the FAF compression proposal in a different environment, ORD airport was selected, specifically Runway 27L. This runway was chosen for its high traffic capacity and relatively low runway occupancy times for each arrival. Additionally, Runway 27L is one of the runways that waiver approval to receive arrivals spaced at an in-trail distance of 2.5 NM, therefore this test assumes an initial in-trail separation of 2.5 NM as the lead aircraft reaches the FAF. The sample size for this test is less than the ATL analysis, because specific times were extracted based upon weather conditions and peak traffic periods.

Comparing the ORD Runway 27L arrivals to the ATL arrivals, there is not the same increase in RVT values when atmospheric conditions require IFR. The RVT values are very similar regardless of whether the arrivals are VFR or IFR. Similar to the results of the ATL analysis, the implementation of FAF Compression decreases RVT values, but with the detriment of an increased missed approach rate of 11.2% (10 out of 89 arrivals).

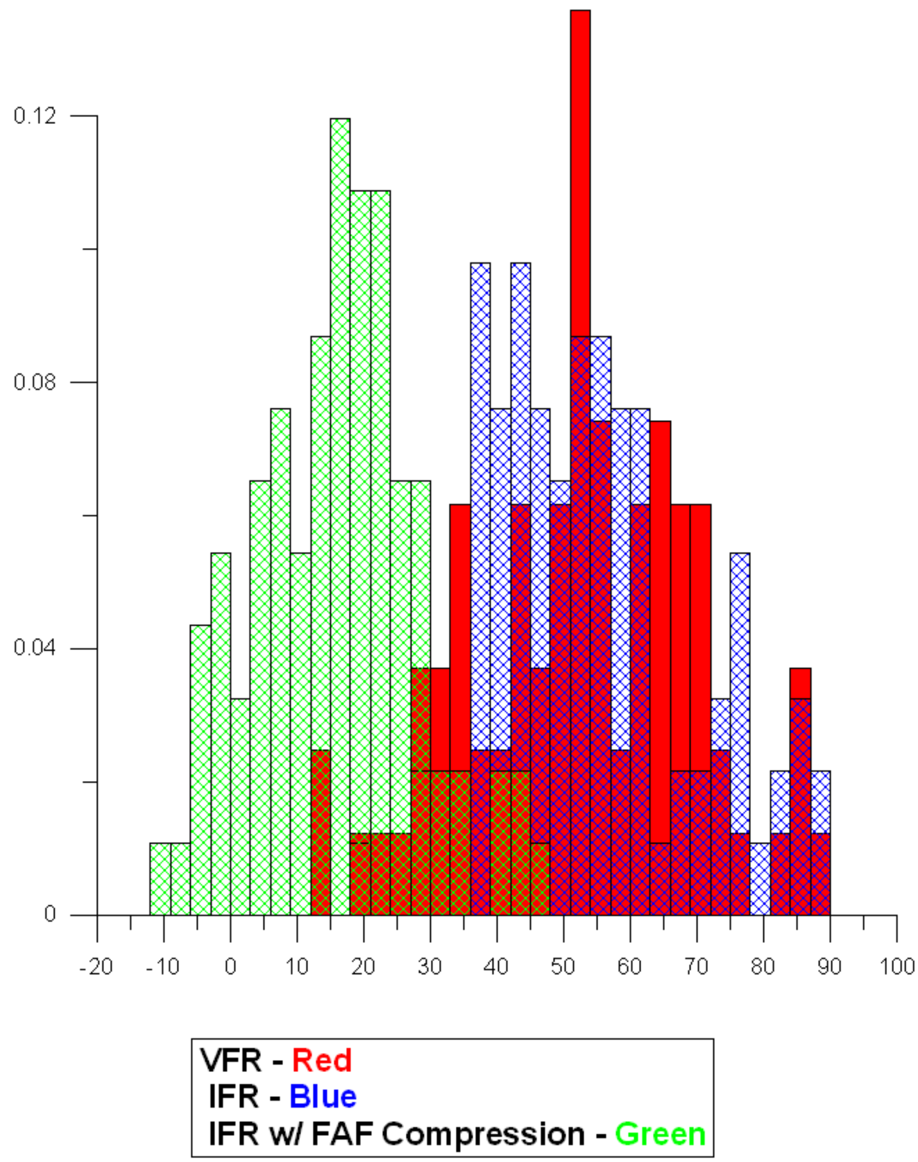

Figure 5: ORD 27L Vacant Runway Times

5.0. Conclusions

Results from the analysis showed that the proposal to allow decreased separation between arrival aircraft once the lead aircraft is inside the FAF does decrease the RVT as operations are currently run. At the same time, the proposal would increase the missed approach/go-around rate of a given runway. The results showed that the proposal would produce missed approach/go-around rates of 16.6% and 11.2% for ATL and ORD Runway 27L, respectively. In conclusion, this increased missed approach/go-around rate would introduce more inefficiencies to the flow of traffic than could be gained from the decreased RVTs. Additionally, Terminal Procedures (TERPS) 8260 series orders pertaining to missed approach obstacle protection are based, in part, on the missed approach/go-around rate. Such an increase in the missed approach/go-around rate, as demonstrated in this study, would result in more than ten times the current nominal rate of 1 in 100. As such, there would be at least a ten-fold risk increase based upon the missed approach/go-around portion of the Collision Risk Model (CRM) used for TERPS. Until there can be some assurance that a lead aircraft will maintain or exceed a minimum speed (dependent on the speed of the trailing aircraft) inside the FAF, a buffer distance at the FAF will be necessary.

6.0. Reference

1. FAA Order JO 7110.65T CHG 2, Air Traffic Control, 3/10/2011.