The evolution, challenges, and future of air traffic flow management

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ATFM Workshop Asia Pacific 2014
Traffic growth worldwide

Data source: ICAO
Main problems

Delay

Congestion

Safety and Security

Environmental Impacts
Demand-Capacity Balancing

ATFM:
Safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilized to the maximum extent possible
Solution Before

Traffic Increased dramatically. GDP, Ground Stop, MIT, CDM

Traffic congestion occurred at airport and terminal airspace, then propagated into en route

Increasing needs

System Update

Next Generation of ATM: 4DT management

System R&D

1960s

1970s

1980s

1990s

2000s

2025–
Trend in ATFM research

Data source: scholar.google.com
The characteristics of ATM system

Uncertainty

Diversity

Complexity
<table>
<thead>
<tr>
<th>Primary Characteristics of Complex Systems</th>
<th>ATM System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Structural Complexity</td>
<td>✔</td>
</tr>
<tr>
<td>2 Behavioural Complexity</td>
<td>✔</td>
</tr>
<tr>
<td>3 Nested Complexity</td>
<td>✔</td>
</tr>
<tr>
<td>4 Evaluative Complexity</td>
<td>✔</td>
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</table>
ATM as a complex system

The network of Chinese ATM system

Nonlinear interaction in a sector

Traffic complexity

Sector configuration

Controller

Pilots
The ATFM problem becomes more and more complicated......

how to solve it ???

we need to consider.......
Key components of ATFM system

**Fundamental theories**
- Systems theory
- Information theory
- Cybernetics

**ATFM System**
- Organization Structure
- Operation Procedures
- Capability of each subsystem

**DATA**
- Data storage
- Data management
- Data mining
- Data analysis
- Data visualization
- Data application

Collecting data → Provide Suggestion and Solutions
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Collecting data → Information exchange mechanisms → Provide Suggestion and Solutions
Theoretical model for ATFM
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Collecting data → Information exchange mechanisms → Provide Suggestion and Solutions
The structure of ATFM System in Europe
The structure of ATFM System in US
China ATFM organization

The Structure of ATFM System in China
Operation mechanisms

Strategic ATFM

Pre-tactical ATFM

Tactical ATFM

The Operation procedures of ATFM System in China
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Collecting data → Information exchange mechanisms → Provide Suggestion and Solutions
Operation procedures

- Demand Prediction
- Scheduling
- Airport Surface
- Arrival
- Departure
- En-route
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Collecting data → Information exchange mechanisms → Provide Suggestion and Solutions
Capability assessment

- Capability Assessment
  - Airports
  - ATC
  - Airlines
  - Human
  - System
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**Information exchange mechanisms**
- Collecting data
- Provide Suggestion and Solutions
Performance evaluation

- Post-operation evaluation
  - Indicator Scheme
    - Airspace Indicator
    - Traffic Indicator
    - Airport Indicator
    - Airlines Indicator ….
  - Management Efficiency and Effectiveness
    - Organization Structure
    - Operation Mechanisms
    - Human Performance
Systematic View

Congested airport cluster

Delay propagation

Performance evaluation

Distributions of flying times (ZBAA to ZGSZ)

Distributions of flying times (ZBAA to ZSSS)

~6 min

The same airline!

Airline behavior study based on data analysis
Information Technology

Big data + Meaning = Information
Thank you!