TFM History

- De-regulation: leads to new demand patterns
- High fuel prices
- Air Traffic Controller’s Strike***
  - TFM is born (mid ’80s: eliminate airborne holding)
- And then conflict and distrust which sparked CDM
  - FAA: airlines “cheat”
  - Airlines: “FAA over controls and over constrains”
- TFM and CDM influence global ATM
The FADE Wargame: December 1994

- Participants: 11 airlines, FAA, ATA, contractors
- Four scenarios chosen by scenario control team
- Each airline assigned to a unix work station: FAAs command center in a separate room
- The purpose is to work our procedural details, develop rules of engagement and identify potential problems/issues

CDM History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>FAA ordered GDP Substitution Analysis</td>
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<td>1992</td>
<td>FAA Airline Data Exchange (FAE)</td>
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<td>1993</td>
<td>FAA/Airline Meteor runs “War Game” to measure GDP power to save 10-35% delay</td>
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<td>1994</td>
<td>FAA/Airlines conduct GDP/FSM Human-in-the-loop Tests</td>
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<td>1995</td>
<td>CDM initiatives included in Free Flight Action Plan</td>
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<tr>
<td>1996</td>
<td>GDP Enhancement Pre-Operational Testing</td>
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<tr>
<td>1997</td>
<td>AOCnet established (later becomes CDIMen)</td>
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<tr>
<td>1998</td>
<td>GDP Prototype Operation Expands to STL &amp; LGA</td>
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<td>1999</td>
<td>Compliance Window reduced to +/-5 min.</td>
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<tr>
<td>2000</td>
<td>NavCanada begins using RT PSA to Monitor Canadian GDPs</td>
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<tr>
<td>2001</td>
<td>CDIMen begins integrating GDPs into operational environments</td>
</tr>
<tr>
<td>2002</td>
<td>CDIMen begins integrating GDPs into operational environments</td>
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<tr>
<td>2003</td>
<td>Playbook Routes Added to RMT</td>
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</table>

Jane Garvey, FAA Administrator, orders GDPE Prototype Operation expanded to all CONUS airports, and major TRACONs.
CDM and change: The Stages of Change

- Indifference
- Obstruction
- Let them fail
- Bandwagon
- Promotion of the non-participants

There has been change

- Common situational awareness
- Collaboration does continue and is spreading (European CDM)
- Data exchange
- Performance analysis
- The dispatcher
- Measuring success
TFM is about balancing capacity and demand:

EWR demand (pre-GDP)

Flights Affected: 300 Flights
Total Delay: 18,582 Minutes
Average Delay: 62.4 Minutes/Flight
Maximum Delay: 129 Minutes

EWR demand (GDP initiation)
An ATL GDP: reacting too late (under control)

EWR demand - 2.5 hours after GDP implementation: potential for wasted capacity: can only be solved through collaboration
CDM: FAA actions alone can’t ensure system efficiency

Although, the capacity at an airport is reduced and ATC delay has been applied, users may cancel and delay flights as well as notify the FAA of earliest feasible departure times of flights.

**FAA Actions**
- Issue ATC delay

**Airline Actions**
- Generate Demand
- Cancellations
- Airline Delays beyond ATC delay
- Earliest Departure/Arrival Time updates

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**The Pillars of CDM**

- **Analytical Capability**
  - Measurement
  - What-ifs

- **Distributed Planning**
  - Efficiency
  - Equity
  - Dynamic
  - Decision Points

- **Common Situational Awareness**
  - Infrastructure
  - Message Formats
  - Display Tools
FAA wants airlines to send in true schedule information to provide accurate demand picture and quit “cheating”
Determine a set of feasible arrival slot times \( \{ s_i \} \)

\[
\begin{align*}
    s_1 & = T_1 \\
    s_{i+1} & = s_i + 1/ AAR_{s_i}
\end{align*}
\]

where \( T_1 \) = the start time of the program and \( AAR_t \) = the arrival acceptance rate at time \( t \)

**Assign flights to arrival slots**

**Initial Approach to Assigning Arrival Slots: Ration by Reported Demand**

Each flight \( i \) has a reported arrival time \( t_i \)

Let \( x_{i,j} = 1 \) if flight \( i \) assigned to slot \( j \), 0 otherwise

Solve to minimize total delay

\[
\text{Minimize } \sum_{i,j} x_{i,j} (s_i - t_i)
\]

subject to

\[
\begin{align*}
    \sum_j x_{i,j} & \leq 1 \text{ for } j = 1, \ldots, m \\
    \text{(each slot is assigned at most one flight),}
    \\
    \sum_i x_{i,j} & = 1 \text{ for } i = 1, \ldots, n \\
    \text{(each flight is assigned to one slot),}
    \\
    x_{i,j} & = 0 \text{ if } x < t_i \\
    \text{(no flight is assigned before its current arrival time).}
\end{align*}
\]
Equitable Allocation of Arrival Slots: Ration by Schedule

- Arrival slots are distributed according to published schedule rather than reported demand.

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Equitable Allocation of Arrival Slots: Ration by Schedule

- Arrival slots are distributed according to published schedule rather than reported demand
- When flights are cancelled or delayed, airlines retain rights to those slots
- Airlines can assign flights to slots in whatever way best suits their business needs
- An optimal solution is found that is accepted and understood

Maximizing Available Resources: Compression

- Often airlines are unable to use their allocated slots
- Without FAA action, resources would be wasted
- Compression, moving flights up to fill vacant slots, benefits everyone
- A strong Incentive for participation
Pre-CDM GDP Process

- No opportunity for the airlines to solve the problem and avoid the GDP
- No ability for the FAA to respond to changing conditions with revisions or compressions
- No smooth transition out of the GDP

Current CDM GDP Process

- FAA/FAA Evaluation Demand Vs. Capacity
- GDP Modeling Send Proposed GDP Advisory
- Issue GDP (Ration by schedule)
- Airline Response (Substitutions & Cancellations)
- Program expires or is cancelled
- Airline Response (Substitutions & Cancellations)
- Is GDP still required?
  - Yes: GDP Revision /Extension, Compression
  - No: Exit loop when program expires or is cancelled

Send GDP Advisory
CDM the Practical:
It’s the easy part

- Information Exchange and Infrastructure
- Data quality
- Predictive models
- Expanded user base
- Benefits: avoid over/under demand predictions

A Look at SWAP

Intense weather that is close in or moving toward and will probably impact the N.Y. Metro area and/or weather in the Ohio Valley region initiates the SWAP process.
Current Approach to SWAP

On July 7th 2005, to deal with severe weather here …

… specialists ran Ground Delay Programs at 14 airports

Up until June, 2006 GDP’s were used to slow traffic during SWAP Events.

Flights that are not routed through the constrained airspace end up taking delays because their destination is a “GDP in support of SWAP” Airport.

Delayed by GDP in Support of SWAP
Flights routed through constrained airspace end up not taking ground delays because their destination is not a GDP in support of SWAP Airport.

**AFP Benefits**

- Distributes delays equitably among flights through the constrained resource.
- Avoids imposing unnecessary delays on flights that don’t use the constrained airspace.
- Provides customers with more predictability & flexibility /options (such as rerouting out of the AFP).
CDM the Conceptual:
It's difficult: what to do next and how to allocate limited resources?

- Tools, procedures, training need to be pursued collaboratively
- What are the problems and what are the priorities?
  - It's getting harder as more and more users participate?
- The need for human-in-the-loop simulation

\[
P-\text{DELAY} = \#\text{PSGR} \times \text{min DLYD}
\]

<table>
<thead>
<tr>
<th>Passengers</th>
<th>P-Delay min</th>
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<tbody>
<tr>
<td>60</td>
<td>26580</td>
</tr>
<tr>
<td>116</td>
<td>3600</td>
</tr>
<tr>
<td>93</td>
<td></td>
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<td>87</td>
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<td>87</td>
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<tr>
<td>Total 443</td>
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Original P-Delay is 738% greater than revised