Tower Flight Data Manager
Prototype System

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Outline

• Motivation
• System overview
• Information management framework
• Decision support tools
• Computer human Interfaces
• Field evaluation
• Summary
Evolving From Current Tower Operations

**Challenges:**
- Multiple stove-piped systems
- Coordination within tower
- Coordination with other facilities
- Adequate situational awareness
- Operational efficiency

**Approaches:**
- Net-centric architecture
- Integrated computer-human interfaces
- Data sharing
- Fusion and correlation
- Decision support
Tower Flight Data Manager (TFDM) System Components

Data Sources:
- Flight Plan
- Weather Obs.
- Surveillance
- Traffic Constraints
- Forecasts
- Flight Plan
- Weather
- Surveillance

External Stakeholders:
- Airline Operation Centers
- Other ATC Facilities
- Airport Authority

Common Services:
- Message broker
- Archive

Decision Support Algorithms
- Surveillance
- Fusion
- Decision Support
- Weather

Controller Interfaces
- Archive
- Surveillance
- Flight Plan
- Weather

Information Bus
**Information Management Framework**

- **Extensible system**
  - Supports multiple tower positions
  - Adaptable to sites and different class airports
  - Flexible information architecture
  - Enables integration with current and planned NAS systems
  - Evolvable system – replaceable components

- **Based on SWIM guidelines**
  - Enables data sharing with other facilities
  - Concept validation platform
  - Enabler for validating ongoing FAA data modeling e.g. Flight Object…)

Net-Centric architecture is key to providing integrated system
Data Fusion

- **Surveillance Processor**
  - Combine ASDE-X dropped or split track data into single consistent track using multiple sensor reports
  - Smooth aircraft position and heading using Kalman Filter models
  - Handle high rate of ASDE-X reports
  - Extend tracks to 60nm

- **Surface Monitor**
  - Locate targets relative to surface features (runway, taxiway...)
  - Determine if aircraft is airborne or on ground
  - Model vehicle motion and predict position in near-future
  - Control runway entrance/threshold hold bars
  - Generate safety alerts

- **Target Broker**
  - Match data within and between different external data sources (ASDE-X, FDIO, TFMS...)
  - Provide unique and consistent identifier for flights within TFDM system

Operational algorithms for identifying, tracking, and locating targets
Decision Support Functions

**Time**

**Strategic**

- Setup efficient airport configuration
  - Consider surface winds
  - Consider traffic demand

- Preempt delays & gridlock
  - Reroute flights
  - Coordinate departure time

- Balance runway use
  - Assign taxi routes
  - Manage push-backs

- Assist in meeting departure time
  - Establish efficient take-off sequence
  - Account for traffic constraints

- Ensure aircraft depart safely
  - Adhere to surface separation and enroute traffic constraints

**Traffic Management Function**

**Decision Support Module**

- AP Config Analysis
- Dep Routing
- Mastering
- Taxi Routing
- RW Assign
- Seq & Sched
- Conformance
Efficient Departure Routing

Route Availability Planning Tool

Flight plan data
Accurate take-off time predictions
Taxi Routing
Seq & Sched

Decision support modules facilitate collaborative rerouting

Dep Routing

Demand on Easterly blocked routes
South-East routes available

Supervisor

NextGen Tower-8
VM 10/22/2011
Metering Concept

Adding aircraft:
- Increases delay
- Increases fuel burn

\( Q^* = \text{Saturation point} \)

- \( Q \): Number In Queue
- \( Q^* \): Saturation point

**Q-control:**
Control strategy to maintain queue at saturation

- Future scheduled departures
- \( T \): minutes prediction of aircraft queue
- Number of departures
- Number on surface
- Aircraft push-back control

\[ Q^* \]
Example for Metering Decision Support
(24 February 2011)

Surveillance Display

Electronic Flight Strip Display

Ground Control

Predict queue build up

Throttle push-backs

Weather triggered airport operation well above saturation point

Opportunity to provide metering decision support
Accurate Taxi Time Models

Accurate taxi-time estimates required near push-back

**Inputs:**
- Taxi distance
- Airline
- Origin
- Arrivals
- Departures

**Supervised Learning**

**Trained Model**

\[ T = \sum_{n=1}^{N} w_n \phi_n(f) \]

**Average Taxi-Time Error Near Push-Back**

- Linear Regression
- Supervised Learning

Supervised learning model: Accurate & robust for real-time data
Human Factors Role
In Design & Development

- Tower Visits
- User Groups
- Simulation
- Operational Tests

1. Operational concept and high level requirements
2. Requirements and detailed design
3. Functional and benefits assessment
4. Operational assessment

Feedback: Operational utility, efficiency, workload, alerting/cueing, functionality, & robustness
Key Features: Surveillance Display

- Surveillance out to 60 NM
- Aircraft icons based on type, weight category
- Surveillance data smoothing
- Runway and taxiway closure indications
- Context-specific data block information
- Zoomable, rotatable display with multiple flexible subwindows
- Alarms and alerts
- Ribbon display
- Runway hold bars
Key Features: Flight Data Manager Display

- **Flight Data Manager Display**
  - Color coding consistent with Surveillance display
  - Coordinated selection with surveillance targets
  - Drag-and-drop touch screen interface
  - Multiple sorting options
  - Alarms, alerts, and prompts
  - Strip content tailored to controller position
  - User- and position-configurable layout
  - Quick-entry hot buttons
  - Editing, multisect, create, delete, undo options
  - Attention highlighting
  - Highlighting, acknowledgment, notes, flip capability
  - Search capability
  - Metering advisories

NextGen Tower-14
VM 10/22/2011
Key Features: Supervisor Display

- Airport configuration manager
- Runway-to-fix map tool
- Flight-specific impact of weather
- Runway time & sequence prediction
- Integration of traffic management initiatives
- Coupled to other tower positions and displays
- Active flight list
- NOTAMs, RVR, checklists
TFDM Field Demonstrations

Dallas/Fort Worth Airport:
- Size: 29.8 square miles
- Operations: 1,800 per day
- Passengers: 156,000 per day
- Runways: 7
- Towers: 2 primary, 1 backup

Testing:
- Duration: 6 days, 8 hours per day
- Operations: 2700 flights
- Controllers: 18

Test 1 – August 2010
- Flight data and surveillance

Test 2 – April 2011
- Decision support and video surveillance

Follow-On Demonstrations
- FY12, DFW or alternate site
User Rating Of TFDM Displays

**TIDS** will be beneficial to tower controllers.

- 10 (77%)
- 1 (8%)
- 1 (8%)

**The FDM** will be beneficial to tower controllers.

- 7 (58%)
- 2 (17%)
- 3 (25%)

**Supervisor Display Utility**

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Successful System Evaluation

**Example Positive Feedback:**
- “Tower ready”
- “Very easy to use”

**Example Suggested Improvements:**
- Add Automated Radar Terminal System information
- Improve timing on change of aircraft state to airborne

**Surveillance Display**

**Example Positive Feedback:**
- Coupling with surveillance and Supervisor Display
- Attention cues and prompts

**Example Suggested Improvements:**
- Propagate runway-to-fix pairing from Supervisor
- Add Beacon Code to electronic flight strip

**Electronic Flight Strips**

**Example Positive Feedback:**
- Ability to propagate information to tactical controllers
- Departure routing and metering decision support

**Example Suggested Improvements:**
- Ability to combine fixes and reroutes
- Greater ability to modify traffic management initiatives

**Decision Support**
Summary

• First highly integrated and operationally tested system for the tower environment

• Success enabled through early and frequent participation of experienced controllers in designing for user acceptance

• Work continuing to refine user interfaces and decision support tools