An Efficient Method for Airspace Analysis and Partitioning Based on Equalized Traffic Mass

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ETMS “TZ” Records Processing

Populating Hexagonal Grid

Challenge: hexagonal grid doesn’t allow direct indexation
Solution: generate hexagonal grid from rectangular grid

Performance

- One day’s ETMS; approx. 5-6M TZ hits ingested & displayed in 17 sec
Traffic Mass as a Metric

Traffic Mass = Total of all TZ hits in a hexagonal bin

Distinct from Traffic Density

Traffic Mass and Workload
- Linear or slightly non-linear relationship (up to a point)
- Example: TAAM calculations

Hourly workload-vs-traffic count, a busy TRACON sector, two different workload calculation methods in TAAM

Linear

Non-linear

y = 0.0212x^2 + 1.3634x - 0.0877
Populating NAS Grid

Traffic Mass in Strata

FL0 – FL180
FL181 – FL330
FL331 – FL600
Airspace Partitioning - Objectives

- Alternatives with fewer ATC Centers than today
- Pre-determined number of Centers to try
- Repartition NAS airspace by equalizing Traffic Mass in Centers
- Design criteria to satisfy
- Robustness vis-à-vis changes in traffic patterns
- High performance ("need for speed")
- Aim: a good set of boundaries as a starting point for further work
Center Growth Algorithm

*Example: Eight Seed Locations*

- 50 iterations
- 100 iterations
- 200 iterations
- Complete (<800 iterations)
Center Boundary Sensitivity to Weather

2 ‘good’ Wx days (Mar 13 and Apr 17, 2004)

6 Centers
FL180-340
Center Boundary Sensitivity to Weather
A ‘good’ and a ‘bad’ day (Mar 13 and Sep 15)

6 Centers
FL180-340
Center Boundary Sensitivity to Weather

Mar 13 / Sep 15: Delta-Traffic-Mass View

Severe weather on 9/15

Tropical storm on 9/15

More flights to FL in March
Boundary Averaging Method*

* Using 12 Typical Days

- 4 day-types depending on weather impact
- 3 days of each type
- Automatic algorithm for scanning boundaries
- Averaged coordinates for each $\theta$ increment: single-day boundary intersections with radials are weighted by each day’s % occurrence

Resulting averaged boundary is more robust than any single day’s boundary

* Dr. Chen and Dr. Sivaraman of GMU have contributed ideas for this method
Partitioning

Alternative Metrics

Traffic Mass

Traffic Mass with Non-Linear Tail ($N + 0.00002N^2$)

Maximum TZ Hit Rate in 30-min Intervals
Conclusions

- Traffic Mass introduced as airspace partitioning metric
- Very efficient algorithms designed for:
  - NAS data processing on hexagonal grid
  - Seed Growth algorithm – creates Centers with equal traffic mass
  - Center boundary scanning/averaging for increased robustness
- Additional NAS analysis metrics proposed
  - Delta-traffic-mass
  - Maximum-TZ-hit-Rate
  - Traffic Mass with non-linear tail
- All the above, and more, implemented in a single software tool
BACK-UP SLIDES
Center Size Variability
5 Low Altitude Centers – Two Examples

If we freeze the boundaries and measure Traffic Mass for the 12 typical days...

Traffic Mass variability within averaged boundaries (blue) is lower than within one day’s boundaries (red)

That is, averaged boundaries are more robust