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Revised PREFERENTIAL RUNWAY ADVISORY SYSTEM (PRAS)

Summary

Prepared for

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Preferential Runway Advisory System (PRAS)

PRAS at Logan is a computer system that produces recommendations to the FAA controllers for selecting runway configurations that will provide a more equitable distribution of the airport's noise impacts on the surrounding communities. Logan has a long history–over 25 years–with preferential runway systems.

History of Preferential Systems at Logan

1968 - FAA Order 7110.13 authorizes formal and informal runway use programs for noise relief.
- Logan initiates preferential runway procedures with simple priority selection methods.

1977 - Massport contracts BBN to conduct Preferential Runway Study for Logan.
- FAA issues Letter to Airmen with runway selection priorities, including 15L/33R nocturnal priority.

1978 - FAA Order 7110.81 on Runway Use Programs provides additional guidance. It notes that such programs are second only to considerations of safety, and that they may result in operational penalties.
- BBN study (phase 1) report: Preferential Runway Committee established; 6 alternatives examined; recommended alternative to minimize exposure above 70 & 75 Ldn without significantly increasing exposure above 65 Ldn.

1980 - New departure tracks for runway 22R are implemented at Logan.
- Preferential Runway Study Phase 2 initiated by KEE.

1982 - FAA Order 8400.9 issued with National Safety and Operational Criteria for Runway Use Programs.
- Phase 2 study completed: annual goals, as well as dwell and persistence criteria are quantified and adopted by PRAS advisory committee; manual and computerized version of PRAS developed.

1983 - Initial version of PRAS installed at Logan for one-year test.
- Massport and KEE implement modifications to PRAS.

1984 - KEE review of 1983 PRAS performance: Arrivals on runways 4 & 22 and departures on runways 4 and 9 are above goals; persistence and dwell have significant impact on annual goal exceedences.

1885-7 - FAA finds PRAS increasingly difficult to accept due to growing traffic volumes at Logan and new/modified operational procedures.

1988 - Massport contracts FTA for feasibility study of enhanced PRAS to deal with increased traffic levels, improved Logan operations, and need for increased flexibility.

1989 - FTA phase 1 report delivered: PRASIM demonstrates potential benefits of enhanced PRAS; system specifications prepared.

1990 - FTA phase 2 effort initiated to design enhanced PRAS.

1991 - FAA increases involvement in new development.

1992 - Enhanced PRAS prototype & users' manual completed. FAA & Massport training sessions.

1993 - Enhanced PRAS installed for FAA operational evaluation. FAA requests additional features & full automation of data entry.

1995 - FTA phase 3 initiated to respond to additional FAA requests. Two stages: interim modifications and permanent revisions. SAIDS equipment procured for integration with PRAS.

1996 - Revised PRAS installed in TRACON.

PRAS Goals and Compliance

The goals for the automated PRAS at Logan were established by the advisory committee to the development of the original computerized development in 1980-83. The advisory committee was composed of representatives from Massport, the FAA, airlines, and 12 neighboring communities. It concluded that the PRAS should provide an equitable distribution of aircraft noise over the long-term (i.e. annually), as well as short-term relief from excessive operations over certain neighborhoods.

Long-Term Goals

The PRAS advisory committee agreed that the long-term goals should:

* Reduce the annual average total noise impact from Logan operations on the population residing in affected communities, without significantly increasing the impact on any populated area within the day-night sound level (Ldn) contour of 65dB; and

* Maximize the use of runway 15R for over water departures and 33L for over water arrivals.

To quantify the long-term noise goals, the committee reached a consensus on annual runway end use percentages in terms of equivalent jet operations. Equivalent operations include all daytime (7 am to 10 pm) jet flights, plus nighttime (10 pm to 7 am) jet operations multiplied by a factor of ten. This is consistent with the methodology for computing Ldn, in which 10 dB are added to nighttime operations. The agreed annual runway end use goals are shown in Table 1.

Table 1. Annual PRAS Goals for Equivalent Jet Operations by Runway End		
Runway Designation	Arrival Percentage	Departure Percentage
04 L/R	21.1	5.6
09		13.3
15 L/R	8.4	23.3
22 L/R	6.5	28.0
27	21.7	17.9
33 L/R	42.3	11.9

PRAS maintains a continuous count of the jet operations on each runway end for the past twelve months. Whenever a new recommendation is needed, it checks the wind and weather conditions and the expected demand level, and then identifies runway combinations which are available to meet these requirements. If there is more than one choice available, the one that will produce the best match with the goals in Table is recommended.

Short-Term Goals

Due to the random variation of wind, weather and demand conditions throughout the year, it is unlikely that the actual runway end use will exactly equal the specified goals. Since typical operations for an hour will contribute less than 0.01% toward the annual goals, the PRAS could recommend using the same runway(s) for extended periods in order to bring the actual utilization closer to the annual goals. Similarly, a persistent wind direction could otherwise result in PRAS recommending the same runways for several days in a row. In order to provide some temporary relief to affected neighborhoods in such situations, the PRAS committee established two short-term goals for the system in addition to the annual goals:

* Provide relief from excessive *dwell* (duration of continuous operations during each day between the hours of 7 am and midnight); and
* Provide relief from excessive *persistence* (prolonged utilization of a given runway during the hours of 7 am and midnight in a period of three consecutive days).

In contrast to the annual goals which count the number of equivalent operations on a runway, dwell and persistence are measured by the number of hours that a given area is subjected to aircraft overflights. The PRAS committee designated eight runway combinations for computing the effects of dwell and persistence on the communities. Five of these are single-direction operations (landings or takeoffs), and three are reciprocal operations (landings in one direction or takeoffs in the other). Figure 1 illustrates the eight dwell/persistence areas that are included in PRAS. The specific goals that were adopted for the control of dwell and persistence are summarized in Table 2.

Table 2. Short-Term PRAS Goals for Dwell and Persistence by Runway Combination		
Runway Operations	Dwell	Persistence
4 L/R arrivals	6 hours' use between the hours of 7 am and midnight in any day	23 hours' use between the hours of 7 am and midnight in three consecutive days
33 L/R arrivals		
15 L/R departures		
22 L/R departures		
27 departures		
22L arrivals 4R departures		
27 arrivals 9 departures		
15 L/R arrivals 33 L/R departures		

PRAS continually counts the hours of persistence and dwell for each of the eight designated runway combinations in Table 2. If either dwell or persistence exceeds the established threshold, the recommendation based on the annual goals is modified, if possible, in order to provide short-term relief.

PRAS Compliance

Statistics on the PRAS performance have been collected since the original system was installed in 1983. Figure 2 summarizes the compliance with the annual runway end use goals from 1984 through 1995. Several observations can be made from this figure.

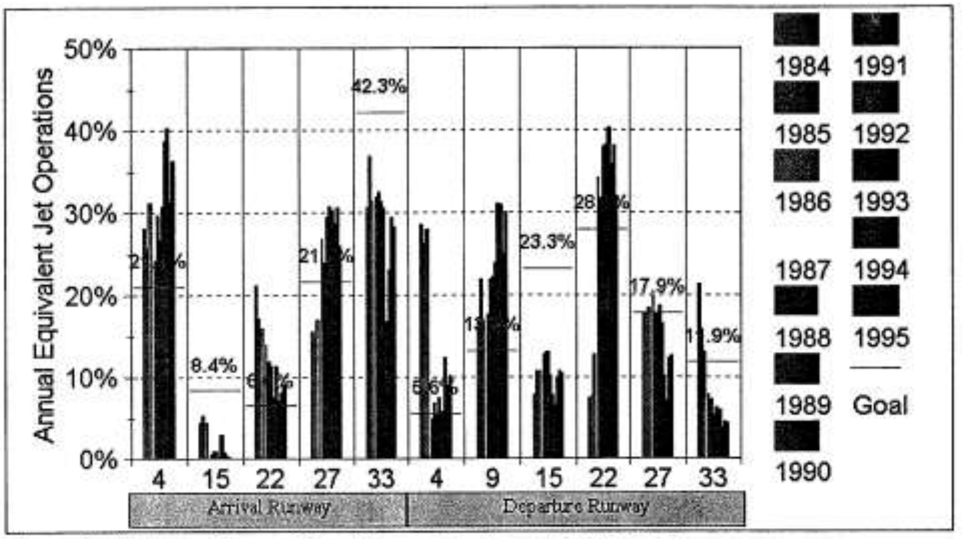

Figure 2. History of Logan Compliance with Annual PRAS Goals.

Firstly, arrivals on runways 4 and 22 have always exceeded their respective goals. The exceedence on runway 4 has been getting somewhat worse with time, while it has been improving on runway 22. It is especially notable that arrivals on 15 and 33 have always been well shy of their goals. Since 1988 runway 27 arrivals have been above the goal whereas they were formerly below it. This switch is due to the use of simultaneous landings on 22L and 27, while taking off on 22R.

Referring to the departure runways, runway 9 has always exceeded the goal and the situation has generally tended to worsen with time. Runway 15 departures have always been far below the goal; runway 33 departures have been well blow the goal since 1988 although they were above the goal prior to that time. Runway 4 and 22 departures have shown a dramatic shift since 1987: runway 4 going from high above to fairly near the goal, and runway 22 shifting from far below to somewhat above the goal. Runway 27 departures were close to the goal until 1992 when they dropped by about a third.

The variations depicted in Figure 2 are due to a number of factors. Primary among these are the weather conditions from year to year, the total level of airport operations, and the FAA operational techniques (e.g. hold-short operations on 22L and 27). Many other factors also enter in, such as airfield construction, individual airline schedules, controller commitment, etc.

The ability to effectively achieve the 1982 PRAS goals has been debated for several years. Simulation studies conducted by FTA and by Massport have concluded that better compliance is possible, and thus Massport commissioned the development of the revised PRAS. The revised PRAS will operate full-time rather than under relatively benign weather conditions; it will consider all possible runway configurations, variations in expected demand levels, the latest weather forecasts, controller workload for runway changes, and a variety of other information to provide recommended runway plans for an entire shift. However, the final ability to meet any defined goals is ultimately limited by the airfield layout and the random local weather patterns.

During Phase I of the Airside Improvements Feasibility Study for Massport, L_{dn} contours were prepared for several hypothetical future 1999 situations. One case of interest here is the Full PRAS Compliance conditions, in which it was assumed that the annual runway utilization at the airport in 1999 would comply exactly with the PRAS annual goals. Figure 3 presents the 65 dB L_{dn} contour that would result if the PRAS annual runway use goals could be achieved in 1999. For comparison, the 1999 no-build 65 dB contour is also shown. The No-Build alternative represents current operational procedures with the postulated 1999 fleet mix and traffic levels. The results are not surprising, particularly in light of Figure 2. The PRAS Compliance case reelects a shift of arrivals from runways 4 & 27 to 15 & 33, and a shift of departures from runways 9 and 22 to runways 15, 27 and 33.

The PRAS goals would provide significant reductions in the noise over Revere, Winthrop, the Orient Heights area of East Boston, and the City Point area of South Boston; they would increase the noise over East Boston and Chelsea in the vicinity of the McArdle Bridge, and the Fort Point area of South Boston. They would also increase the noise levels to the southwest over the harbor toward Hull.

The impacts of 100% PRAS annual goal ccmpliance on the population exposure is summarized in Table 3. The 100% PRAS goal compliance case would provide a net reducton of residents within the 65-70 and 70-75 dB contour bands. Major decreases would occur in Winthrop and Revere, but with a large increase in Chelsea and smaller increases in both South Boston and East Boston.

Table 3
Comparison of Population[a] Exposed to Specified L_{dn} Level for 1999 with 100% Compliance with PRAS Annual Goals and for 1999 No-build[b]

L_{dn} Interval	South Boston	East Boston	Revere	Chelsea	Winthrop	Total
Runway Utilization for 100% Compliance with Annual PRAS Goals						
> 75 dB						0
70 -75 dB		49			277	326
65 -70 dB	159	2,994		1,547	588	5,288
Total > 65 dB	159	3,043	0	1,547	865	5,614
1999 No-Build						
> 75 dB						0
70 -75 dB		106			585	691
65 -70 dB		2,587	2,741		1,214	6,542
Total > 65 dB	0	2,693	2,741	0	1,799	7,233
Differences						
> 75 dB	0	0	0	0	0	0

Table 3 Comparison of Population[a] Exposed to Specified L_{dn} Level for 1999 with 100% Compliance with PRAS Annual Goals and for 1999 No-build[b]						
L_{dn} Interval	South Boston	East Boston	Revere	Chelsea	Winthrop	Total
70 -75 dB	0	-57	0	0	-308	-365
65 -70 dB	159	407	-2,741	1,547	-626	-1,254
Total > 65 dB	159	350	-2,741	1,547	-934	-1,619

a Population from 1990 US census.
b Runway utilization for PRAS goals criterion.

Revised PRAS

The original computerized PRAS at Logan was installed in 1983. Its development was based on conditions that existed at least 15 years ago: i.e., airport traffic levels, FAA procedures, and technology (both aviation and computer). Although the system represented the 'state of the art' at the time it was designed, the FAA and Massport recognized within a couple of years that it had several limitations. For example, the original PRAS split the day into four discrete demand periods (High, Moderate, Low, Very Low). Similarly, the wind speed was classified into either two or three strength levels. The possible runway combinations were permanently programmed into the system by means of tables which stored at most three combinations for each wind direction. Any change in the demand pattern, runway configurations or FAA procedures required changing the computer software. Wind, weather and demand data were entered manually, and a recommendation was only provided in relatively benign 'preferential' conditions (e.g. winds less than 20 knots, dry runways, visibility at least 1½ miles, etc.) and only for the current conditions. The runway selection logic gave priority to the short-term goals. For the current wind and demand conditions, the three (or often two or only one) possible runway combinations were ranked by annual goal compliance. The top one was checked against the persistence and dwell goals; if it passed it would be recommended. Otherwise the next possible combination was tried. If all possible combinations failed persistence and dwell checking, the top combination for annual goals would be recommended.

The revised PRAS was developed to eliminate the limitations in the original PRAS and to provide flexibility to accommodate changes in airport operations and/or FAA procedures. It was designed as a forward-looking system to assist the FAA in planning operations throughout a shift. It automatically acquires current and forecast weather, airport traffic data, runway conditions, etc. It operates 24 hours per day, and provides a choice of recommended eight-hour configuration plans to the FAA operator, who can modify the plan as needed. The revised PRAS incorporates an estimate of the controller workload required to change configurations into its planning logic. Information on all possible runway combinations is available in a separate data file which can be readily modified whenever necessary. The original definition of the annual and short-term goals are retained, but specific numerical values can be easily revised. The selection logic uses the goals somewhat differently than before. Annual end use deviations, persistence exceedences, dwell exceedences, and controller workload are all combined in the planning algorithm. Each of these is assigned a separate weighting factor, which can be adjusted to improve system behavior. For example, the relative weighting of dwell can be increased if it is desired to tradeoff short-term versus annual goal compliance.

PRAS Dwell and Persistence Areas