ATL 1.5 Metering Scheme

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ETA Prediction Tool: RUC20

- **RUC20 Data**
  - Lateral Grid: 301x225 (20km spacing)
  - Vertical Resolution: 25-hPa increments from 1000-100 hPa
  - Forecast is given in 1 hr intervals for a 12 hr span every hour (only the 1hr, 2hr, 3hr, and 6 hr forecasts are available with regularity and currently archived)
ETA Prediction Tool: RUC20 (cont’d)
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- **RUC20 Data Organization**
  - Provided as numbered “messages” organized in isobaric sheets
  - Messages must be correlated into usable data structure
  - Create sector-based structure giving Northern, Eastern, and vertical wind intensities as functions of altitude for every RUC20 grid sector
ETA Prediction Tool: Uncertainty

- Uncertainty Model
  - Compare known wind conditions from archived ACARS data to RUC wind forecasts
  - Model uncertainty intensity as a function of forecast time for individual airspace cells
ETA Prediction Tool: Uncertainty (cont’d)

- Aggregate effects of forecast uncertainty as a probability distribution
ETA Prediction Tool: Uncertainty (cont’d)

- Determine uncertainties over entire trajectory
  - Combine uncertainties throughout the trajectory
- Add uncertainty to “deterministic” ETA calculated using RUC winds
- Provide ETA distributions to speed optimizer
Approach
Optimization: Objective Function

\[ \text{min } Z = \sum_{n=1}^{N} \dot{f}_i \cdot T_i \]

\[ \dot{f}_i \geq a_{i,1} M_x + b_{i,1} \]

\[ \dot{f}_i \geq a_{i,2} M_x + b_{i,2} \]

\[ \vdots \]

\[ \dot{f}_i \geq a_{i,m} M_x + b_{i,m} \]

Linearized fuel constraints
Optimization: Constraints

Separation determined by TASAT analysis

Maximum one speed change per aircraft

Limit number of aircraft able to make a change

Performance limits upper Mach number

Lower mach number determined by range between initial Mach and maximum Mach

\[
(t_{i+1} - \Delta t_{i+1}) - (t_i - \Delta t_{i+1}) \geq S_i
\]

\[
\delta_i \leq M|\Delta t_i|
\]

\[
\delta_i \geq \frac{|\Delta t_i|}{M}
\]

\[\delta_1, \delta_2, ..., \delta_n\] binary

\[
\sum_{j=1}^{j} \delta_i \leq j
\]

\[M_i + \Delta M_i \leq M_{i,\text{max}}\]

\[|\Delta M_i| \leq \Delta M_{\text{max}}\]
Optimization: Initial Results

- Comparison of Initial and Final Mach numbers for 10 aircraft 2 hours prior to the last aircraft arriving
Optimization: Initial Results

- Comparison of Initial and Final Mach numbers for 10 aircraft 3 hours prior to the last aircraft arriving.
Optimization: Enhancements

- Expand formulation to allow...
  - Sequence change
  - Two speed changes per aircraft
  - Include wind information in calculation of final Mach number