ABSTRACT

The NextGen initiative is defining new concepts for operating and managing air traffic into and out of the busiest U.S. airports. The impetus for these efforts include accommodating air traffic demand projections, the move to trajectory-based air and surface operations, methods for maximizing the efficiency and utility of existing runway, taxiway and gate infrastructures, the need to reduce operational costs per aircraft and vehicle movement, and the desire to abate or mitigate airport noise and emissions.

To meet these demands and achieve the desired objectives, the Total Airport Management concept recognizes that airports and surrounding airspace are best operated and managed as coupled systems whereby the aggregated set of operations required to service air traffic from top of descent, through arrival, gate turn, departure, and back to top of climb can no longer be treated independently. Hence, the integration of previously decoupled procedures and systems is now under serious consideration.

Though developed as a runway safety system, unanticipated benefits and applications for the Airport Surface Detection Equipment, Model X (ASDE-X) System, and related surface surveillance data, have emerged as the system is deployed that will support NextGen Total Airport Management operations. These include active and passive characterization of excess emissions and movement costs, 4D surface trajectory conformance monitoring and prediction, active surface management, and situational awareness supporting surface, as well as National Airspace System (NAS) wide, collaborative decision making. Each of these benefits and applications will be explored to illustrate the utility of ASDE-X as part of an overarching Total Airport Management operational framework and as part of the underlying foundational technology necessary for the NextGen initiative.

KEY WORDS

NextGen, Total Airport Management, ASDE-X, Collaborative Decision Making (CDM), Metrics and Efficiency.

1. Introduction

The FAA Airport Surface Detection Equipment, Model X, also know as ASDE-X, has proven very effective at reducing runway incursions and improving situational awareness for tower cab air traffic controllers. In addition to these primary benefits, ASDE-X has secondary system capabilities which complement, extend, or expand upon the fundamental safety features of the system. Several of these secondary capabilities will be explored in the context of NextGen Total Airport Management operations to illustrate the additional potential of ASDE-X as a key part of the future National Airspace System (NAS). This exploration will begin with a review of ASDE-X system capabilities, then proceed to an overview of NextGen, and finish with a discussion of ASDE-X as a fundamental component of Air Portal operations.

2. ASDE-X System Capabilities

The ASDE-X system is comprised of four basic sub-system components: surveillance sensors and sources, data fusion processing, safety logic, and the controller working position, or CWP.

Surveillance sensors and sources comprise three types: existing terminal surveillance radar (TSR) providing both primary and secondary airdside coverage to 60 NM; surface movement radar (SMR) providing primary coverage for the airport surface; and multilateration (MLAT) providing secondary coverage for the airport surface. Additionally, MLAT receives and processes ADS-B aircraft position reports from equipped aircraft via the Mode-S extended squitter protocol.

Data fusion processing collects and processes the position reports from each of the surveillance
sensors and sources and fuses the data to produce tracked aircraft targets. The fused tracks for all aircraft are then analyzed by the safety logic subsystem to identify potential safety conflicts between aircraft, aircraft and surface vehicles, and aircraft and protected airport surfaces like the active runway. Any potential conflict is displayed on the CWP for appropriate controller action.

In addition to advising controllers about potential conflicts, the CWP provides a comprehensive 2D view of the airport surface with all cooperative and non-cooperative aircraft and vehicle targets displayed and tracked. The CWP is refreshed once per second by the data fusion processor based on the high update rate of the MLAT and SMR surveillance sources. Between the CWP update rate and the inherent accuracy of MLAT, tower cab controllers are provided both an accurate and timely depiction of airport surface movement and state. The ASDE-X CWP is depicted in Figure 1 and reflects a typical airport surface as displayed to tower cab controllers.

The ASDE-X deployment footprint is planned for 35 U.S. airports with installation to be complete by 2011. Significantly, the footprint overlaps with all but six of the 35 FAA OEP airports. The OEP exceptions include Portland, San Francisco, Cleveland, Pittsburgh, Cincinnati, and Tampa. The planned ASDE-X footprint is illustrated in Figure 2.

The ASDE-X system has two additional inherent capabilities: operational recording and playback and external surveillance data sharing via the Data Distribution (DD) cabinet. Operational recording and playback is used for incident analysis and system status, monitoring, and assessment. The DD supports a firewall filtered and real-time stream of

![Figure 1 ASDE-X Controller Working Position](image1)

![Figure 2 ASDE-X Deployment Footprint](image2)
ASDE-X surveillance data to third parties. Taken as a system, ASDE-X provides the following fundamental capabilities:

1) 2D Airport Surface Situation Display (CWP)
2) Controller Conflict Alerts
3) Surveillance and System Data Recording
4) Surveillance Data Distribution

In practice, tower cab controllers rely on the CWP and conflict alerts to safely move aircraft from gate to runway and runway to gate. Operations and maintenance personnel depend upon the system status and recording capabilities to insure a high level of system availability.

Third parties are expected to leverage the surveillance data stream by providing value added services. Each of these capabilities will be found to have either alternate uses or provide additional benefit as the utility of ASDE-X at a NextGen enabled Airport is further explored.

3. NextGen Total Airport Management Operations

As the source and sink of all passengers, cargo, and aircraft, airports represent one of the most complex entities in the NAS. In reality, airports are operational and economic eco-systems with multiple stakeholders each trying to independently optimize their operations. A systems perspective and operational view of airports that balances security, safety, capacity, and efficiency, while addressing stakeholder needs, is a promising path forward and is reflected in many aspects of the NextGen initiative. Hence, the coined term “Total Airport Management” is an acknowledgment and recognition of the very complex dynamics associated with airport operations and the benefit that can accrue from understanding these dynamics when initiating and implementing operational improvements.

By definition then, Total Airport Management could be characterized as:

"An airport and surrounding airspace enabling the safe and secure movement of aircraft from top of descent, through approach, landing, taxi in, gate arrival and aircraft turn with the corollary taxi out, departure, and ascent through top of climb all achieved with the highest practical operational efficiency and schedule integrity while satisfying stakeholder preferences and needs."

Given this definition, Total Airport Management operations focus on all activities that collectively support the highest practical operational efficiency and schedule integrity at any particular airport.

Within the framework of NextGen policies and initiatives, there are many approaches for improving Total Airport Management operations. Examples include, and are not limited to: new groundside infrastructure such as runways and taxiways, new airside capabilities for improving throughput during parallel runway operations, and new dynamic separation standards that reduce fixed wake vortex aircraft spacing.

While each of these examples will contribute to improvements in operational efficiency, the focus here is on new concepts and cross domain capabilities that leverage data and information sharing to minimize or eliminate Total Airport Management inefficiencies while enabling user preference and needs. From a NextGen perspective, the most important of these concepts and capabilities include the following:

1) Business-Based User Preferences,
2) 4D Trajectory Based Operations,
3) Network Enabled Operations, and

Each of the preceding concepts and capabilities alone is worthy of substantial discourse. That said, the underlying set of ideas behind this grouping is simple to grasp, but a challenge to implement. Simply stated, users should be able to operate their aircraft, as preferred to meet business needs, while the underlying ATM infrastructure should accommodate and enable the most cost effective, time effective operations feasible to the extent that operational efficiency, flight safety and system security are not unduly compromised.

Operating under these concepts and capabilities would enable users to file 4D flight plans based on their schedule and business needs. The 4D flight plans would account for the performance characteristics of user aircraft or fleets such that zero energy, continuous descent arrivals and fuel efficient departure climb out is the norm.

Collectively, the operational status of a particular airport or the NAS would be distributed and made available to all relevant parties via a system wide information management (SWIM) infrastructure such that users could modify their operations as desired or necessary based on the latest and most accurate
system information. An example might include a flight plan re-route made necessary by changing weather, a change in operator plans, or possibly an aircraft malfunction necessitating an alternate destination. Once the flight plan is modified, the revised 4D trajectory would be broadcast and available for consumption by other systems and stakeholders. This would include the new downstream ATC facilities, the Air Traffic Control System Command Center (ATCSCC), the air carriers System Operations Center (SOC), the new destination airport, and third party services that monitor and track flight movement for public consumption.

The implementation of SWIM is an enabling step toward Networked Enabled Operations (NEO). NEO would leverage the pervasive availability of system information to monitor, assess, accommodate, and mitigate the impact of dynamic changes in the NAS as well as collective and individual changes in aircraft movement or schedules. Closely related to NEO / SWIM is collaborative decision making (CDM). Applied to the airport surface, CDM would enable stakeholder dialog that dynamically supports user preferences as airport operations unfold throughout a day of operations.

Moving to specifics how might these concepts and capabilities apply to NextGen Total Airport Management operations; figure 3 depicts an answer by representing the flow of aircraft into and out of a hypothetical airport. Each of the traditional domains is reflected from left to right with an associated operational objective captured underneath. Below the objectives are representative system technologies allocated across the Air Navigation Service Provider (ANSP), Air Carrier, or Airport Operator.

Taken together, these new system technologies represent some of the best current thinking on how to accommodate 4D trajectories and dynamic user preferences, while enabling collaborative decision making via NEO and SWIM.

Notice that ASDE-X is depicted as central to the ATC capability at each airport. Not shown on this diagram are the assumed control and data flows between new technical capabilities like AMAN, DAMN, SMAN, and surface CDM systems. Each of these capabilities will require substantial conceptual and technical work before implementation. That said, the FAA is pursuing many of these ideas via new R&D programs including integrated arrival and departure management, the surface traffic management system, en route descent advisor and tailored arrivals.

To summarize, the NextGen Total Airport Management operations concept is gaining traction with serious consideration being given to the best approaches for accommodating air traffic flows into through, and out of the busiest and most complex airports and related airspace.

Figure 3 NextGen Total Airport Management Operations
4. ASDE-X and NextGen

With a grasp of existing ASDE-X capabilities in hand and an initial understanding of NextGen Total Airport Management operations in place, the future role for ASDE-X might seem unclear. That perception, however, would be misplaced. Both as a platform for new capabilities and as a source of valuable data applicable to efficient NAS operations, ASDE-X will be a pivotal system in the future. Moving forward, ASDE-X can be leveraged in at least three basic ways:

1) As the Tower Cab platform for arrival, departure, surface management and surface CDM,
2) As a source of surface surveillance data and airport status information enabling NEO / SWIM, and
3) As a real-time and recorded source for metrics that assess and monitor airport efficiency, emissions, noise, and safety.

Implementing arrival, departure, surface management and surface CDM necessitates an interface suitable for controller interaction. Since the ASDE-X CWP is deployed in tower cabs for use by ground and local controllers, this display is the logical human interface for hosting new capabilities and decision support tools. Additionally, the underlying ASDE-X system components, installed in tower equipment rooms, can serve as the host platform for new data and algorithmic processing and data generation for display on enhanced CWPs.

Conceptually, local controllers would utilize an arrival manager to coordinate the estimated time of arrival (ETA) for each inbound landing aircraft with the associated upstream ATM facilities. In parallel, the arrival manager would interact with a departure manager to interleave active runway departures during natural or deliberate breaks in the airport arrival stream. Similarly, a ground controller would utilize a departure manager to insure an optimum departure aircraft sequence is delivered to the active runway. Further, a surface management tool would assist the ground controller by generating conflict free taxi paths and identifying surface movement conflicts before these impede the flow of surface aircraft and vehicles. Finally, the CWP would serve as an information conduit linking tower ATC personnel with other airport stakeholders via a surface CDM system.

Since the update rate for ASDE-X surface surveillance sources is once per second, the position, speed, and identity of cooperative targets is accurately reflected on the CWP and simultaneously recorded. This real-time stream of surveillance data can significantly improve situational awareness when shared with other airport stakeholders and distributed for use by related ATM facilities.

Distribution and access to this data could occur in at least two ways: through a NEO / SWIM interface with the ASDE-X system LAN or via the DD designed specifically for third party access. The latter method is already being used in the field with promising results.

One of the greatest untapped benefits of ASDE-X today is the analysis of real-time and recorded data to assist in understanding airport operations, to capture significant and useful airport metrics, and to assess and monitor airport efficiency. For reference and scale, the daily recorded surveillance data set for each ASDE-X airport is typically several Giga Bytes.

Significant operational insights into airport surface movement can be gleaned from recorded surveillance data. This can include the dominant taxi paths for each airport configuration, the impeded and unimpeded taxi times by aircraft type, flight, and carrier, and the excess fuel costs and emissions that accrue from inefficient and excessive taxi movement. For example, initial analysis of surveillance data from deployed ASDE-X systems suggests that excess taxi movement currently accounts for millions in additional fuel costs to air carriers.

The number of useful metrics discernable from the surveillance data is quite large and expected to grow as new stakeholders gain access to the data stream. Examples include runway occupancy time, runway utility in ops per hour, taxiway throughput, and very accurate threshold crossing and wheels up times that correspond to the OOOI events “On” and “Off.” In particular, accurate OOOI event capture and prediction could be extremely valuable to the ATCSCC. Many of these metrics could be generated for operational consumption in real time via a metrics data processor/server appended to the existing ASDE-X system.

The generation of value-added metrics and operational insights can be implemented and achieved quickly today and will most likely be a foundation capability as NextGen unfolds. Distributing surveillance data to improve situational awareness is already occurring and could be
expanded. The complexity associated with defining and developing the arrival, departure, surface management and surface CDM capabilities will require significant additional R&D. However, that should not deter the use of ASDE-X for these developments and the ultimate fielding of new capability on the ASDE-X platform.

5. Conclusion

The FAA is busily planning for multiple aspects of NextGen implementation to include the requisite R&D, demonstrations, developments, acquisitions, and deployments that will support the Total Airport Management concept and future airport operations. In the context of these activities, existing and future capabilities of ASDE-X were explored as cornerstone capabilities and enablers of NextGen. Specific features of the ASDE-X system platform, CWP, surveillance data stream and data recording capabilities where highlighted and explored to demonstrate how ASDE-X can and will contribute to the NextGen initiative.