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WAKE VORTEX CAPACITY BENEFITS FOR SIMULTANEOUS APPROACHES AT ST. LOUIS AIRPORT

Prepared for

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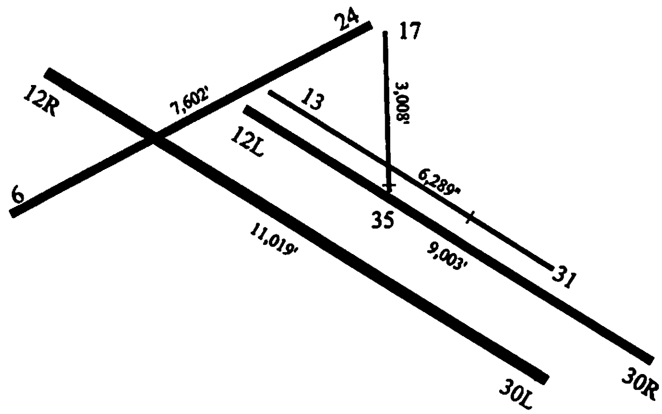

Figure 1 St. Louis Lambert Runways

1. INTRODUCTION

This paper details the results of FTA's investigation into the potential capacity gains of applying 1.5 nautical mile (NM) diagonal separation between parallel arrival operations at St. Louis Lambert International Airport (STL). Currently, dependent parallel arrivals are permitted only when runways are separated by 2,500 feet or more due to concern over wake vortex turbulence. If conditions exist which eliminate or reduce this effect, the application of diagonal separation may be permitted between runways separated by less than 2,500 feet. A similar study was completed for Boston's Logan International Airport and much of the material in this memorandum reflects the previous Logan analysis[1]. Figure 1 depicts the existing runway layout at STL. The centerline separation between Runways 30L and 30R is approximately 1,350 feet. The manner in which the runways are used is dependent upon several factors including weather, traffic demand, and the type of aircraft operation (e.g. jet versus propeller). Information on STL operations was obtained from the STL Tower and the Air Traffic Division of the FAA Central Region Office.

1.1 RUNWAY USE

According to data provided by STL Tower[2], a six-month sample of runway use indicates that Runways 30L/R serve as the primary runways slightly over 60 percent of the time. For the remaining 30 percent, 12L/R are the primary runways. The division of arriving aircraft between runways 30L and 30R is based primarily on origin or destination. For example, aircraft departing to the west would most likely be assigned to Runway 30L; aircraft departing to the east would use Runway 30R. ILS approaches are published for 30L/R and 12L/R.

When 30L/R are in use, Runways 24 and 31 serve as secondary runways if weather conditions permit (i.e. the winds are favorable, the ceiling is not less than 1,200', and there is at least 5 miles of visibility). Runway 24 is used by both arrivals and departures (mixed mode) while Runway 31 is used only for departures of the smaller aircraft categories.

Separation between simultaneous operations on Runways 24, 31, 30L and 30R is achieved by applying a combination of standard IFR separation, use of the Converging Runway Display Aid (CRDA), and visual separation. Once the ceiling becomes less than 1,200' or the visibility less than 5 miles, STL will utilize the CRDA to separate simultaneous instrument arrival operations to a configuration consisting of mixed operations on Runways 24 and 30R if wind speed and direction permit.

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[1] See FTA-TM-503-2r2, *FTA Runway Capacity Model (RUNCAP) and Delay Simulation (DELAYSIM) Analysis*, 12 April 1994.

[2] See Appendix A

In order to model the STL operation, specific aircraft types must be assigned to a runway. The assignments shown in Table 1 have been used for the RUNCAP model. The percentages of each aircraft type assigned to the runways were discussed with STL Tower and are intended to represent the average balance between the runways. There are no restrictions on the aircraft types which may use Runways 30L/R. This in contrast to airports, such as Logan, which have noise abatement programs that can limit jet operations on a particular runway. Runway 31 is limited to the smaller aircraft types due to its length.

TABLE 1
STL RUNWAY ASSIGNMENTS
(30L, 30R & 31)

Weather Conditions Less than 1,200'/5nm				
% of Ops	30L	30R	31	Total
Arr-Jet	60	40	0	100
Arr-Prop	40	60	0	100
Dep-Jet	60	40	0	100
Dep-Prop	25	60	15	100
The mix is 72% jets, 28% props				

1.2 AIRCRAFT FLEET MIX

Based on data obtained from the May 1993 issue of the *Official Airline Guide*, the operations at STL were broken into the following weight classes: Heavy (H) 2.7%, B-757 (L7) 0.2%, Large (L) 95.9%, and Small (S) 1.2%. The results of applying these figures to the runway assignment percentages are shown in Table 2.

TABLE 2
STL RUNWAY ASSIGNMENTS
(% of Ops)

Arrivals	30L	30R	31
Arr-H	2.7	0.0	0.0
Arr-L7	0.2	0.0	0.0
Arr-L	52.2	43.7	0.0
Arr-S	0.5	0.7	0.0
Total Arr			100.0
Departures	30L	30R	31
Dep-H	1.6	1.1	0.0
Dep-L7	0.1	0.1	0.0
Dep-L	48.2	43.7	4.0
Dep-S	0.3	0.7	0.2
Total Dep			100.0

1.3 SEPARATION STANDARDS

Tables 3 through 5 illustrate the IFR separation standards in use at STL. Since the total distance between the three parallel Runways 30L/R, and 31, is less than 2,500', they are all considered as a single runway for wake vortex separation purposes. Due to this, adjacent operations are separated using the "in-trail" radar distances shown in the tables. For example, an aircraft arriving to Runway 30R must be separated from a 30L departure by 2 miles (which must increase to 3 miles within 1 minute after depature). The application of visual separation by the tower or pilots, or the use of visual approaches has not been considered for two reasons. First is the lack of reliable information on the actual separations achieved under these conditions. More significantly, the focus of this effort is to evaluate the potential for increasing capacity under IFR conditions when additional capacity is most needed.

Table 3
Existing IFR Radar Arrival-Arrival Separations (Nautical Miles)

Weight Class and Runway Assignment for **Lead** A/C	Weight Class and Runway Assignment for **Trailing** A/C									
	H-30L	L7-30L	L-30L	S-30L	H-30R	L7-30R	L-30R	S-30R	H-31	NH-31
H-30L	4.0	5.0	5.0	6.0			5.0	6.0	No Arrivals to Runway 31	
L7-30L	4.0	4.0	4.0	4.0			4.0	4.0		
L-30L	2.5	2.5	2.5	4.0			2.5	4.0		
S-30L	2.5	2.5	2.5	2.5			2.5	2.5		
H-30R	No Heavy or B-757 Arrivals to 30R									
L7-30R										
L-30R	2.5	2.5	2.5	4.0			2.5	4.0		
S-30R	2.5	2.5	2.5	2.5			2.5	2.5		
H-31	No Arrivals to Runway 31, No Heavy or B-757 arrivals to Runway 30R									
NH-31										

Hatched areas show where diagonal spacing of 1.5 nm was used in leu of standard "in-trail" radar spacing. NH = Non-Heavy, B-757 separation reflects changes effective 1 July 1994

Table 4
Existing IFR Departure-Departure Separations (Seconds)

Weight Class and Runway Assignment for **Lead** A/C	Weight Class and Runway Assignment for **Trailing** A/C									
	H-30L	L7-30L	L-30L	S-30L	H-30R	L7-30R	L-30R	S-30R	H-31	NH-31
H-30L	120	120	120	120	120	120	120	120		120
L7-30L	60	60	60	60	60	60	60	60		30
L-30L	60	60	60	60	60	60	60	60		30
S-30L	60	60	60	60	60	60	60	60		30
H-30R	120	120	120	120	120	120	120	120		120
L7-30R	60	60	60	60	60	60	60	60		30
L-30R	60	60	60	60	60	60	60	60		30
S-30R	60	60	60	60	60	60	60	60		30
H-31	No Heavy Departures from Runway 31									
NH-31	30	30	30	30	30	30	30	30		60

30 sec. used for 31 departures versus Runway 30L/R-other than heavies

Table 5
Existing IFR Radar Arrival-Departure Separations (Nautical Miles)

Weight Class and Runway Assignment for **Lead** A/C	Weight Class and Runway Assignment for **Trailing** A/C									
	H-30L	L7-30L	L-30L	S-30L	H-30R	L7-30R	L-30R	S-30R	H-31	NH-31
H-30L	2	2	2	2	2	2	2	2	No Heavy A/C Rwy 31	2
L7-30L	2	2	2	2	2	2	2	2		2
L-30L	2	2	2	2	2	2	2	2		2
S-30L	2	2	2	2	2	2	2	2		2
H-30R	2	2	2	2	2	2	2	2		2
L7-30R	2	2	2	2	2	2	2	2		2
L-30R	2	2	2	2	2	2	2	2		2
S-30R	2	2	2	2	2	2	2	2		2
H-31	No Heavy A/C Runway 31									
NH-31	2	2	2	2	2	2	2	2		2

A departure may initiate takeoff roll as long as the arrival is 2 miles away and separation will increase to 3 miles within 1 minute

2. SCENARIOS

Four scenarios were used to examine the benefits of applying diagonal separation at STL. Two of them considered arrivals and departures to Runways 30L/R alone; the other two included departures on Runway 31 as well.

2.1 SCENARIO DEFINITION

The separation standards shown in Tables 3 through 5 represent the baseline scenario in which existing wake vortex separation standards are applied. The second scenario considered utilizes a proposed diagonal separation of 1.5 NM between adjacent arrival operations. The use of the diagonal separation is assumed to be restricted to crosswind conditions that would be insufficient to push vortices created by arrivals to Runway 30L over to Runway 30R. This has not yet been defined for STL, but is estimated to consist of a "southwestern crosswind component" which is less than or equal to approximately 4 knots. Higher crosswinds from the northeast which push vortices in the opposite direction (towards 30L) would be acceptable up to the operational limits of the aircraft involved. In either case, 1.5 NM would not be used between a 30R arrival and a subsequent 30L arrival of a smaller weight class. Heavy and B-757 aircraft are, therefore, restricted in the scenario to landing on Runway 30L. These two primary scenarios were also analyzed both with and without Runway 31 being used as a secondary departure runway. Finally, each of the four scenarios was investigated with departures representing 40, 50 and 60 percent of the total operations. In all, 12 separate cases were analyzed by RUNCAP.

2.2 BASIC ASSUMPTIONS

Several assumptions were required to define the scenarios including:

- Weather minima exist which allow this operation (as described above)
- The fleet mix remains constant
- Only IFR separation standards are used
- No changes to existing in-trail radar separations were made
- Runways are used as illustrated in Tables 1 and 2
- Departure/Arrival separation is unchanged from current standards
- Departure operations on 30L, 30R and 31 are dependent
- 30 seconds was allowed for departures to clear Runway 31
- Aircraft will maintain similar speeds on final
- Controller workload levels will be decreased through automation

3. RESULTS AND CONCLUSIONS

FTA's RUNCAP (Runway Capacity) model was used to determine the theoretical runway capacity for each of the scenarios described above. The figures in Table 6 represent the saturation capacity in hourly operations.

TABLE 6
RUNCAP RESULTS: STL MAY 1993 FLEET MIX

Runway Use	Separation Rules	Arrivals Only	40% Departures	50% Departures	60% Departures
A&D 30L/R D 31	Existing Radar	35	58	64	70
A&D 30L/R	Existing Radar	35	57	63	69
A&D 30L/R D 31	1.5 Radar	40	66	67	70
A&D 30L/R	1.5 Radar	40	65	65	69

The results of the analysis indicate that application of the 1.5 NM diagonal separation as described in this memo could increase STL arrival capacity by 7 to 8 operations per hour when Runways 30L/R are in use. According to data provided by STL, this is the most frequently used configuration. Increases in capacity would primarily be gained when arrival operations are 50 percent or more of the traffic mix and the weather is less than 1,500/5. When better weather conditions prevail, the application of visual separation between operations would likely increase capacity beyond the use of 1.5 NM diagonal radar separation. The frequency of occurrence of STL weather below this minima should be investigated to establish the need for further development of such separation standards. Additionally, the homogeneous fleet mix (over 95 percent Large aircraft) further enhances the ability to apply diagonal separation as described in this memo. With greater percentages of heavy and small aircraft, additional spacing is required and the overall benefits of diagonal spacing are reduced.

4. OTHER ISSUES

Several additional issues must be explored in order to demonstrate the feasibility of the proposed 1.5 NM diagonal spacing. These issues would primarily concern the safety of such an operation. The strategy modeled would require changes to the current rules for dependent approaches to parallel runways separated by less than 2,500 feet. A safety substantiation process would be necessary to demonstrate that the new strategy is consistent with current accepted levels of safety. The following sections briefly discuss other areas which must be investigated further.

4.1 CONTROLLER WORKLOAD AND EQUIPMENT

The decrease in separation between IFR operations and the complexity of applying diagonal separation would significantly increase demands upon the controller. In order to offset the increased workload, advanced automated systems could be adapted or developed specifically for this type of operation. Such systems might include displays similar to the Converging Runway Display Aid (CRDA) now in use at STL. The CRDA provides a "ghost" target to assist in applying the required separation between successive approaches to converging runways. The use of ghost targets could be modified to provide a "vector point" on final and thus free the controller from estimating appropriate separation standards; each subsequent arrival could simply be vectored directly to the indicated point.

Additional equipment requirements might include the Precision Runway Monitor (PRM) which combines a high-update radar with a high resolution display. This equipment allows the controller to more closely monitor the progress of aircraft on final approach. Additionally, software to provide short-term collision alerts based on projected flight paths can aid the controller in identifying and resolving potential conflicts.

Due to higher levels of IFR traffic, the need for voice communications will increase. The provision of a data-link system such as Mode-S would allow routine communications such as airport conditions and weather to be up-linked directly to the aircraft from the ATC facility. This would free controllers from the need to make routine, standard transmissions and allow voice communications to be concentrated on control instructions.

4.2 BLUNDER DETECTION AND RESOLUTION

With parallel runways separated by as little as 1,350 feet, it must be demonstrated that potential losses of required separation can be quickly detected and resolved. Consideration must be given to pilot/controller reaction times, and the procedures to be used in the event of a blunder. The existing PRM system has been used to monitor independent parallel arrival operations for runways separated by as little as 3,400 feet. Further investigation in this area is required.

APPENDIX A

Data Provided by STL Tower