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Current Practices in Runway Configuration Management (RCM) and Arrival/Departure Runway Balancing (ADRB)

*Gary W. Lohr and Daniel M. Williams
Langley Research Center, Hampton, Virginia*

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

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Abstract

Significant air traffic increases are anticipated for the future of the National Airspace System (NAS). To cope with future traffic increases, fundamental changes are required in many aspects of the air traffic management process including the planning and use of NAS resources. Two critical elements of this process are the selection of airport runway configurations, and the effective management of active runways. Two specific research areas in NASA's Airspace Systems Program (ASP) have been identified to address efficient runway management: Runway Configuration Management (RCM) and Arrival Departure Runway Balancing (ADRB).

Current procedures for selecting active runways are primarily centered on prevailing winds and forecast winds. Other factors such as noise constraints, traffic loading, and weather are considered also, however, wind is the primary driver. With higher demands on the NAS from increased traffic, systemic interests will become increasingly more important in runway selection, particularly as winds fall below thresholds requiring the selection of specific runways, and when noise is not a consideration. Greater emphasis on these System interests stem from new interdependencies which are created from the significant increases in air traffic (as more aircraft populate the System, factors such as conflicting flight paths become more of a factor). Runway configuration selection, where there is latitude to choose, must consider these factors. Effective future RCM requires enhanced weather forecasting capabilities, current and System status information and real-time and projected traffic information.

The runway is the transition point between the surface and airspace environments. The efficient use of this limited resource is critical to efficient air traffic operations. One strategy, runway balancing is currently practiced at airports across the country at various levels of sophistication. A concept that balances arrival traffic across runways has been successfully implemented in high density operational environment. The main driver behind this concept, p-FAST, is equitable traffic loading across runways. Concepts have also been developed that propose viable schemes for managing departure traffic. The German Aerospace Center has also developed and successfully demonstrated a concept, Coordinated Arrival Departure Management (CADM) that considers and coordinates arrival and departure traffic in order to optimize operations at an airport. This is all valuable work reflecting insightful approaches to the problem of runway resource utilization. There is, however, much to be done. A vision of efficient ADRB, which is responsive to future TFM capabilities, and assists the airport in supporting systemic traffic flow management is needed and is being pursued. Concepts that address airport surface optimization and precision spacing in the airspace environment are currently the subject of research. Concepts in these areas require investigation in concert with RCM and ADRB procedures if a truly systemic approach to capacity increases is to be realized.

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Abbreviations

AAR	Airport Acceptance Rate
ADR	Airport Departure Rate
AMAN	Arrival Manager
ARDB	Arrival/Departure Runway Balancing
ARMD	Aeronautics Research Mission Directorate
ASOS	Automated Surface Observation System
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATCT	Airport Traffic Control Tower
ATM	Air Traffic Management
AWOS	Aviation Weather Observing System
CADM	Coordinated Arrival Departure Management
CSPR	Closely Spaced Parallel Runways
CTAS	Center-TRACON Automation System
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DMAN	Departure Manager
FAA	Federal Aviation Administration
FAC	Final Approach Course
FAST	Final Approach Spacing Tool
IAP	Instrument Approach Procedure
IMC	Instrument Meteorological Conditions
ITWS	Integrated Terminal Weather System
ILS	Instrument Landing System
JPDO	Joint Planning and Development Office
LAHSO	Land and Hold Short Operations
LOA	Letter of Agreement
MIT	Miles-In-Trail
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEXRAD	Next Generation Radar
NextGen	Next Generation Air Transportation System
NGATS	Next Generation Air Transportation System
p-FAST	passive-Final Approach Spacing Tool
RCM	Runway Configuration Management
RVR	Runway Visual Range
SOP	Standard Operating Procedure
SOS	Systems Operations Services
STAR	Standard Terminal Arrival Route
SUA	Special Use Airspace
TDWR	Terminal Doppler Weather Radar
TFM	Traffic Flow Management
TMA	Traffic Management Advisor
TMC	Traffic Management Coordinator
TRACON	Terminal Radar Approach Control
VMC	Visual Meteorological Conditions

Note: The use of the term “System” in this paper refers to the National Airspace System (NAS)

1.0 Background

The National Aeronautics and Space Administration (NASA) is pursuing focused research in support of the Next Generation Air Transportation System (NGATS or NextGen) through its Aeronautics Research Mission Directorate (ARMD). The Joint Planning and Development Office (JPDO) *Concept of Operations for the NGATS, Version 2.0*, (NextGen) provides basis for ARMD pursuing research into the improvement of the National Airspace System (NAS). JPDO emphasizes that the current NAS is approaching system capacity. Four of the nation's 35 busiest airports are already at capacity and 27 will reach capacity limits by 2025 in the absence of improvements (Ref. 1) . Projected air travel is expected to double or triple by 2025 (Ref. 2). The ARMD Airspace Systems Program includes the NGATS Air Traffic Management (ATM) Airportal Project which focuses on improving airport and terminal area system and process improvements and the ATM Airspace Project which focuses on enroute improvements (Ref. 3). Cross-Project coordination is critical to the successful completion due to functional overlaps of research focus areas. The Airportal Project has a research focus area, Coordinated Arrival and Departure Operations Management, which has defined a key area of research to be Runway Configuration Management (RCM) and Arrival/Departure Runway Balancing (ADRB).

RCM and ADRB are two separate but related activities. RCM is considered to be the process of designating active runways, monitoring the active runway configuration for suitability given existing factors, and predicting future configuration changes. ADRB is the process by which arrivals and departures are assigned runways based on local (airport) and Systemic (NAS) goals through the effective distribution of arrival and departure traffic across active runways.

2.0 Introduction

Well planned and managed runway selection and usage is central to airport efficiency and extends into the efficiency of the NAS. Runway configurations are selected, and traffic managed across specific runways based on maximum capacity or throughput for the airport. This becomes a “balancing” act of the current operational situation, including many factors, constraints, and competing interests. Understanding the complexity of this planning and real-time decision-making process is crucial to identifying and pursuing RCM and ADRB processes and System improvements. This investigation into current practices forms a baseline for Airportal Project research that seeks to improve RCM and ADRB. In today's environment, airports serve interests at the “local” and “System” levels. Local interests are generally satisfied by moving as many aircraft into and out-of the airport as possible. System interests extend beyond the airport's geographic and functional boundaries to consider joint interests at adjacent airports, in the local airspace, and NAS Traffic Flow Management (TFM). As the NAS evolves to meet the challenges of anticipated future traffic growth, it is clear that systemic approaches to air traffic operations are required. Airports will have to assume their role in meeting System objectives by managing traffic based on TFM strategies.

3.0 Objective

The objective of this paper is to assess and characterize current airport decision processes and information requirements involved in runway configuration management and balancing

arrival/departure operations. Also discussed in this paper are current practices in areas that would be affected by enhancements to the RCM and ADRB processes. A “Bibliography” of publications related to RCM and ADRB is provided in Appendix 1 for reference. The organization of the RCM and ADRB sections differ; due to the differences in the how these two activities are exercised in the NAS.

4.0 Approach

To determine current practices in the area of RCM and ADRB, a literature search was conducted, visits to ATC facilities were made, and surveys were completed through telephone and face-to-face interviews. It is understood that procedures and processes, may be site specific; however, an effort was made to capture practices that were common across most air traffic facilities.

The literature search was conducted on procedures currently in use. Visits to air traffic control facilities were then conducted for discussions with staff and operations personnel. Facilities visited included four major airport traffic control towers (ATCTs), three Terminal Radar Approach Control facilities (TRACONs) and an air route traffic control center (ARTCC). This was followed by observations of current operations.

Finally, a survey (see Appendix 2) was developed in order to add to the base of understanding for these processes in a structured manner. The survey was focused on airport operations; however, it was also used as a basis for information gathering conversations with TRACON personnel. Based on the survey, information was gathered from 15 of the top 25 airports in the United States (based on the annual number of operations), and from five major TRACON facilities (Table 1).

Table 1. Air traffic facilities surveyed

Air Traffic Control Towers		TRACONs
Atlanta/Hartsfield – Jackson Atlanta Int’l	Detroit Metropolitan/Wayne County	Chicago TRACON
Houston/George Bush Intercontinental	New York/John F. Kennedy Int’l	Northern California TRACON
Boston/General Edward Lawrence Logan Int’l	Dallas – Fort Worth Int’l	Southern California TRACON
Minneapolis – St. Paul Int’l	Newark Liberty Int’l	Potomac TRACON
Los Angeles Int’l	Washington Dulles Int’l	New York TRACON
Philadelphia Int’l	San Francisco Int’l	
Chicago O’Hare Int’l	Denver Int’l	
Philadelphia Int’l		

Questions in the survey addressed factors involved in selecting runways and distributing traffic across those runways. The surveys were conducted through telephone and face-to-face interviews. Results from the surveys are imbedded in the following sections, rather than reported separately.

5.0 Factors affecting Runway Configuration Management (RCM) and Arrival/Departure Runway Balancing (ADRB)

There are a number of factors to consider when selecting runway configurations and assigning arrival/departure traffic to specific runways. The following is a list of some considerations and constraints.

- Weather – effects of weather minimums, convective weather, etc.
- Environmental considerations (primarily noise and emissions)
- User (aircraft) requirements – runway length, flight plan routing, etc.
- Physical capacity-limiting issues – e.g. limited number of or no high speed turn-offs resulting in increased runway occupancy times and less capacity throughput
- Physical layout of airport, location of users' facilities – landing and departing operations closest to user's terminals/ramps
- Spacing between runways – use of configurations that are sufficiently spaced to permit current day and/or future anticipated simultaneous operations on parallel, and/or converging runways
- Airspace restrictions – Special Use Airspace (SUA) adjacent to or near the airport that pose restrictions for arrival and departure operations at an airport.
- Surface restrictions – e.g., taxi chokepoints, or space limitations, among others
- Dedicated use of runway vs. joint use for arrivals and departures
- Balancing and sequencing by aircraft type or accommodation of significantly different performance characteristics
- Availability of Land and Hold Short Operations (LAHSO)¹ – LAHSO provides operational flexibility, capacity
- Staffing issues (required “monitor” positions in the TRACON can dictate runway configurations when available staffing is limited)
- Terminal traffic flow, including configuration of nearby airports. (In areas where there are multiple proximate airports, conflicting flight paths become constraints among the airports, and can become a major factor in how adjacent airports are operated. Terminal airspace and traffic flows are generally structured to optimize traffic flow for the most commonly used runway configurations for the major airports.) When there is a “mixed” operation, i.e., airports with conflicting runway configurations in use, significant delays can be incurred.)

The current air traffic system must consider these factors as well as many others in the process of making decisions aimed at conducting efficient air traffic operations.

6.0 Runway Configuration Management

RCM is the process of designating active runways, monitoring the active runway configuration for suitability given existing factors, and predicting future configuration changes. Active runways are used for arrivals, departures, or both. At airports with multiple runways, variations of runway configurations have to be managed to meet system, airport, and user demands. Individuals (air traffic control supervisors) conducting RCM consider the pre-determined runway configuration options and from these options select the optimal configuration for the current, and in certain cases, the forecast situation.

¹ LAHSO is a procedure in which aircraft land and hold short of an intersecting runway or taxiway. For this procedure, sufficient runway length for the category of aircraft holding short must exist.

This section describes the drivers, current process of RCM, and briefly provides recommendations for RCM improvements.

6.1 Drivers behind runway configuration selection

Runway Use Programs. Runway Use Programs are initiated by airport municipalities from a noise abatement runway selection plan, and must meet FAA Order 8400.9, National Safety and Operational Criteria for Runway Use Programs (Ref. 4). The Runway Use Program is approved either as a Formal Program defined in a “Letter of Understanding between FAA Flight Standards, Air Traffic Service, the airport proprietor and the users,” or an Informal Program that is voluntary for aircraft operators and pilots. Safety Criteria for Runway Use Programs are defined in FAA Order 8400.9. In summary, for a Runway Use Program to be in effect: There must not be any significant wind shear or thunderstorms that affect the use of the runway; visibility must be greater than one statute mile; runway braking effectiveness must be “good”. For clear and dry runways, any crosswind component must not be greater than 20 knots; tailwind component must not be greater than 5 knots or 7 knots with anemometers installed at runway ends. For runways that are not clear or not dry, any crosswind component must not be greater than 15 knots, and tailwind component must not be greater than 3 knots or unless otherwise approved by FAA Flight Standards office. Other local airport safety factors that may be considered before a Program’s approval include runway length, runway gradient, aircraft type and performance, and approach aids. Airports have submitted and been approved for waivers that enhance their Runway Use Programs e.g., up to 10 knots of tailwind permitted.

Standard Operating Procedure (SOP) and Letter of Agreement (LOA). A Runway Use Program is put into operation through a local SOP and LOA that define ATCT and TRACON roles and responsibilities to conduct operations, including RCM at the specific airport facility. SOPs and LOAs are used as a decision-making foundation for ATCT and TRACON supervisors to apply in the operational situation (current and forecast winds, ceiling/visibility, airport construction/maintenance, arrival/departure demand, etc.) in order to establish a runway configuration.

Authority. The authority to set a controlled airport’s runway configuration is typically “de-centralized” and held at the ATCT, but may be “centralized” up to the TRACON in some operational environments. Most runway configurations are set by the airport’s ATCT supervisor² who notifies the governing TRACON supervisor and adjacent airport facilities according to SOPs and LOAs. There are exceptions within the NAS when a TRACON may set runway configurations for an airport due to a prioritization of multi-airport or “metroplex” traffic flow constraints above the single airport itself. In general, for airports that have operational interdependencies with other facilities, the ATCT supervisor will coordinate with the TRACON to determine the best course of action.

Wind, Visibility, and Weather Sensors and Instrumentation. Controlled airports usually have multiple wind sensors that provide the current wind field at various locations: runway ends, midfield, etc. Wind sensor information is used in the ATCT cab by the supervisor to determine active runways; and, by observing wind change trends, the supervisor can anticipate the need for a configuration change. Runway Visual Range (RVR) measurements are reported from transmissometer sensor readings along a runway, and ceiling measurements are reported by a

² This role is site dependent, but the supervisor may delegate this responsibility to a controller in charge or traffic management coordinator per the facility SOP.

ceilometer. Air temperature, altimeter and the calculated density altitude may also become critical measurements that drive a runway configuration due to aircraft performance. Variations in large airport sensor reports from runway to runway may complicate the decision to determine the airport runway configuration, and in unusual situations (e.g., rolling fog, or slow-moving fronts), multiple runways may be changed one at a time until the complete configuration is set.

Airport Equipage/Navigation Aids. Airport equipage, i.e., navigational aids, especially instrument landing system (ILS) equipment, is a significant driver for managing runway configurations. This is because runways with these capabilities permit operations when cloud ceiling and/or visibility deteriorate beyond the point where visual approaches can be supported.

Weather Forecasting. Weather display and forecasting systems are available within ATCTs and TRACONs. These systems, such as Terminal Doppler Weather Radar (TDWR), and Integrated Terminal Weather System (ITWS) provide regional weather around an airport, neighboring airport automated reports (e.g., ASOS/AWOS information), and the graphical depiction of winds and visibility, even gust front movements, onto NEXRAD precipitation images.

Airport Acceptance Rates (AARs) and Airport Departure Rates (ADRs). These rates are established maximum arrival or departure rates for an airport that is operating under visual meteorological conditions (VMC) or instrument meteorological conditions (IMC). They represent the airport's current capacity. These rates are fed into the traffic flow management (TFM) system by major airports so Traffic Management Coordinators (TMCs) at all major Air Traffic Control (ATC) facilities can gauge the air traffic demand versus capacity and keep the NAS running effectively. For an airport, the challenge is to implement, manage, and communicate these rates in a timely fashion. Further discussion of the AARs and ADRs can be found in Sections 7.2 and 7.3 respectively.

Airport Construction/Maintenance. During periods of construction or maintenance, runways or taxiways that are affected will cause the runway configurations to be modified accordingly. Such modifications are temporary, but the result may be an altered runway configuration from the original. The net effect of such activities is diminished capacity. Communicating these alterations and the user safety implications is a critical airport operation and ATC function.

6.2 *RCM process*

For airports that have multiple runway configurations, the configurations are usually referred to by a local designation term that facilitates ease of communication among ATC personnel and conveys a specific taxi flow on the airport surface and arrival and departure routings in the terminal area. Because of the drivers mentioned previously, even major airports limit the number of configurations commonly used, mostly dependent on wind velocity. The runway configurations are continually monitored with the current situation and forecast in mind. Changes can be anticipated to the extent possible, and once initiated, they are coordinated clearly with affected ATC facilities and managed by the local ATCT supervisor and controllers.

When current winds, ceiling, and RVR measurements allow configuration flexibility, (e.g., light or calm wind with clear weather), the ATCT supervisor will also weigh weather observations and forecasts with traffic flow management projections of arrival and departure demand. During periods of decreased demand at large airports with multiple runways, the runway configuration may be "compacted" in order to land or depart from runways closest to the terminal to reduce taxi

durations. When the demand increases again, the operation may then be “expanded” to use the full runway configuration.

6.3 Recommendations for RCM improvements

The improvement of weather forecasting and TFM technologies continues to provide increasing levels of accuracy and detail. Integration of forecasting and TFM systems would enhance the process of RCM. A RCM decision aid would examine the current and forecast situation and could provide prioritized recommendations to ATCT and TRACON supervisors. These recommendations could be prioritized by various weighting schemes tailored to local operational needs e.g., meeting cross-wind and tailwind criteria, maximizing throughput, configuring for arrival or departure rush periods, noise abatement requirements etc. By incorporating forecast information, the RCM decision aid would cue the supervisors to consider making a configuration change before the impending weather, winds, visibility, or traffic conditions are in place. Once the option is selected, such a decision aid could also communicate the runway configuration change throughout the NAS by linkage to communications automation support like network-enabled information sharing. Through early notification of a new or anticipated runway configuration, adjacent facility traffic managers and controllers can make necessary adjustments and minimize adverse effects on the overall traffic flow.

7.0 Arrival/Departure Runway Balancing

7.1 Overview of Runway Balancing

The term “runway balancing” is used throughout the air traffic system to reference strategies for responding to overloading of runways at a given airport. The term “balancing” inherently suggests equality, parity, or pursuit thereof. The term balancing has been used with reference to several strategies in the air traffic system. Note the following examples. Depending on the geographical location of an airport, arrival fixes can become overloaded; in response, traffic can be re-routed to “balance” the traffic flows at the arrival fixes. During convective weather, or periods of high demand in congested airspace, MIT restrictions or reroutes are used to balance sector loading. Surface traffic is routinely given “off nominal” taxi routes due to congestion on taxiways.

Runway balancing, in its simplest form, is the establishment of a runway configuration that best serves the traffic flows at an airport under nominal traffic conditions. (As documented earlier in this report, winds are the driving factor for the designation of active runways.) Further refinement of this approach is the formal designation (documented in facility standard operating procedures manuals) of alternate configurations for different conditions (e.g. periods of uneven arrival/departure traffic loading). Factors such as noise constraints and individual aircraft requirements (e.g. runway length) have to be considered as well.

An algorithmic application of runway balancing which was developed several years ago was focused on the active distribution and loading of arrival aircraft during heavy periods of arrival traffic. This application was tested extensively and used successfully in an operational setting. The decision support tool associated with this algorithm is the Final Approach Spacing Tool (FAST) (Ref. 6), which is one of the elements of the Center/TRACON Automation System (CTAS) (Ref. 7). Specifically, one of the modules in the FAST tool, Passive-FAST (p-FAST) provides runway assignment and sequence of arrival aircraft. Other research efforts have

explored optimization of departure flows (Ref. 8), or considered combined arrival and departure operations. A strategy proposed by the Volpe Transportation Center, “Collaborative Optimization” (Ref. 9) considered both arrival and departure operations, and inputs from the airlines regarding priorities, to calculate optimal solutions. The Deutsches Zentrum für Luft- und Raumfahrt (DLR), or German Aerospace Center, developed a concept which also considers both arrivals and departures for dual use runways (used for both arrivals and departures). The concept Coordinated Arrival Departure Management (CADM) (Ref. 10) combines inputs from an Arrival Manager (AMAN) and a Departure Manager (DMAN). Both the AMAN and DMAN are separate processes which optimize operations in their respective domains. Under CADM, an algorithm considers the traffic situation on the ground and in the terminal maneuvering area (analogous to the terminal area in the United States). Gaps or arrival-free intervals are identified in the arrival stream for insertion of departing aircraft. Where those gaps do not exist, the required action to create the gaps is calculated and presented to the controller for implementation.

Currently there is no known effort to strategically coordinate arrival and departure operations to optimize either the traffic flow at the airport or from a System standpoint. As part of the process for selecting active runways, consideration is given to which configuration allows maximum throughput for both arrivals and departures. This configuration can also be a function of traffic loading, and the ratio of arrivals to departures. Arrivals and departures need to be separated and de-conflicted at the airport level for closely spaced parallel runways (CSPRs)³, intersecting or converging runways, and in terminal airspace. However, there are currently no formal procedures or tools in use for the orchestration or optimization of this process.

7.2 *Comments from ADRB survey*

The information-gathering survey that was briefly described in Section 4, yielded several interesting, yet not expected results, and are discussed here in order to better frame the research requirements for NextGen. Airports are inherently diverse in the many variables that define an airport and its operational environment, some of which are noted in Section 5. These variables include runway configuration (including lengths and widths), taxiways (dimensions, high speed turn-off availability), availability of instrument approaches, noise restrictions, and traffic complexion, among other factors. In short, the environment described is much like the System in which it exists; there are many constants, however, there are always exceptions, dynamic considerations, and other variables. The feedback provided by staff and operational personnel was reflective of the diversity of these environments, competing interests, and constraining factors. Comments resulting from the survey and site visits are incorporated into the sections that follow, which describe the basic flow of events for arrival and departure operations.

Airports basically have established procedures which dictate the nominal flow of traffic. Departures are assigned runways based on direction of flight. Aircraft are sequenced such that there will be at least 15 deg. course divergence between successive departures, thus permitting reduced separations. Occasionally there are deviations from the practice of assigning a runway based on direction of flight, or from balancing the traffic loading on departure runways.

Arrival aircraft normally land on the runway closest to the fix where they enter the terminal area. Tactical decisions to balance arrival loading across runways are made on a frequent basis. This arrival balancing provides short term remedies, but other questions emerge regarding possible

³ CSPRs are defined as those with less than 2500' between runway centerlines.

negative effects it can have on surface traffic movement, gate availability, and places to hold aircraft while gates become available. Several airports with predictable periods of uneven traffic loading (more arrivals than departures, or vice versa) will land arrivals on a runway normally used for departures during the “arrival push”, thereby increasing the AAR. Conversely, delays for a “departure push” are mitigated by use of arrival runways for departure aircraft. In both cases, this is a form of runway balancing, however, from the interview responses it seemed clear that the term runway balancing was used informally, and had different meanings across the respondents. An interesting point noted was that none of those interviewed mentioned a strategy for coordinating arrivals and departures to meet System or airport capacity. Rather, any “balancing” that took place served the immediate needs of the arrival or departure runway loading, without consideration for further effects either upstream or downstream in the System.

To summarize, airports are very different based on the many variables by which they are defined. In the operation of these airports, runway balancing is conducted in some airports, at various levels of sophistication. A more focused effort to better coordinate and optimize the management of runway operations from a System level is essential to meeting NextGen objectives. In fact, what is now viewed as runway balancing will likely morph into a more global view of “runway management”. Continued work in the area of coordinated arrivals and departures, will need to incorporate in a complementary manner any envisioned TFM constraints and requirements. This requires a more coordinated effort with other NextGen research efforts, such as those addressing airport surface operations, efficiency in airspace operations, and TFM research.

7.3 Current-day combined arrival and departure operations

Arrival and departure operations present unique, yet similar challenges for the air traffic system. All the airspace users (aircraft) require management against the backdrop of airline interests, many constraints, and local/System needs. For arrival aircraft, ATC strives to minimize delays due to inefficiencies in the System’s handling of aircraft, while from the airline perspective, arrival aircraft are seeking to minimize fuel consumption and time through touch down, taxi-in and engine shut down after parking at the gate. Departures are considered individually, on the basis of the System’s ability to accept individual aircraft. This means that a departing aircraft may not taxi, or in some cases, not start engines if there are traffic flow restrictions (or other restrictions, such as ground delay program) in effect. Thus, “acceptance” of departures by the System is based on many factors that may not be factors for arrivals. These factors include airport surface traffic, traffic in the Airspace system, and delays at the destination airport, among many others.

7.4 Arrival operations

The following sections describe the general process by which aircraft arrive at their landing runway. Based on the runway configuration, the TRACON designates the approach-in-use for each runway; this will normally be a visual approach or an Instrument Approach Procedure (IAP). From a capacity standpoint, greater throughput is normally achieved through the use of visual approaches procedures, or “visuals”, which are normally used when the requisite weather minimums exist. Absent adequate weather minimums to support “visuals”, instrument approach procedures (IAPs) are used. From the perspective of operational flexibility, visual approaches are preferred. There are several requirements for the conduct of IAPs. There is a maximum intercept angle based on the distance from a point on the final approach course (FAC), and a point at which the aircraft is required to be established on the FAC based on weather conditions. (Ref. 5). For precision approaches, aircraft can not be turned on to the FAC at an altitude above glide

slope intercept. There is no such requirement for visual approaches, which means that the use of visual approaches allow Controllers more freedom in managing arrival streams and pilots have more freedom to manage their approach to the runway.

Establishment of the Airport Acceptance Rate (AAR). In order for the air traffic system to deliver the appropriate number of aircraft to meet an airport's capacity, an airport acceptance rate (AAR) is determined for the airport. The AAR is a parameter specifying the number of arrival aircraft that an airport, in conjunction with terminal airspace, can accept under specific conditions throughout any consecutive sixty minute period. This rate is established through coordination between the tower, TRACON, and for selected airports, Systems Operations Services (SOS) in the Air Traffic Control Systems Command Center (ATCSCC). The following is a partial list of factors that affect the AAR:

- Availability of high speed taxiways
- Condition of runways, i.e. wet/dry
- Number of arrival runways in use; do the runways intersect, converge?
- Availability of LAHSO procedures, if applicable
- Traffic mix
- Procedural limitations (noise, missed approach protection, etc.)
- Dual purpose or shared runways (used for arrivals and departures)
- Distance between arrival runways

Maximum single runway capacity can be calculated based on the following formula (Ref. 11):

Groundspeed (knots) at the threshold ÷ Spacing Interval at (nmi) the threshold:

Example: 140 kts ÷ 4.0 nmi = 35 arrivals per hour

Note: Although this formula can be used, experience and rules-of-thumb seem to be the common method for determining the AAR.

Dynamic adjustments to the AAR may be required in response to system conditions or situations such as changes in runway status, equipment outages, TRACON constraints, etc. Once the AAR has been established, the air traffic system regulates traffic in such a manner to meet the existing rate. Changes to the AAR are immediately transmitted to the appropriate organizations and traffic flow adjusted to meet the new rate.

Runway Assignment. In today's system, runway assignment is usually based on the arrival fix at the terminal boundary; aircraft generally land on the closest runway to the arrival fix. Exceptions to this practice are made based on operational needs or in response to existing conditions. For example, a runway assignment may be made to accommodate LAHSO operations. Aircraft may be assigned a runway based on surface conditions. Congestion on a part of the airport surface may necessitate moving arrival traffic to runways where exiting traffic may experience less constrained taxi routes. Weather can also influence arrival runway assignment. Thunderstorm activity, for example, can require deviations from normal terminal traffic flows and preclude the use of one or more arrival runways.

Traffic flows in center airspace and in the terminal area. Based on the AAR, the Center will deliver aircraft at the arrival fixes (also termed "metering fixes") at a set spacing between aircraft. Normally, these fixes are located at the terminal boundary. To assist with the monitoring of arrival fix loading and metering of traffic at the arrival fixes, the CTAS, Traffic Management

Advisor (TMA) decision support tool is installed at all centers and is either implemented, or planned for implementation, at most major TRACON and tower facilities. The spacing interval, miles-in-trail (MIT) is a distance agreed upon between the TRACON, ARTCC and ATCSCC. As conditions change, e.g. airport surface conditions, TRACON overloading, weather considerations, etc., MIT spacings may, correspondingly, need to be changed. As aircraft approach the arrival fixes, a “hand-off” (transfer of control) is initiated by the Center and subsequently accepted by the TRACON. A transfer of communications completes this process. As aircraft are entering the terminal area, they navigate based on a previously issued Standard Terminal Arrival Route (STAR), or receive radar vectors. In either event, they will be sequenced with other arrival traffic and will ultimately transition to the final approach course for an IAP, or be cleared for a visual approach. At any point in this process, assuming a reasonable distance from the runway, a decision can be made to change the planned arrival runway for inbound aircraft. This might be done for reasons such as uneven traffic loading on the inbound arrival streams, tower generated requests, and loss of spacing between aircraft.

Traffic flows in today’s System are regimented, especially near major airports. In a future system wherein changes to runway assignments may be more frequent in order to respond to changing conditions, greater flexibility in this area will be required. Consideration will have to be given to determining the final point at which runway assignments can be changed and reasonably executed. This will be driven by traffic conditions, site specific considerations, weather, and the many other factors previously discussed.

7.5 Departure operations

As with arrival traffic, rates are established for departures (ADR) at given airports based on runway configuration, weather, and traffic mix, among other factors. Unlike the AAR, the ADR is generally not a central factor in the TFM planning process. Ultimately, the tower is constrained by the radar separation standards required for the TRACON (Departure Controller) or MIT requirements for aircraft entering center /adjacent TRACON airspace from the TRACON. Runway assignment for departures at a given airport is fairly standard, based on the runway configuration in use. Initial direction of flight is used as the primary basis for the runway assignment, and controllers will sequence departure aircraft ensuring that there are divergent headings (minimum of 15 degrees) between successive departures.

7.6 Recommendations for ADRB improvements

The need for optimization of arrival operations, departure operations, and combined arrival/departure operations is clear. Previous work in the area of runway balancing for arrivals has proven benefits. Studies focusing on runway balancing for departures indicate that there are potential benefits as well. These results provide a basis for future efforts that will address combined arrival and departure operations. Runway assignments will need to be made with sufficient notice so that sequences are established and spacing between all affected traffic can be gracefully executed. TFM capabilities will be required, to respond to runway assignments generated based on many factors including aircraft separations, arrival/departures traffic flows, and weather, among others. Flexibility may be the most important attribute of future automation systems and ADRB schemes. The inability to respond to changes could negate many benefits in other areas directly related to airport and System throughput. Coordination and information exchange among many entities will be critical to ensure that an effective ADRB plan makes sense, and is executed.

8.0 Concluding Remarks

The current air traffic system is not prepared for the two-to-three-fold increase in traffic projected for the 2025 time-frame. Current System limitations, procedures, and the absence of automation-based tools define a highly constrained environment. To cope with future traffic demands, fundamental changes are required for effectively managing traffic at the strategic and tactical levels. New and innovative approaches to processes supporting optimized traffic flows will also be required. One basic requirement of these approaches is flexibility- the ability to respond to an ever changing environment. This is particularly true with the processes of RCM and ADRB.

Current procedures for selecting active runways are primarily centered on prevailing winds and forecast winds. Other factors such as noise constraints, traffic loading, and weather are considered also, however, wind is the primary driver. With higher demands on the System from increased traffic, Systemic interests will become increasingly more important in runway selection, particularly as winds fall below thresholds requiring the selection of specific runways, and when noise is not a consideration. Greater emphasis on these System interests stem from new interdependencies which are created from the significant increases in air traffic (as more aircraft populate the System, factors such as conflicting flight paths become more of a factor). Runway configuration selection, where there is latitude to choose, must consider these factors. Effective future RCM requires enhanced weather forecasting capabilities, current and System status information and real-time and projected traffic information.

Runway balancing is currently practiced at airports across the country at various levels of sophistication. A concept that balances arrival traffic across runways has been successfully implemented in high density operational environment. The main driver behind this concept, p-FAST, is equitable traffic loading across runways. Concepts have also been developed that propose viable schemes for managing departure traffic. The German Aerospace Center has also developed and successfully demonstrated a concept, CADM that considers and coordinates arrival and departure traffic in order to optimize operations at an airport. This is all valuable work reflecting insightful approaches to the problem of runway resource utilization. There is, however, much to be done. A vision of efficient ADRB, which is responsive to future TFM capabilities, and assists the airport in supporting systemic traffic flow management is needed and is being pursued. Concepts that address airport surface optimization and precision spacing in the airspace environment are currently the subject of research. Concepts in these areas require investigation in concert with RCM and ADRB procedures if a truly systemic approach to capacity increases is to be realized.

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Appendix 2: Questionnaire

Survey # 1: General questions regarding Runway Configuration Management (RCM) and Arrival/Departure Runway Balancing (A/D RB)

Target group: Airport Traffic Control Towers (ATCTs)

The purpose of this Survey is to gather information in support of the Runway Configuration Management (RCM) and Arrival/Departure Runway Balancing (A/D RB) areas of work under Airportal Project, Combined Arrival and Departure Operations Management (CADOM) Research Focus Area. This survey addresses two specific areas: 1) how runway configurations are selected, including tools and data sources, and 2) how active runways are used (why specific runway assignments are made for both departures and arrivals. The number of questions is limited, by design, to minimize the amount of time required of each individual surveyed. This survey is intended to be conducted over the telephone through conversations with operations and staff personnel at selected airport traffic control towers (ATCTs).

Runway Configuration Management (RCM)

1. a. Who determines the designation of active and inactive runways? Who is involved in making this decision?

- b. What information is accessed in determining when to change runways?

- c. What are major considerations in runway selection (e.g. wind speed/direction, other wx considerations, effect on capacity, effect on noise, etc.)

- d. What is the primary reason for changing a configuration?

- e. How much advance warning do you generally have that a runway change will likely be required? _____. Is there generally enough time to effect the change in a way that results in minimal impact to your traffic flow? (also: what is the nature of the effect of changing runways on traffic flow?)

2 . a. In general, how are your runways used for departures/arrivals during:

Visual conditions:

Instrument conditions

b. Describe you preferred runway configuration. Other least preferred? Why?

3. Are there airports near you that affect arrival/departure operations at your airport? How?

4. What tools would be useful in making runway changes?

Arrival/Departure Runway Balancing (ADRB)

4. Does your airport have the following:

Established procedures for runway balancing?

What is the objective of your facilities runway balancing procedures?

Is runway balancing applied to arrivals, departures, combined arrival/departure operations?

5. Does your airport have a TMU or is a traffic management position staffed? If so, how many hours during the day?

6. Are there problems unique to your airports that are “constraints” to maximizing traffic throughput?

7. Does your airport have dedicated runways for arrivals and departures? Do you have runways that are jointly used for arrivals and departures?

8. During periods of uneven traffic loading between arrivals do you change how you use your runways (e.g. change dedicated runways to dual use)?

9. What do you see as potential causes for gridlock at your airport that could be changed/prevented?

10. Are the AOCs involved in runway assignment decisions? Under any conditions?

Departures

10. What is the primary factor that dictates the sequence of aircraft assigned to a runway? (e.g. departure fix, weight class, etc. or no ordering).

Arrivals

11. What is primary factor that dictates arrival runway assignment?

12. Is there interaction with the TRACON regarding runway assignment after the runways configuration has been established?

13. Are there tools that are used in determining what aircraft will land on specific runways? If so, what tools are used?

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