Improving Decision Making in En Route Airspace During Convective Weather

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2021 Spring FPAW Meeting

29 April 2021

1951–2021
70 YEARS
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Outline

- Tactical throughput capacity in convective weather
- Decision making implications of uncertainty in AFP flow forecasts
- Improving operational outcomes for events that warrant the use of FCAs

Session Objective

- Improve utilization of available flow capacity during convective weather without increasing ATC risk
- This requires forecasting feasible tactical FCA throughput and handling uncertainty in the forecasts ("complexity and risk management")

AFP = Airspace Flow Program
FCA = Flow Constrained Area

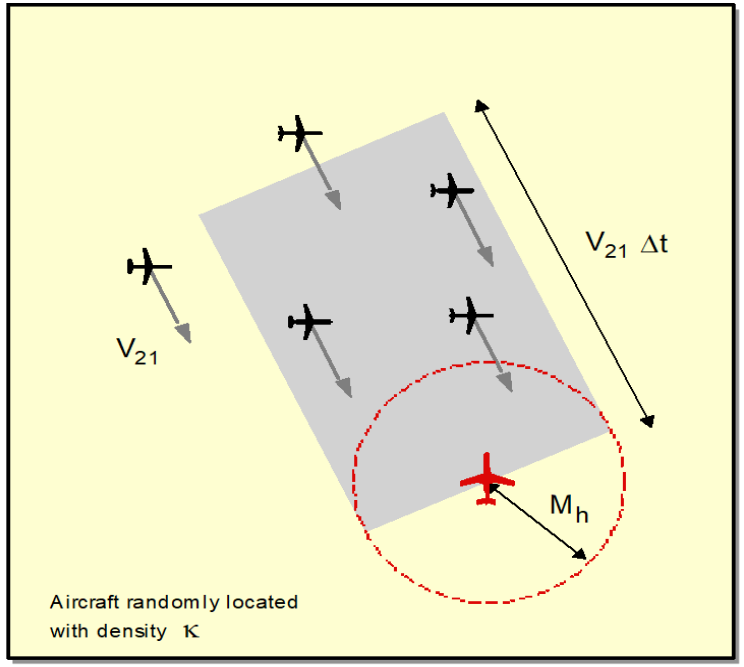
Controller Workload in Convective Weather

Elements of Fair Weather Controller Workload*

Conflict rate
Proportional to square of number of aircraft being handled

Recurring events (scanning/monitoring) rate

Transit (boundary crossing) rate



Additional Tasks Associated with Flight Deviations

1. Anticipate where storms will be in near future (w/o explicit forecasts on display)
2. Anticipate response of pilots to weather
3. Generate plan for resolving conflicts arising from deviations
4. Coordination with adjacent controller if transit to that controller is in a new location

Implications for FCA Convective Weather Capacity Estimation

1. Type of weather is important (not just fractional coverage): vectoring through gaps in a squall line is easier than vectoring around scattered cells
2. Structure of airspace is important

*Welch et al., ATM 2007: Macroscopic model for estimating en route sector capacity

Factors in Area Manager/TMU Tactical Capacity Effectiveness

- **Principal mechanisms for increasing the effective airspace capacity**
  - **Proactive, efficient reroutes**
  - **Keeping routes open longer (overflying storms, quickly reopening routes when impact ends)**
- **Current and forecast echo tops forecasts are really important**
  - **Very significant fraction of CIWS benefits were due to recognizing opportunity to overfly storms**
  - **Martin, et .al., 2006, 12th AMS ARAM showed that considering echo tops results in an average factor of 2 increase in the availability of ARTCC routes impacted by VIL Level 3 precipitation**
- **Communication/coordination is critical; CIWS displays and training for area supervisors made a major difference in the ARTCC ability to generate and execute proactive plans**
- **Airspace structure is a key factor in the ability to accomplish proactive, efficient reroutes**

Key References*

- **Robinson, et. al., 2004, CIWS ops benefits 2002-2003 LL Project Report ATC-313**
  - **6 multi-day simultaneous observations at 6 ARTCCs**
  - **See appendices B, C and E**
- **Robinson, et. al., 2006 ATC productivity for CIWS**
  - **3 multi-day observations at 8 ARTCCs**
  - **See chapter 4 (ZDC vs ZTL) and appendix D**

VIL = Vertically Integrated Liquid

***Can be downloaded from https://www.ll.mit.edu/r-d/publications**

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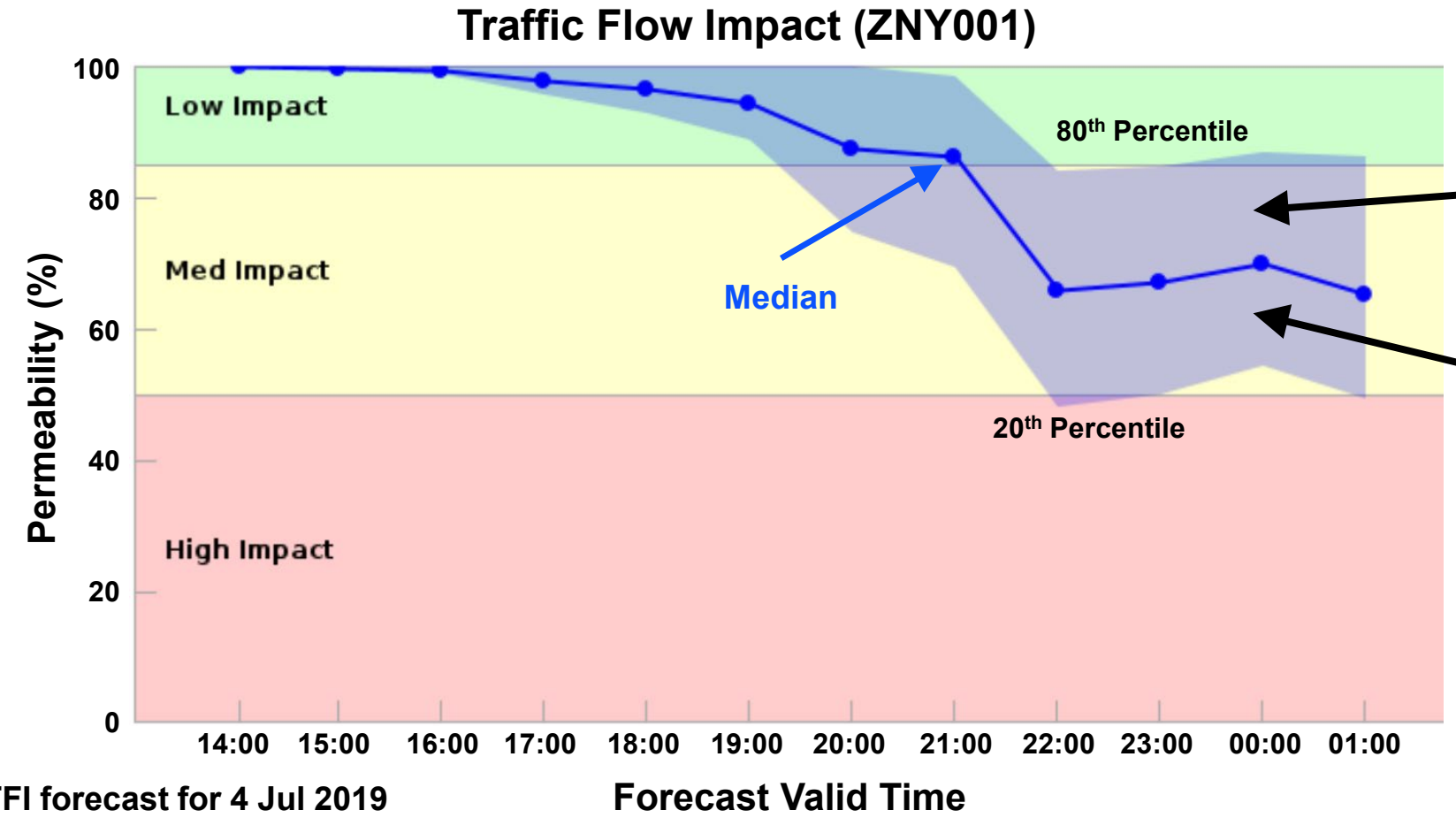
Statistical Decision Faced by User of a Probabilistic Rate Forecast for a Convection Impacted FCA



Possible consequences of using median estimate for the FCA rate if:

Weather impacts are lower:
Under-utilized capacity
(customers unhappy)

Weather impacts are higher:
Over-delivery of demand
(FAA unhappy)
Holding patterns, Diversions

In practice there is a tradeoff between consequences of underutilized capacity & over-delivery of demand

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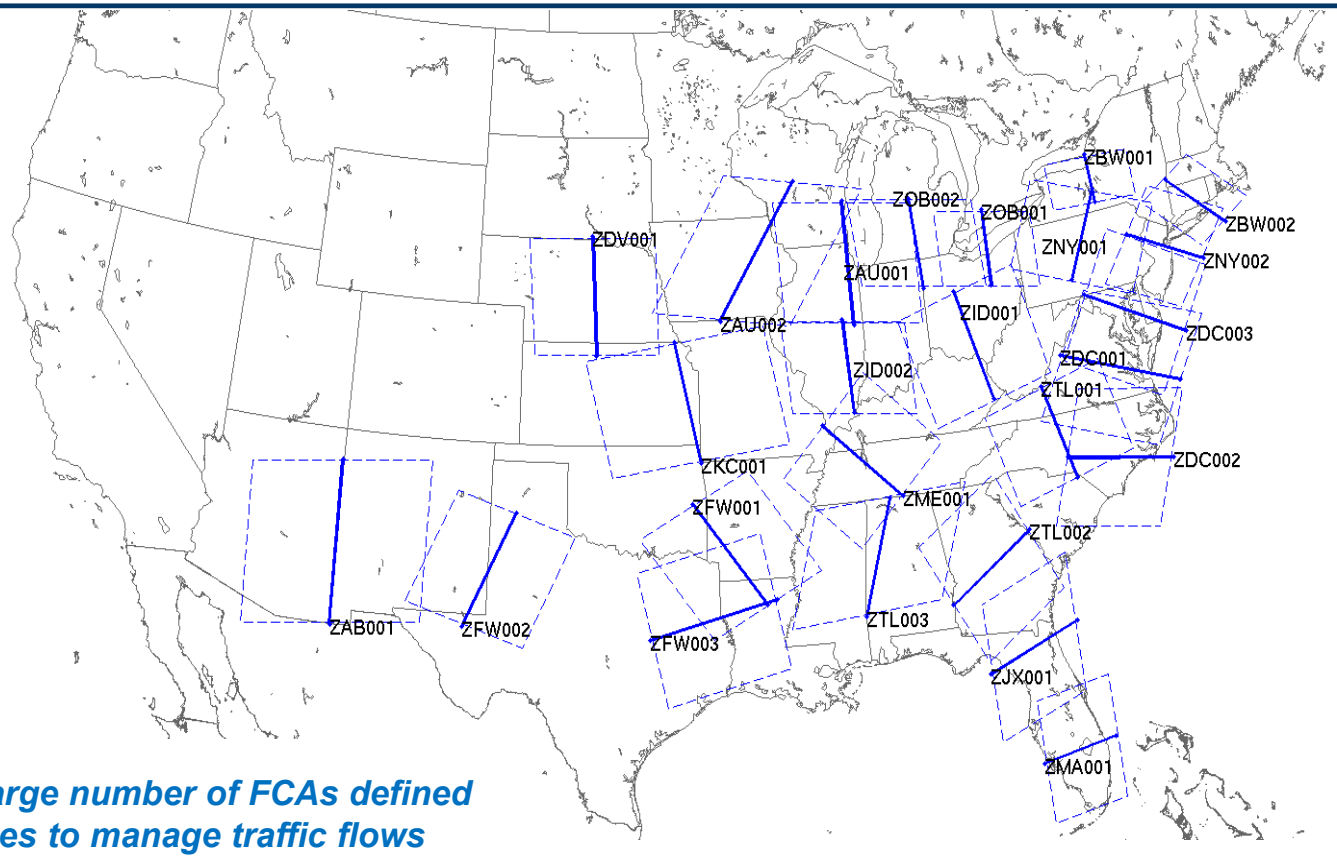
Flow Rates for FCAs Not Impacted by Convective Weather



This is an example of the very large number of FCAs defined by various operational facilities to manage traffic flows

- **FCAs that do not have convective weather impacts can be used to control traffic volumes arising from route outs of traffic that would normally go through a convection impacted FCA**
- **Computing fair weather rates for arbitrary FCAs seems straightforward given ETMS archives**

ETMS = Enhanced Traffic Management System
FCA = Flow Constrained Area

Options to Consider in Improving Operational Outcomes For Convection Impacted FCAs

- **Capacity Modeling**
  - Understand tactical traffic management mechanisms that the pertinent ARTCCs will utilize (e.g., available airspace for FCA flow to be controlled; actual route structures as opposed to generic routes, "operating routes N as 1", etc.) through facility observations in convective weather as well as data analysis
  - Consider stratifying guidance by convective weather type (if possible)
  - Make sure that FCA throughput modeling considers echo tops as well as precipitation
- **Capacity forecast presentation**
  - Need the expected statistical distribution of actual flow rates as a function of various forecast times (as is done by TFI)
- **Need to address ATC risk**
  - Consider tools to help decision makers trade off between ATC risk and underutilized capacity
  - Explore options within the pertinent ARTCCs for tactically handling cases where there is an oversupply of traffic (e.g., pre-planning for possible diversions plus timely recovery of diverted flights, planning for quicker recovery if weather dissipates sooner than expected)
  - May need forecasts of capacity in airspace adjacent to a FCA
- **Focus on a small number of FCAs for which benefit/cost ratio is likely to be high**

Summary

- **Improving operational outcomes for convection impacted FCAs in congested airspace will not be easy**
  - **Focus on small number of FCAs**
  - **Understand the convective weather tactical capability of the pertinent ARTCCs**
- **AFP rate setting for convective impacted FCAs should be considered as a statistical decision with appropriate attention to:**
  - **How quantitative uncertainty will be conveyed and used**
  - **Tactical ATC risk management procedures and decision support**

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