

A-CDM Lite: situation awareness and decision making for small airports based on ADS-B data



9th SESAR Innovation Days

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Motivation

Single European Sky ATM Research Programme - SESAR solutions

Moving from airspace to 4D trajectory management

- S32 Free Route through the use of Direct Routing
- S33 Free Route through Free Routing (cruise/vertical)
- S37 Extended Flights Plan

Airport Integration & Throughput

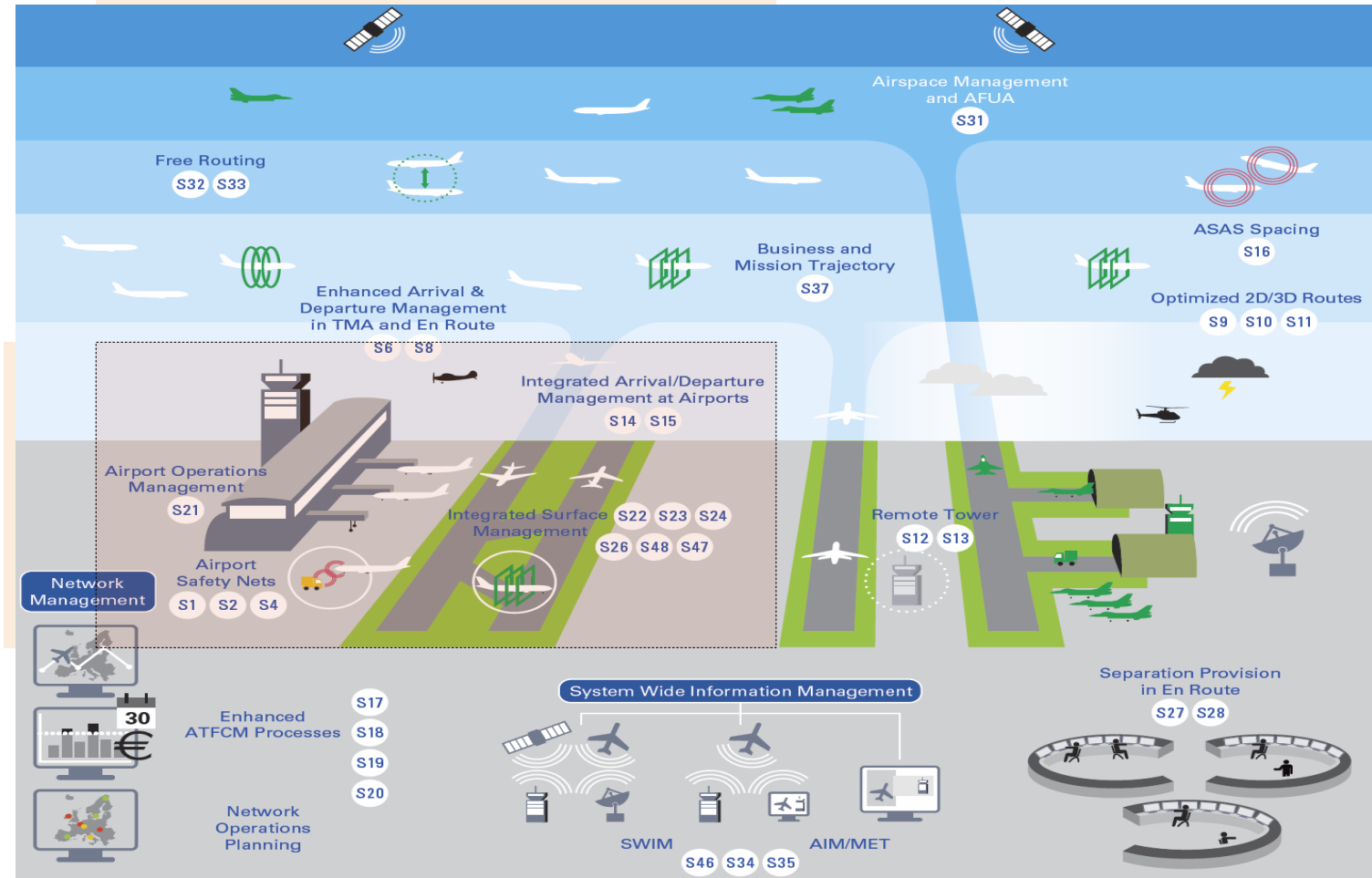
- S1 Runway Status Light
- S2 Airport Safety Nets for controllers ...
- S4 Enhanced Traffic Situational Awareness ...
- S12 Single Remote Tower operations ...
- S13 Remotely-Provided Air Traffic Service ...
- S22 Automated Assistance to Controller ...

Network Collaborative Management

- S17 Advanced Short ATFCM Measures ...
- S18 Calculated Take-Off Time (CTOT) ...
- S19 Automated support for Traffic ...
- S20 Collaborative NOP ...
- S31 Variable profile military reserved ...

SWIM

- S34 Digital Integrated Briefing
- S35 MET Information Exchange
- S46 Initial SWIM



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Background

challenges of growth, digitization, tailored approaches

Need for the digitization of aerodromes

- traffic growth by 53% by 2040
- speed and extent of data sharing massively increased
- new methods to evaluate this data required
- airports are trying to implement innovative approaches in their current operations

Local stakeholders (ANSPs, ground handler, airports, airlines) differ in terms of size, strategy, status, constraints, and business models.

- various levels of collaboration, information sharing
- considering individual benefits of each stakeholder
- imbalances by means of individual costs-benefits of information retrieval and sharing

Stakeholder	Information provided
Air Navigation Service Provider	- estimated arrival/departure times - times based on planning - data provided by handling agent - runway in use and runway capacity
Apron Control	- landing times - in-/off –block times - start-up approval, take-off times
Airport Operator	- stand and gate allocation - environmental information - special events (such as air shows, etc.) - reduction in airport capacity - reduction in runway availability - aircraft movement data
Ground Handling	- changes in turnaround times - target off-block time updates - planning data - information concerning deicing
Airlines	- priority of flights - flight plans - aircraft registration and type



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Airport collaborative decision making (A-CDM)

improve the efficiency of airports and the air traffic network

Airport environment is a competitive and collaborative environment

- stakeholders optimize their economic benefits considering various restrictions
- access to data from different sources to enable predictions about stakeholder's operational progress
- integrated airport management is embodied in an Airport Operations Centre (APOC)

APOCs could be significantly enhanced by **data-driven predictions** and **machine learning techniques** by showing hidden interdependencies in the complex airport system.

But ...

- A-CDM is characterized by extensive negotiations between stakeholders (new procedures)
- concerns that shared data (information) will not only be used for A-CDM, but also for the evaluation of competitor's business structure
- estimated costs for a full A-CDM implementation are about 2.5Mio.€ (annual maintenance costs of 150k€)
- A-CDM seems to be reasonable only for major airports - operating close to its capacities



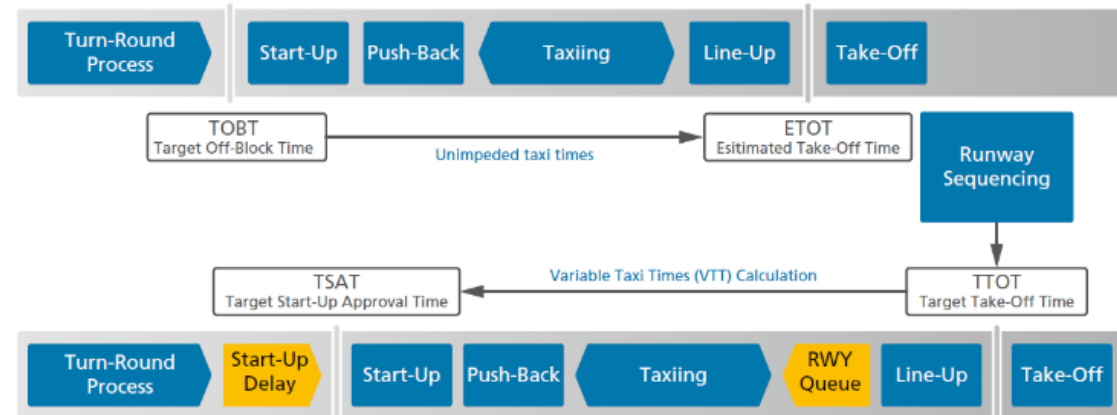
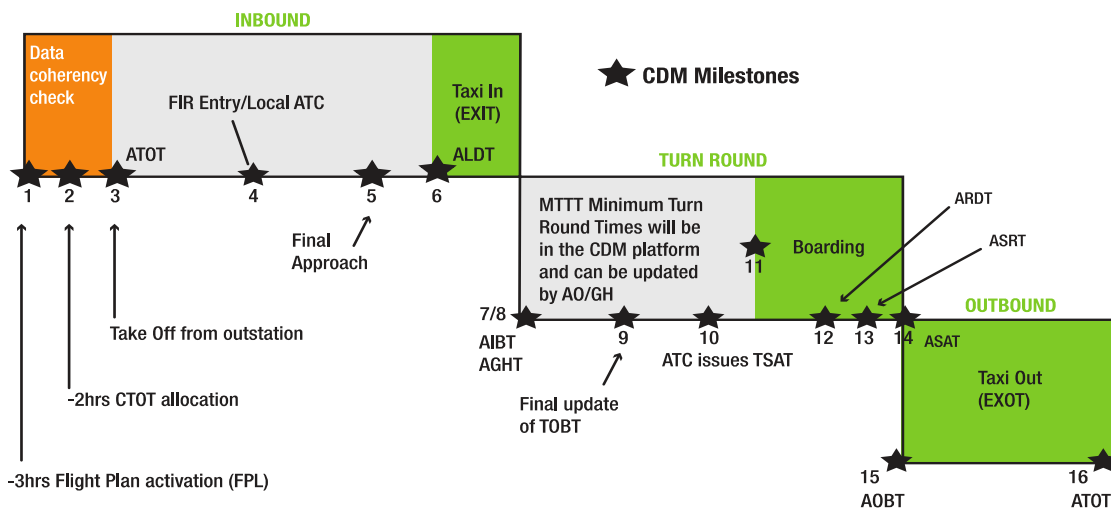
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Airport collaborative decision making (A-CDM) *milestones*

A-CDM concept consists of 16 milestones along the aircraft trajectory at the airport

- monitored by the corresponding stakeholders
- provide reliable target off-block time (TOBT), as the most important control parameter





Data-driven airport management

provide benefits for the entire air transportation system

Setting the scene

- performance-based airport environment needed in order to get full A-CDM benefits, but a full implementation of A-CDM is not favorable for small/medium sized airports.
- jointly coordination of operations to achieve agreed performance targets at airport (such as punctuality)
- local implementations must be both cost-effective and tailored to the corresponding airport environment

Contribution of the current paper:

- (1) establishing an A-CDM-lite approach: keep on milestones for the aircraft trajectory
- (2) use of open-source, public available data for aircraft movement
- (3) provide a conceptual prototype



Data-source

ADS-B data

ADS-B (automatic dependent surveillance broadcast)

- *automatic* aircraft transmits data periodically, without interrogation,
- *dependent* position data comes from on-board global positioning system (GPS) signal or flight management system (FMS),
- *broadcast* data transmitted to any listeners (including air traffic control ground stations, satellites, other aircraft).

Obligation

- aircraft have to be equipped with a transponder (Europe: June 2020; US: January 2020)

Expectations:

- current surveillance systems will be extended by ADS-B,
- future ground stations will be fully based on this technology
- equipment of ground vehicles at aerodromes enable a comprehensive monitoring



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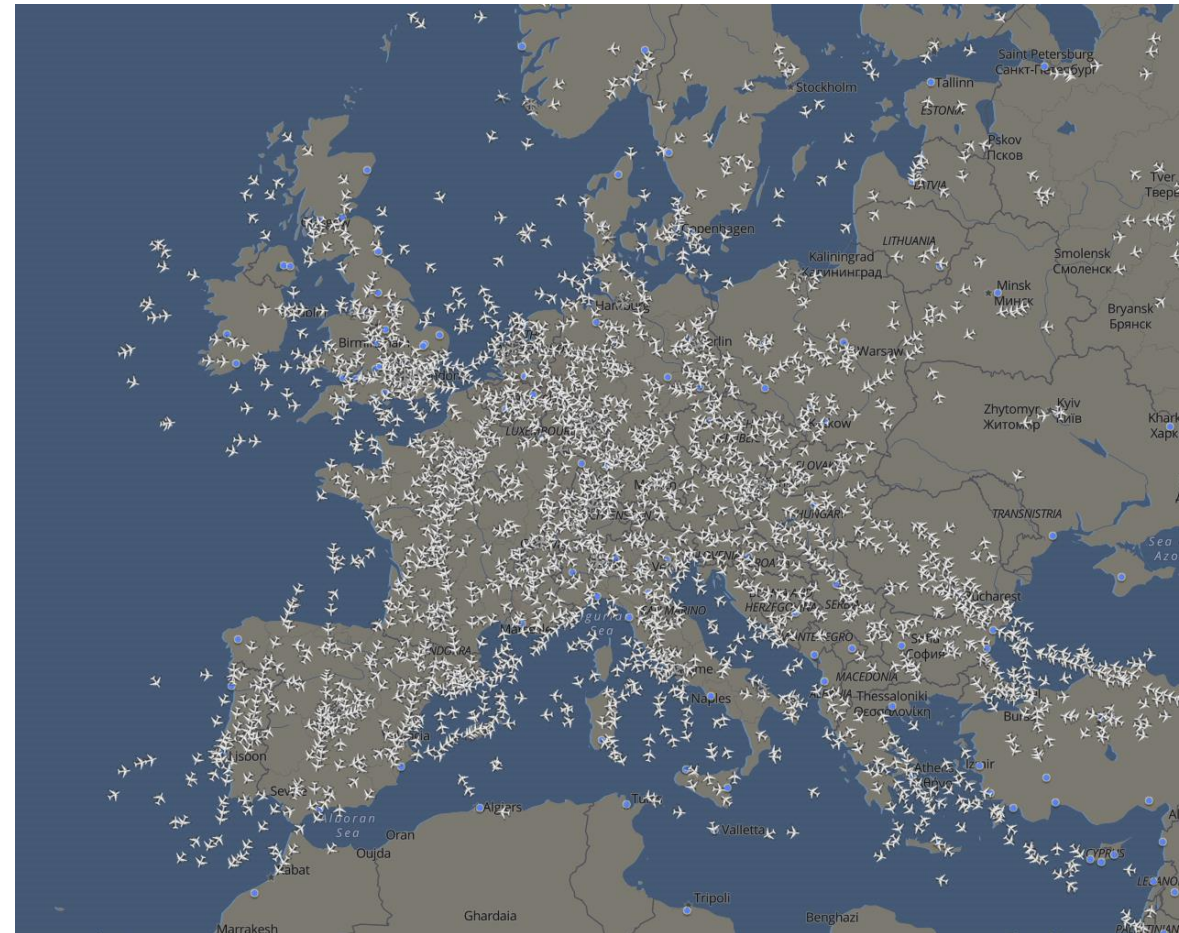
Data-source *ADS-B data*

Simple requirements on the receivers

ADS-B has contributed to the
development of online services

Display the current air traffic in real
time with worldwide receiver networks
such as

- OpenSky Network (opensky-network.org)
or
- Flightradar24 (flightradar24.com)



Tailored A-CDM milestones approach

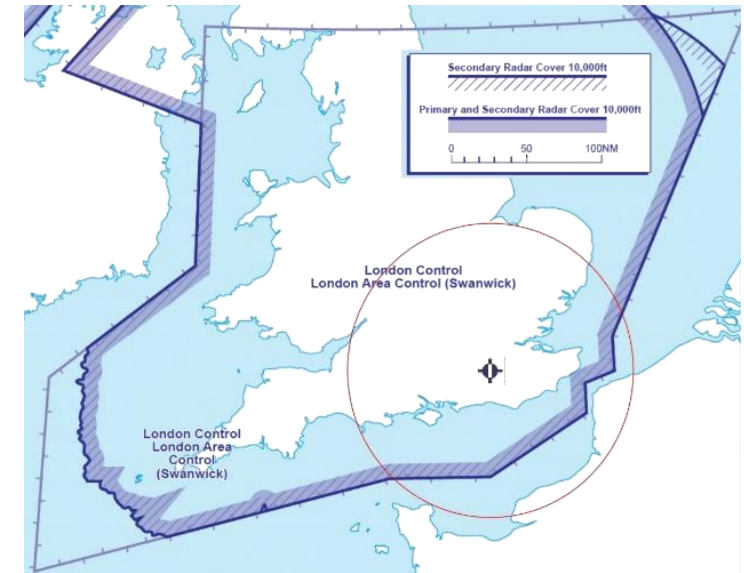
A-CDM lite

A-CDM-lite focusses on the following objectives:

- (1) reduce the number of milestones,
- (2) find appropriate proxies for missing data,
- (3) provide equivalent degrees of accuracy,
- (4) automatically predict single flight events and airport performance.

Developed prototype based on

- data provided within the ADS-B messages
- 8 milestone per aircraft trajectory
- London Gatwick as test scenario: less complex layout, highly dense traffic, appropriate data coverage, already used for other research projects (e.g. weather impact on local operations)



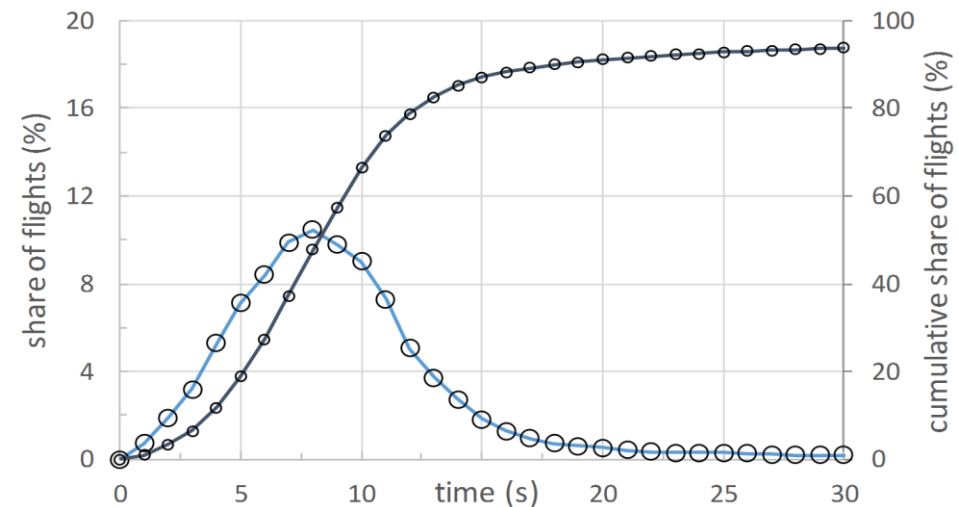
Data available

ADS-B messages contain relevant information

- latitude and longitude (°), 4 digits
- altitude (ft, 25ft steps)
- time (UTC, s)
- ground speed (kts)
- on ground indicator (boolean)
- climb rate (ft / s)
- aircraft type
- aircraft tail number
- flight number
- unique identifier for each flight

Inter-arrival times between two received messages, containing a specific, aircraft-based

- 20% of the updates are received within 5 s,
- 66% within 10 s
- 92% within 20 s



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Trajectory extraction

data handling: pre-processing and cleaning

data offset



missing data



special operations



Milestones

A-CDM lite

Ground trajectory created by connected tail numbers

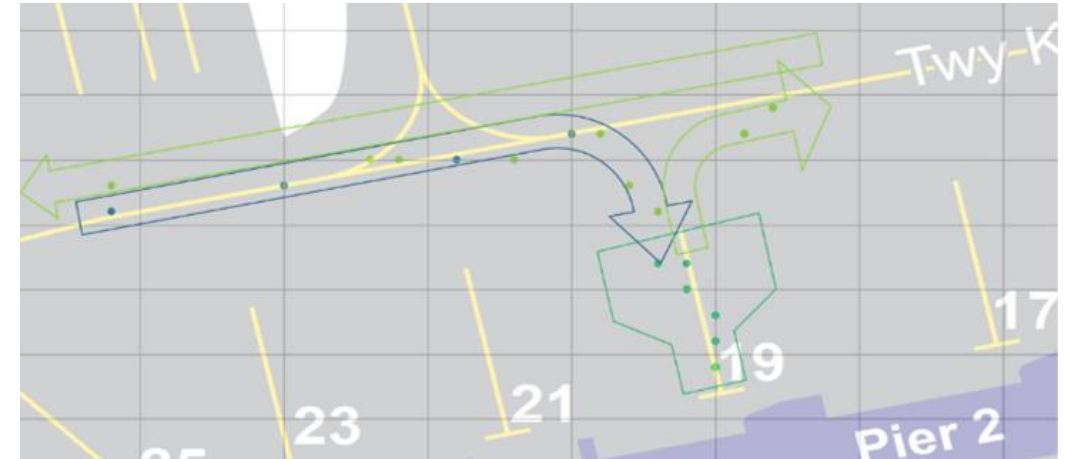
Landing and **take-off** times triggered by change of altitude to/from 0 m, 'on ground indicator', climb rate

Off-block

- position change from initial position, where the ADS-B signal is firstly recorded ('aircraft ready') – threshold of 40m

In-block milestone

- Position, where aircraft stops transmitting ADS-B messages, corrected by time when approaches this final position first time (threshold of 40m)



Aircraft movements (dots) close to the parking position and movement directions (arrows)



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Milestones

A-CDM lite

Milestone (according to A-CDM)	Description	Flight phase	Status	Data
4	Local radar	Inbound	Local radar in	First contact
5	Final approach		On final	Altitude < 2500 ft
6	Actual landing time (ALDT)		Landed	On ground == true
7	Actual in-block time (AIBT)		In-block	Distance > 40 m
12	Actual ready time (ARDT)	Outbound	Ready	First contact
15	Actual off-block time (AOBT)		Off-Block	Distance > 40 m
16	Actual take-off time (ATOT)		Departed	On ground == false
x	Local radar		Local radar out	Last contact

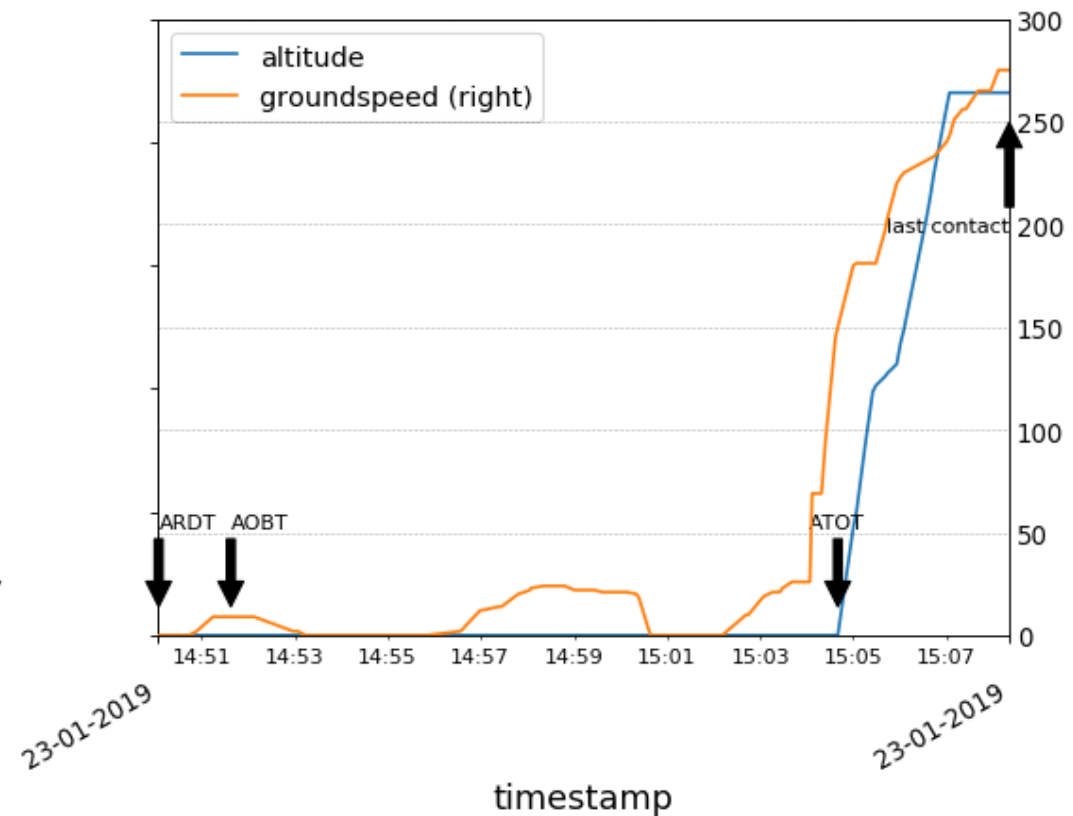
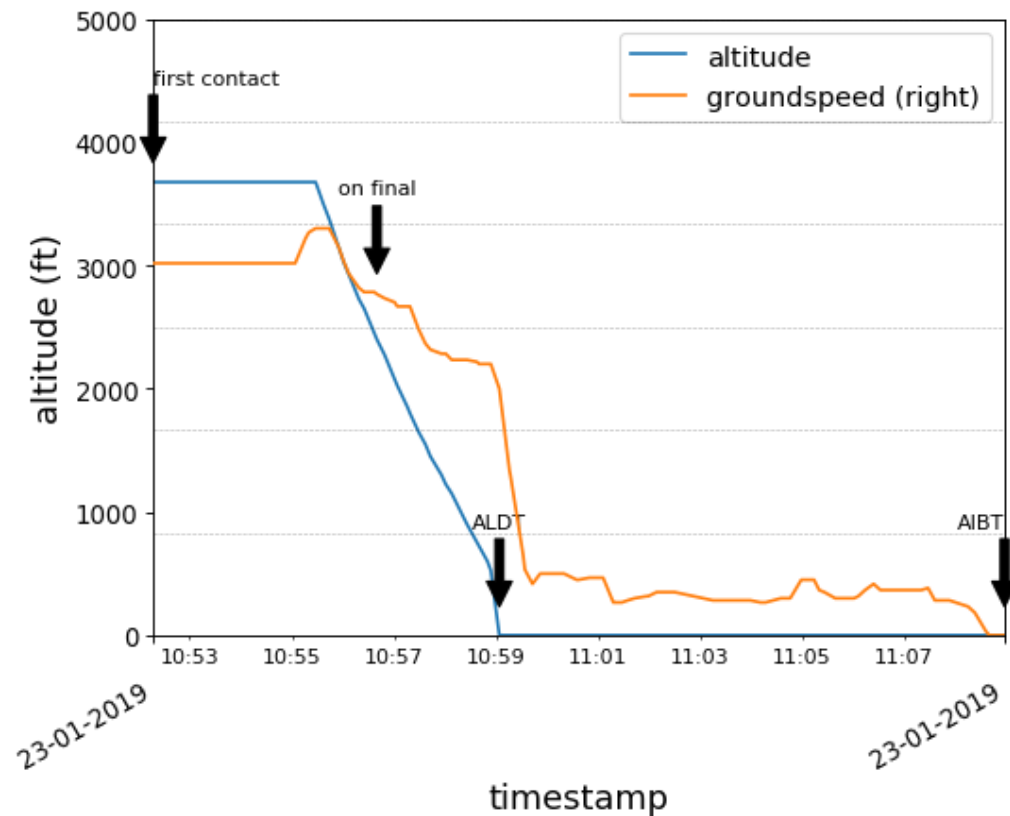


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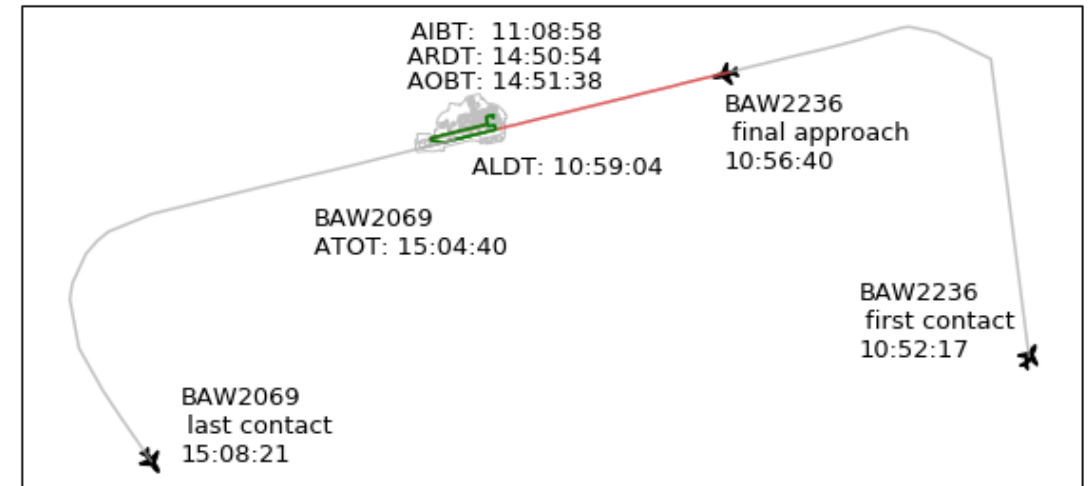
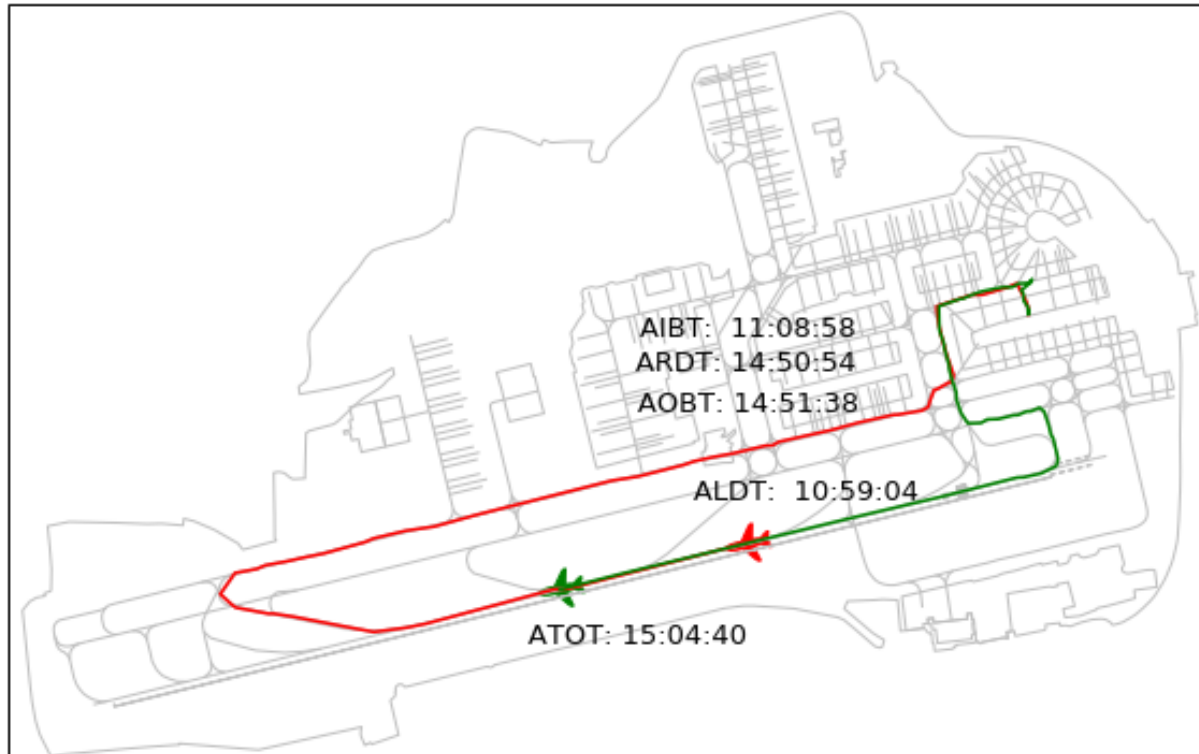
A-CDM lite milestones

exemplary aircraft trajectory – speed and altitude

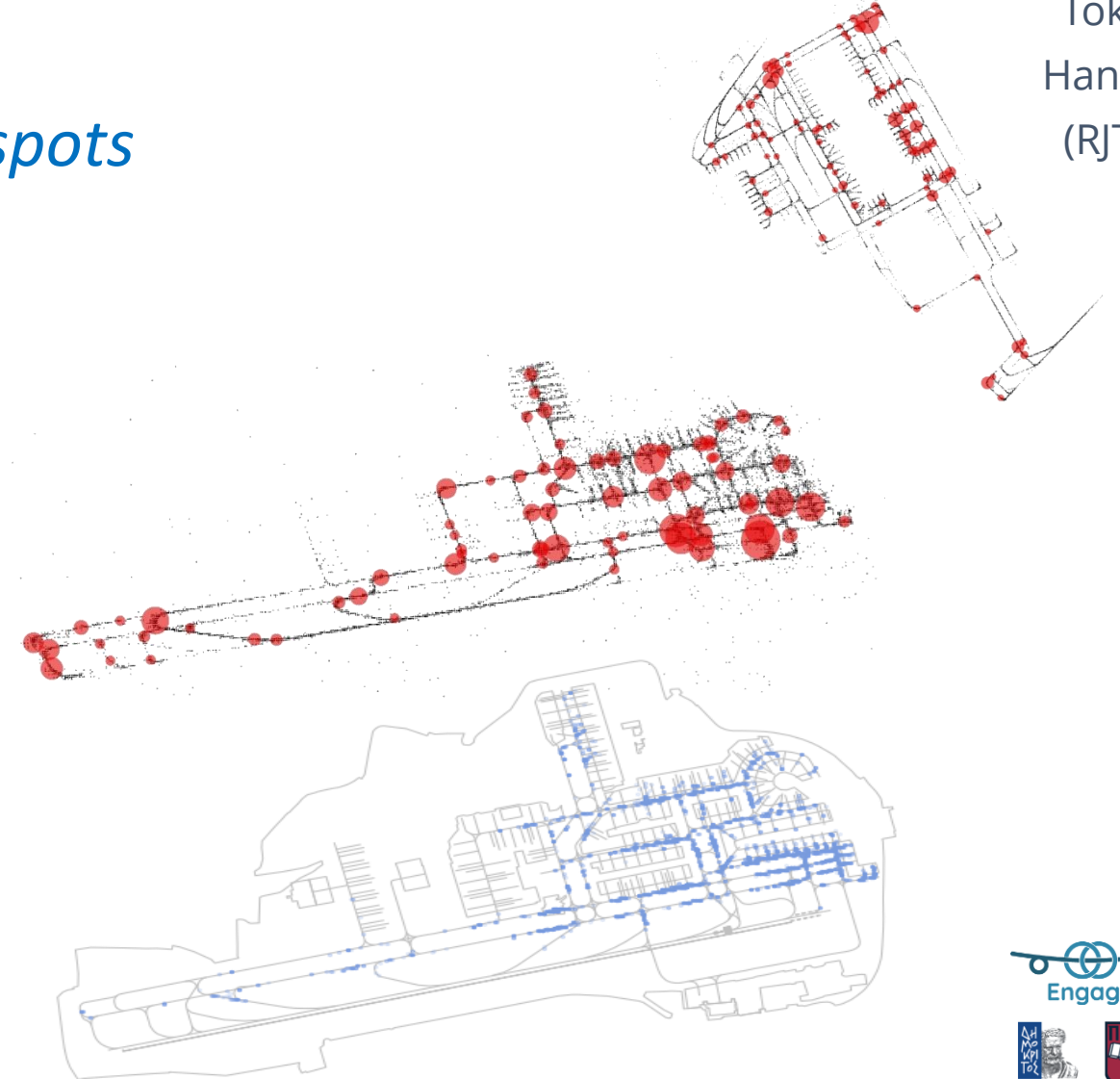
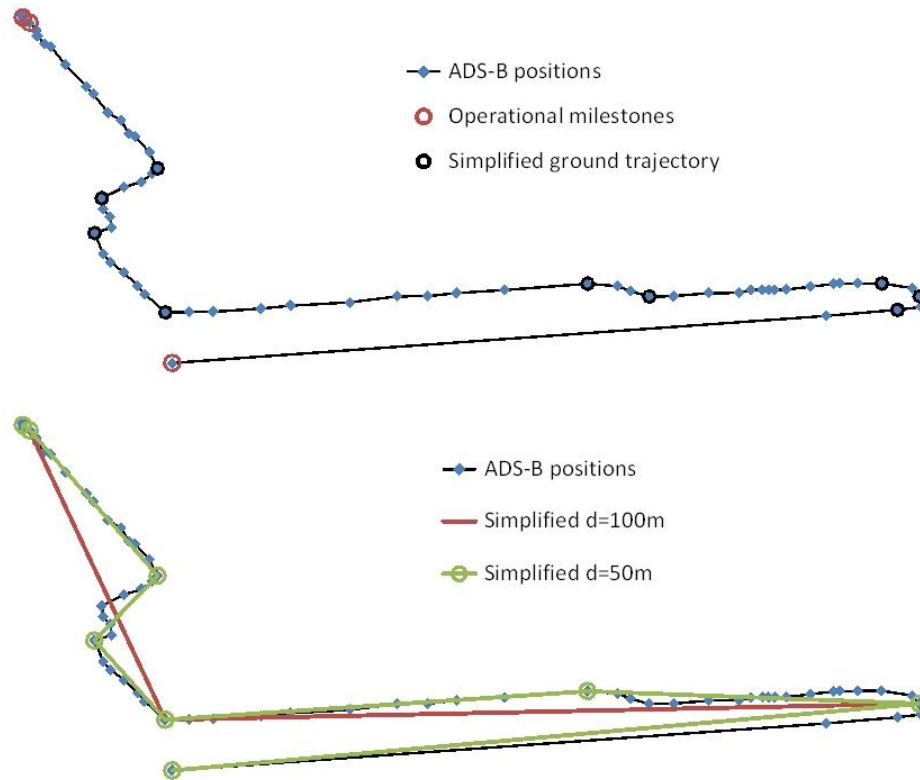


A-CDM lite milestones

exemplary aircraft trajectory – ground and air view



Data reduction *identification and operational hotspots*



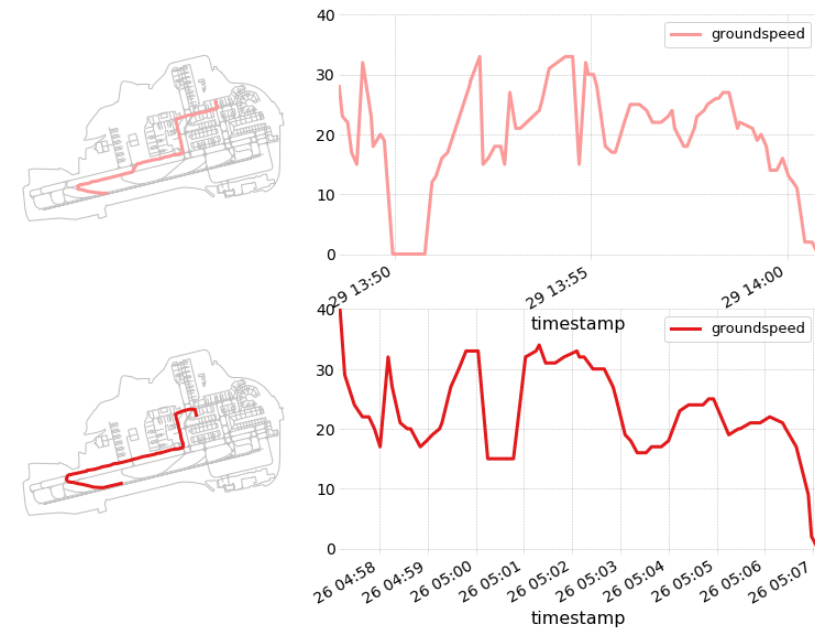
Tokyo
Haneda
(RJTT)

Data clustering

Different clusters based on aircraft position
and groundspeed



Different speed profiles (waiting queues)





Conclusion

data-driven airport management using ADS-B data

Challenge

- airports need to implement innovative, data-based approaches to improve current operational efficiency
- full A-CDM capabilities demand for a comprehensive and expensive sensor environment
- operations at small/medium sized airport have impact on network performance

Paper contribution A-CDM lite

- provide a cost effective approach to be implemented at any airport, equipped with ADS-B receiver
- enables a network wide integration of collaborative decision making
- 8 milestone are derived to describe an operational-focused aircraft trajectory

Next steps

- implementation of enhanced clustering algorithms to identify specific operational concepts
- application of machine learning techniques to derive target times for operational planning



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Thank you.



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