



 *Air Traffic Analysis, Inc*

Dynamic FPAs: a New Method for Dynamic Airspace Configuration

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DAC Objectives: Sector Boundary Changes

- Dynamically adjust airspace to maximize throughput vs. changing weather and traffic demand
- Optimize controller workload and airspace efficiency
- Dynamic boundary changes: 'workable' from ATM perspective
 - Continuity, no drastic changes from hour to hour
 - Robustness vs. moderate shifts in traffic
 - 'Smooth' boundaries; 3D, not just 2D
 - Avoid riding major traffic flows
 - Be mindful of location of major airports, intersections
- Accommodate new airspace classes

Computational Geometry & Optimization Methods: Challenges

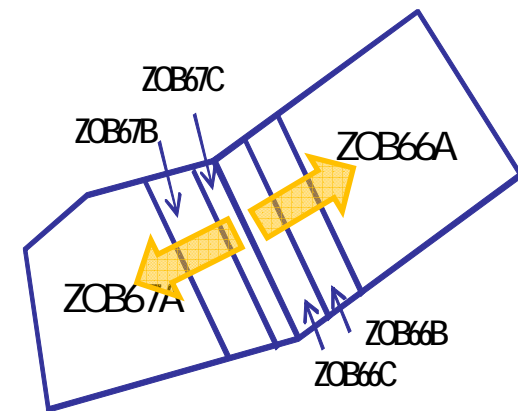
- Traditionally applied methods:
 - Aimed at fully equalizing sector workload
 - Usually attempt global optimization for entire day
 - Boundaries generated from hour to hour may differ significantly
 - Can be slow, especially with multiple constraints
 - Typically work only in 2D
 - Not easy to find solutions 'workable' from ATM perspective
 - Our own experience: Seed Growth Algorithm
 - worked well for large Centers / global 2D optimization,
 - less suitable for smaller-scale, hour-to-hour, 3D, dynamic airspace adjustments

Proposed New Approach: Dynamic FPAs

- Use today's FPA concept
 - FPAs (Fix Posting Areas): pre-designed building blocks for Sectors
 - Sector's FPA composition can change dynamically
 - Today, this is infrequent and not sufficiently dynamic
- *Expand this concept*
 - Create more "FPAs", especially near sector boundaries
 - Share FPAs between sectors dynamically, as needed
 - Not limited to present FPA layouts
 - Design FPAs that make sense from ATM perspective
 - Metric: initially, sector occupancy count as % of MAP value

Building and Dynamically Sharing FPAs

- Design FPAs using an on-screen drawing mechanism
- For each FPA, specify parent sector and “share with” sectors
 - An entire sector may be an FPA
- FPA sharing in “layers”: starts at the common boundary and progresses inward
- Same principles apply in vertical dimension
- An FPA can be shared with > 1 sector



Dynamic FPA Assignment Algorithm (1)

Ceding an FPA to a Neighboring Sector

Scan all sectors in 15-min intervals

For each sector A: **if** Metric > OVERLOAD_THRESHOLD, check all FPAs for ceding to other sectors:

if sector A has an FPA "A1" that can be shared with a neighbor sector B

AND

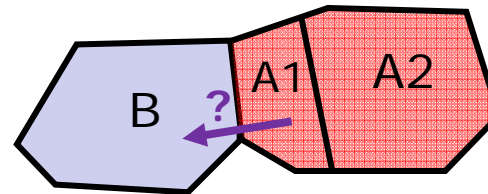
new Metric in (A1+B) would be < OVERLOAD_THRESHOLD,

AND

new Metric in (A2) would be > MIN_LOAD_THRESHOLD,

then give FPA "A1" to sector B

...



Dynamic FPA Assignment Algorithm (2)

Combining Underloaded Sectors

...

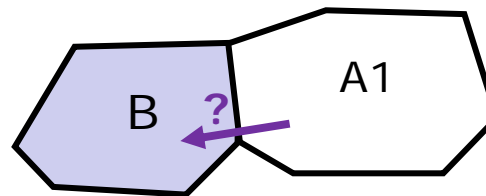
Else, **if** Metric in sector A < COMBINE_THRESHOLD, check if sector A can be combined with another sector:

if sector A has an FPA "A1" that can be shared with a neighbor sector B

AND

new Metric in (A1+B) would be < OVERLOAD_THRESHOLD

then give FPA "A1" to sector B

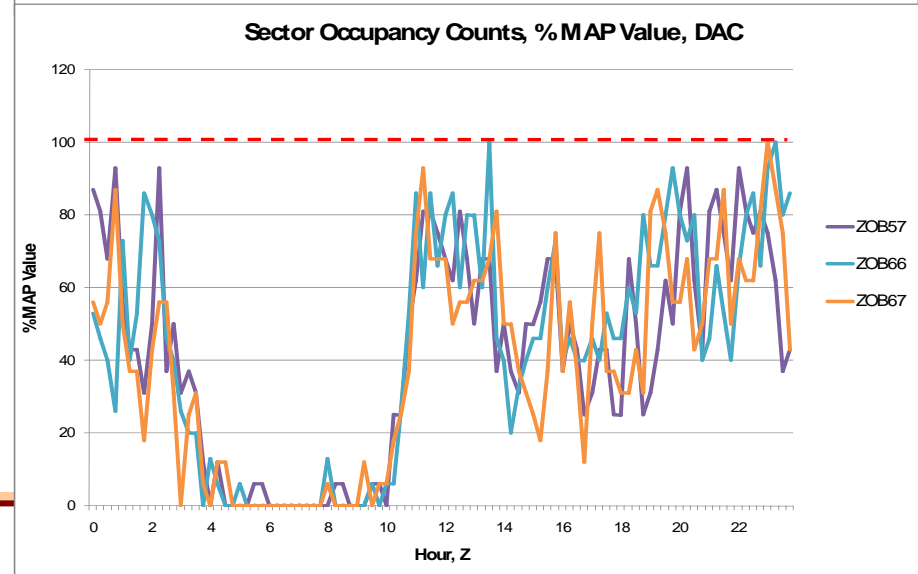
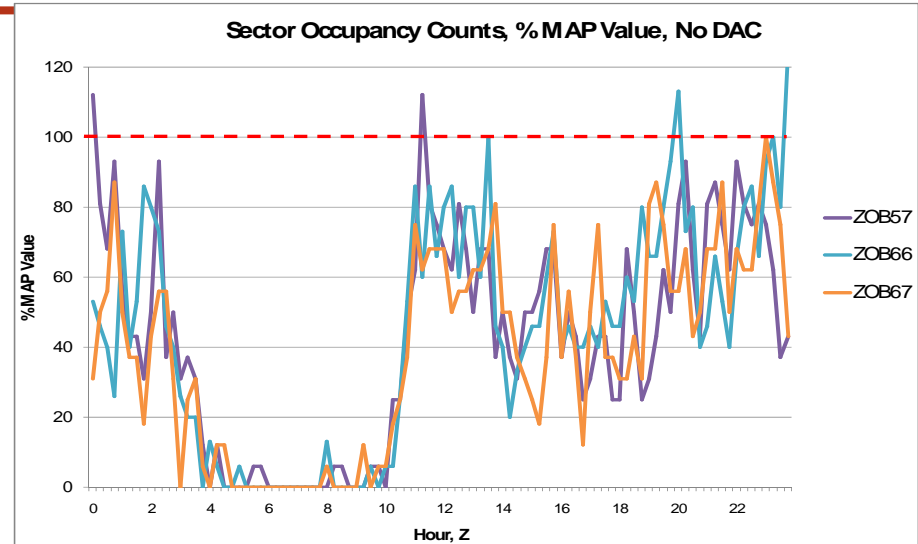


Sector Boundary Adjustment

ZOB Airspace Playbook example: July 16, 2007

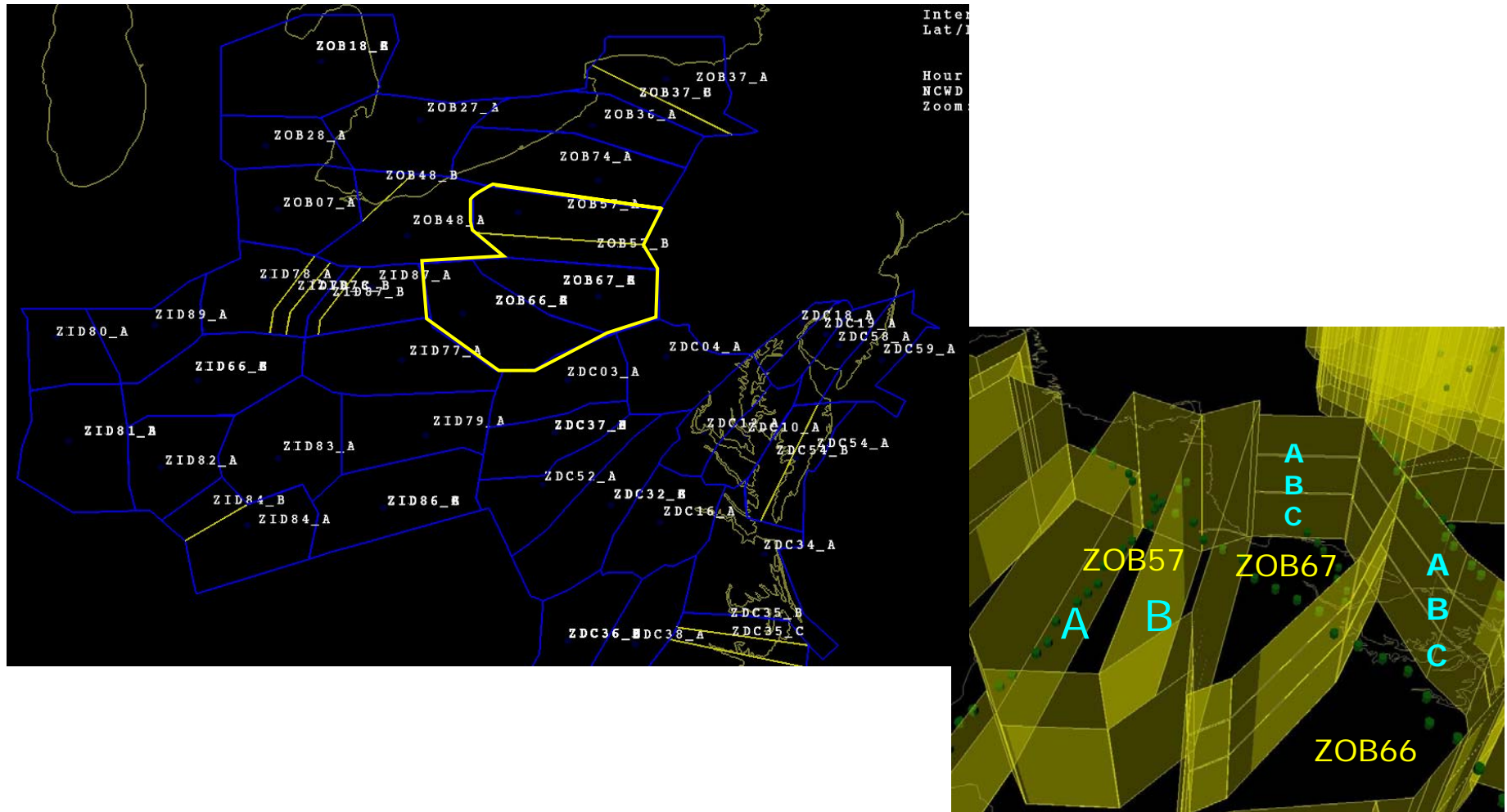


- ZOB57/66/67
- July 16, 2007 traffic demand increased by 35%
- Excessive workload (top chart)
- Dynamic FPAs help reduce peak occupancy counts and balance workload (bottom chart)



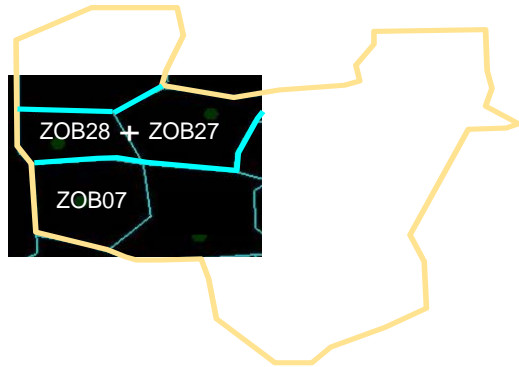
ZOB57/66/67 FPAs

Combination of 2D and 3D adjustments

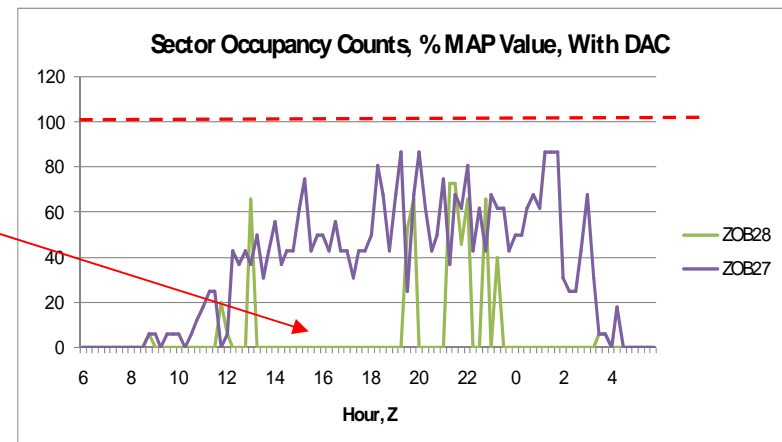
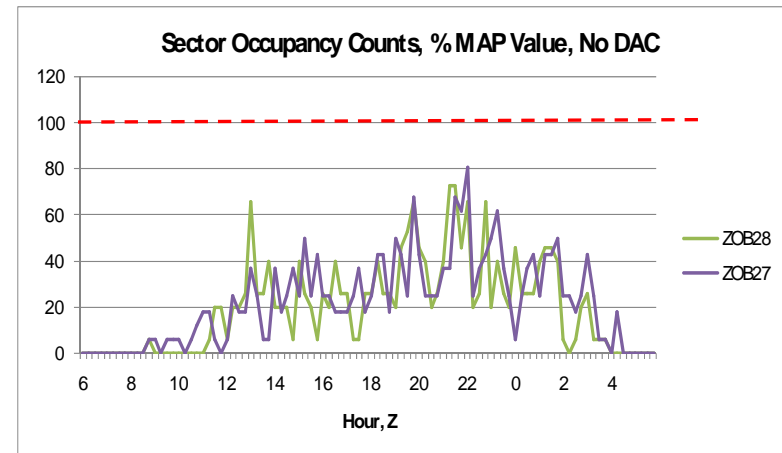


Combining Under-loaded Sectors

Another ZOB Airspace Playbook example

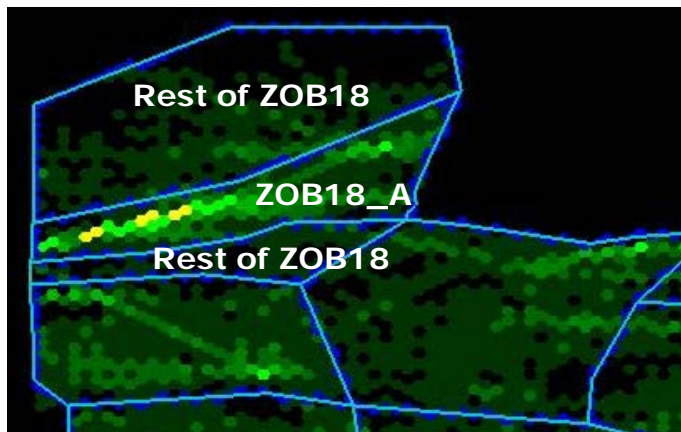


- ZOB27/28
- Current traffic demand
- Under-loaded sectors (top chart)
- Sectors combined for periods of time (bottom chart)



Potential New Airspace Class: Tube (1)

“Chicago Inbound Tube” Carved Out of Existing Sector



This would create an extra sector, which can be avoided by extending the “Tube” into adjacent Center...

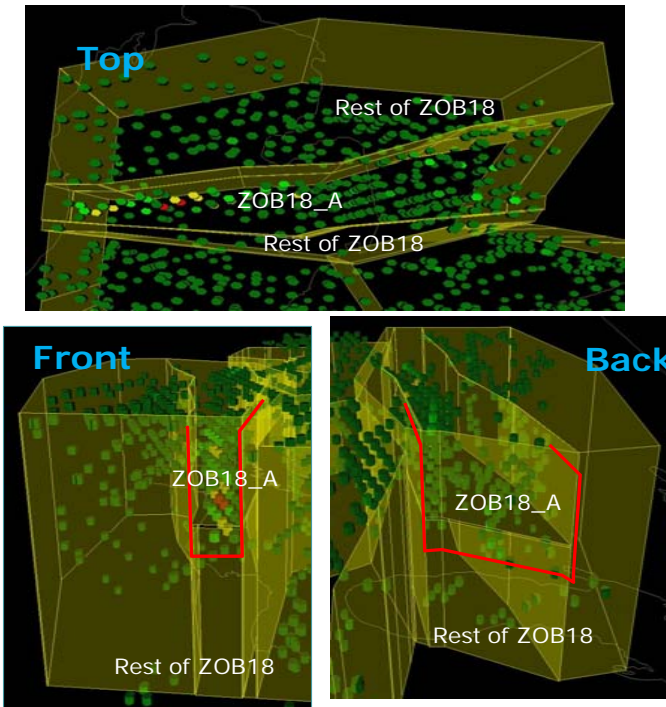
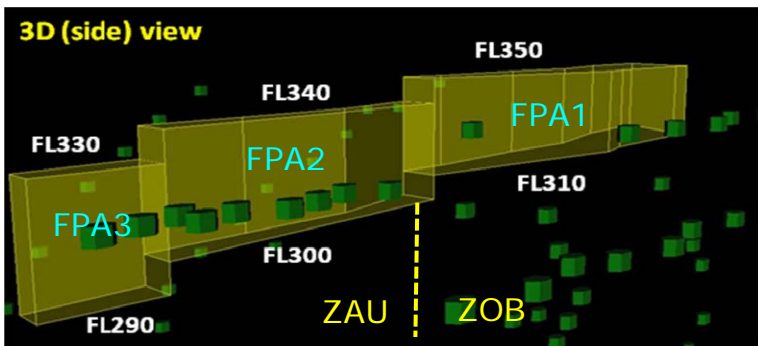
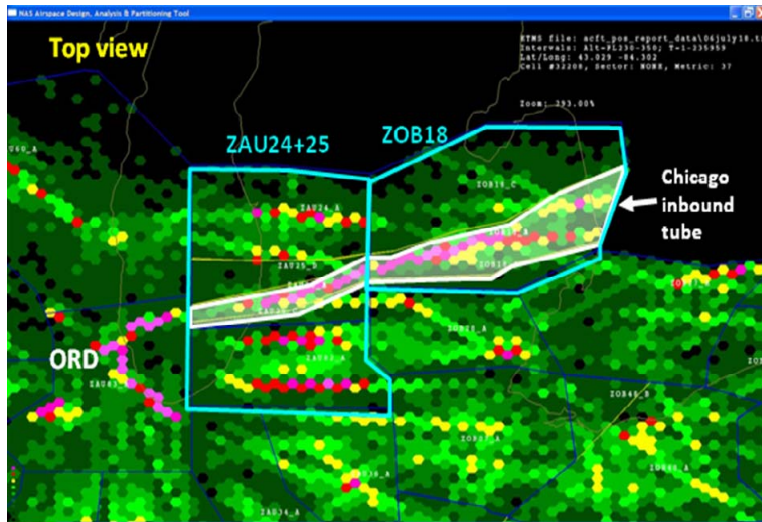


Figure 2b: ZOB18 “tube” in 3D (top, front and back views). Its border is highlighted in red.

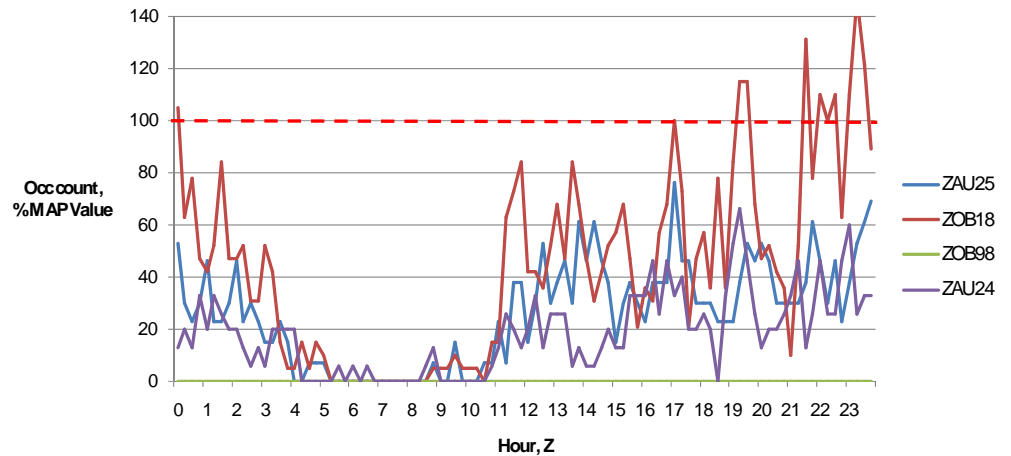
Potential New Airspace Class: Tube (2)

*“Chicago Inbound Tube” Spanning Two Centers
Coupled With Combining Two Under-loaded Sectors*



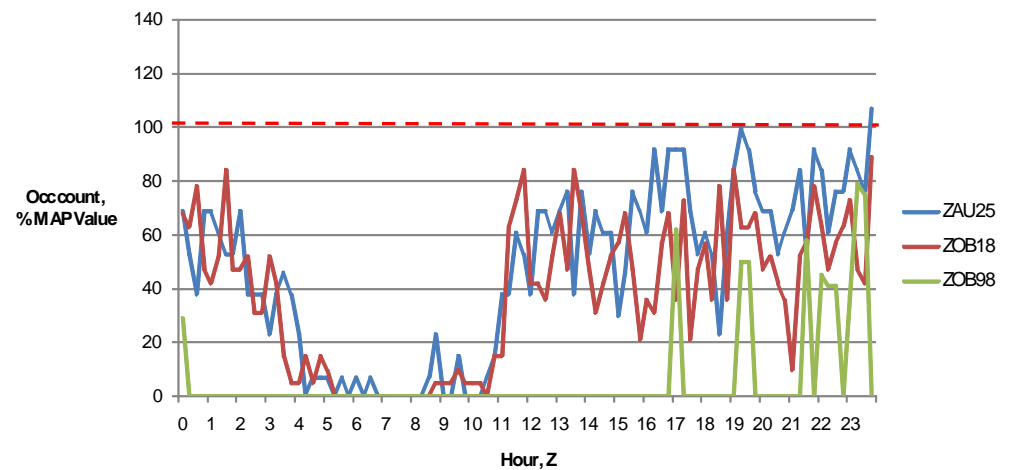
$$\text{ZOB98} = \text{FPA1} + \text{FPA2} + \text{FPA3}$$

Jul 18, 2006, +35% more traffic, NO DAC

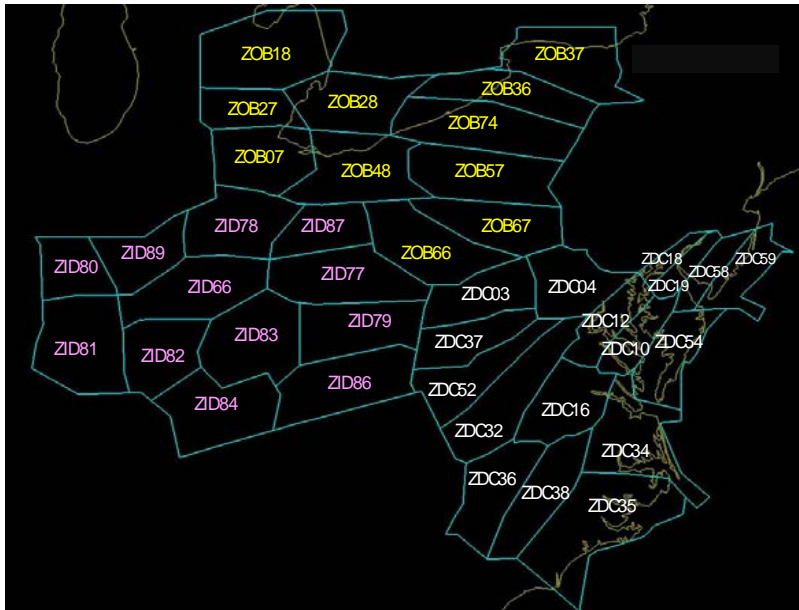


Jul 18, 2006, +35% more traffic, With DAC

ZAU24 and ZAU25 merged. ZOB98 is the ZOB-ZAU Tube (ZAU25_A,E+ ZOB18_A)



Multi-Center Airspace, Future Traffic *Increased Traffic Demand, 3-Center Airspace*



Red: if one or more sectors are overloaded (occupancy count > 100% MAP for > 15 min)

+10%
+20%
+35%
+50%
+70%

+10%
+20%
+35%
+50%
+70%

Preliminary Conclusions

Advantages of Dynamic FPA Method

- Controlled sector boundary adjustments in 2D/3D
 - In pre-built increments incorporating ATC/ATM operational perspective
- Absolute optimum (e.g., completely balanced workload) not the goal
 - The only consideration: bring metrics back within required limits (e.g., sector occupancy not exceeding 100% MAP)
- Fast and flexible
- Easy to retain continuity of DAC process throughout the day
- A bridge from current NAS airspace design to NextGen concepts
 - Uses airspace elements and concepts familiar to current airspace operators and designers
 - Applicable to both existing & some potential new airspace classes (such as Tubes)

Is There a Price to Pay?

As in everything, there *is* a price to pay

- FPAs have to be designed manually, up-front
- FPA sharing sequences need to be planned
- 15-min granularity may lead to short FPA exchange “spikes”
 - Methods can be developed to mitigate this
 - 15-min granularity currently used in the NAS for dynamic sectorization

But, once a good set of FPAs is created, dynamic airspace adjustments:

- are computed quickly
- for any day / traffic fluctuations / traffic demand levels

Link to Other Boundary Optimization Methods

- Use boundary optimization / airspace partitioning methods to generate “first-cut” or “clean-sheet” airspace design
- Then create Dynamic FPAs for these boundaries
- Dynamic FPA method addresses many of the DAC requirements
- Can be used in today’s airspace
- Combined with “clean-sheet” airspace partitioning, can help design NextGen airspace

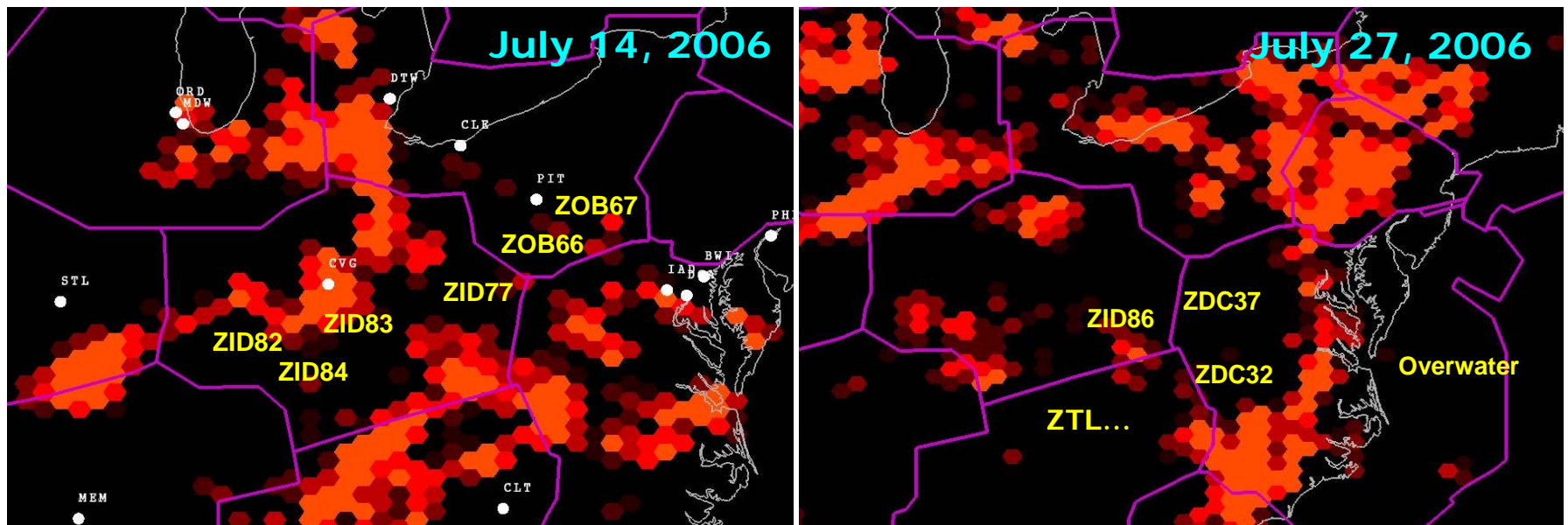
Back-up Slides

Metrics

- Current: Sector occupancy count as % of the sector's MAP value
- Future: Simplified Dynamic Density (SDD)
 - Smaller subset of DD metric [Kopardekar et al, 2007]
 - Components include:
 1. Sector occupancy counts
 2. Proximities
 3. Altitude transitions
 4. Transfers across sector boundaries
 5. Number of aircraft per sector volume
 6. Variance of aircraft headings in the sector
 - Can be computed *solely* from an ETMS file
 - Needs to be calibrated/validated before it can be used in DAC trials

Dynamic FPAs Use in Airspace Playbook: *Multi-Center "Traffic Corridors"*

- Dynamic FPAs would be well suited for handling "traffic corridors" that span several Centers
- Multi-sector / Center boundary adjustments
- Examples: Chicago Inbound Tube; ZID/ZOB/ZDC corridors below



Use of Actual & Flight-Planned Tracks

- Two methods of generating aircraft positions:
 - Actual tracks (ETMS TZ records)
 - Flight-planned tracks (Pseudo-TZ records generated from fl. Plans)
- Future NAS scenarios
 - 1) Clone actual tracks to increase traffic demand
 - Drawback: traffic already includes TMIs
 - But: currently the only way to reflect traffic shifts caused by Wx
 - 2) Use future-NAS traffic schedules with increased demand
 - Advantage: correct reflection of unimpeded traffic demand/growth
 - But: doesn't show how traffic would be rerouted & imbalances in workload would be created due to Wx
- For this reason, method #1 (cloned actual tracks) was used

Dynamic FPAs: Further Research Required

- Improved accuracy of traffic / weather forecasting
- Interaction between adjacent sectors and Centers (procedures!)
- More complex workload metrics
- Dynamic FPA implementation would be dependent upon the development of:
 - Related operational procedures
 - Information displays
 - Decision support systems
 - Training