Tactical Departure Management with DMAN

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Introduction

- Arrival and departure management were identified as two key areas which needed to improve by introducing decision support tools
- Eurocontrol launched several studies concerning departure management
- DLR elaborated a concept for tactical departure management
  - first prototype (DARTS, Airport Zurich, operational 2003)
  - first generic prototype ROPS (Runway Operation Planning System) in 2002
- In 2003 Eurocontrol commissioned DLR to develop a DMAN (operational prototype) which should cover wide range of application areas in respect of
  - set of airports the DMAN can be configured
  - the ways the DMAN is operated
- Continuously development (DMAN I, II, III)
- DMAN projects
  - EMMA, Prague;
  - shadow mode trials Brussels;
  - G2G RTS1 and RTS3, Stockholm Arlanda
Objectives and Requirements of DMAN Development

- **Objectives**
  - Development of operational prototype that can be easily adapted to
    - different airports
    - different purposes
    - stand-alone demonstration
    - life trials in simulated or real tower environments
  - Verification of the concept of use with particular attention to dynamics of the management process
  - Study of different assessment criteria
    - capacity / throughput enhancement
    - efficiency of management
    - predictability of operations
    - compliance with operational regulations (Separations, CFMU slots, etc.)
    - workload
  - Objectives (cont.)
    - Creation of a test and development tool for advanced research into tactical AMAN-DMAN coordination
    - Provision of a solid basis for industrial development of an operational departure management system

- **Requirements**
  - data-based models for operations and scheduling constraints
  - stochastic event simulation for stand-alone demonstration
  - modular architecture that allows
    - varying number of supported CWP
    - use of the DMAN planning core with external (foreign) HMI (A-SMGCS situation displays)
Modular DMAN Architecture

Controller Working Positions
- one CLD
  - en-route clearance (ENR)
- one or more GND
  - start-up (SU)
  - push-back (PB)
  - taxi clearance (TX)
- one RWY (for up to 3 runways)
  - takeoff clearance (TO)
- all CWP
  - various options for information management and planning constraints

(technical) Supervisor
- data management
- event and message handling
- operational models

Planning Core
- event-driven, optimal planning of takeoff schedules
HMI for Runway Control
Operational and Constraint Models

**Operational Models**
- **purposes**
  - control human machine interactions
  - next and possible clearances
  - movement of flight strips
  - derive planning constraints
  - expected overall times for remaining operational steps
- **“model language”**
  - rule based, but expressed with tables
    (Excel sheets)
  - *Example*: IF stand belongs to STANDS1 AND aircraft type does NOT belong to LARGE1 THEN model name is NOPUSHBACK

- **stand, aircraft type**: flight plan items
- **STANDS1, LARGE1**: user defined groups of stands and aircraft types
- **NOPUSHBACK**: particular model, describing sequence of responsibilities, possible clearances for each CWP

**Constraint Models**
- **coverage**
  - multiple, mutually interfering (e.g. crossing) runways
  - segregated or mixed mode operations
- **categories**
  - wake vortex separations
  - SID separations
  - runway occupancy separations
- **“model language”**
  - table based (Excel Sheets)
  - hierarchy of tables
Planning

- **basis**
  - vector optimisation using a scalar substitution function (weighted sum of different objective functions)
  - search tree (A* Algorithm)
  - sliding window technique (take-select strategy) using a “natural departure sequence”

- **objective functions**
  (penalty functions for delays with respect to a reference time)
  - throughput
  - taxi-out delays
  - CFMU slot compliance & punctuality
  - planning stability
  - ... maybe extended (e.g. TTOT of a pre-tactical planning)

- **dynamics**
  - event driven
  - repetitive (revolving) planning with sliding horizon

- **considered constraints**
  - hard, i.e. will never be violated
    - safety (separations)
    - physical constraints (earliest times)
  - soft, i.e. can be violated (in a planning phase!), but the more the violation the worse the solution
    - CTOT compliance

- **timing**
  - planning the managed takeoff times
  - back-propagation of latest push-back / start-up times
First Results from Real-Time Simulation Trials

- operational test in G2G project; 15th-18th December 2004; Malmo,
- simulated airport: Stockholm Arlanda
- configuration:
  - 19R Departures; 26 Arrivals
  - CWP: GND-W; GND-N; RWY
  - CDM environment
  - A-SMGCS (level 1); no out of the window sight; no use of surveillance data by DMAN
- traffic scenario
  - 50 Departures
  - 40 Arrivals
  - realistic traffic mix (LFV)
- tests
  - baseline (without DMAN)
  - with DMAN
First Results from Real-Time Simulation Trials

- Traffic situation display with flight strip list
  - Show planning information (sequence number also in aircraft label)
  - Input of confirmed clearances
- Operational concept
  - Follow the proposed schedule as long as there are no good reasons
  - When overruling, DMAN will adapt planning
First Results from Real-Time Simulation Trials

Expectations and Results

- **capacity**
  - expectation: DMAN will enhance capacity (throughput)
  - result: no difference between supported and conventional departure management

- **CFMU slot compliance**
  - expectation: DMAN will improve slot compliance
  - result: no difference between supported and conventional departure management

- **efficiency of operations**
  - expectation: DMAN will increase efficiency of operations
  - result: taxi out times decreases substantially as well as queue length (estimated fuel save: 5 tons per hour and runway)

- **workload**
  - expectation: DMAN will increase workload
  - result: DMAN reduces workload substantially!

- **predictability**
  - expectation: DMAN will improve predictability
  - result: DMAN will improve predictability of operations
Taxi out times with and without DMAN

RTS1 Taxi - Out - Time

- without DMAN
- with DMAN

Sequential Number of Air

Taxi - Out -Time (s)

0 200 400 600 800 1000 1200 1400 1600 1800
Queue length with and without DMAN

RTS 1 Queue of waiting Aircraft

- without DMAN
- with DMAN

Simulation Time

Aircraft
Planning Stability (variation of planned takeoff time; example)
Planning Stability (variation of planned takeoff times for 40 departures)
Summary and Outlook

Summary

- The operational concept of tactical departure management has been proved to be
  - matured to be applied
  - beneficial with respect to efficiency, predictability and reliability
- Concept of tactical departure management is
  - easy to understand
  - easy to perform
- The benefits with respect to throughput and slot compliance have to be proved under more complicated operational conditions
- DMAN seems to be an enabler for other techniques, especially
  - CPDLC
  - CDM

Outlook

- DMAN will be used in different projects in simulated and real environments
- Future research and development
  - AMAN-DMAN coordination
  - DMAN-SMAN integration
  - DMAN in a CDM environment (cooperation with NLR (AT-ONE))