Service Level Expectation Setting for Traffic Flow Management

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Current FAA Practice in Developing Daily Traffic Management (TM) Strategy

Operational Challenge

- Flight operators participate in strategic TM planning by verbal input. Operators can sometimes have a disproportionate influence on decisions that affect a broad range of others who are less vocal.
- Discussion focuses on specific parameters rather than performance goals.
- Different traffic managers may create different plans for the same situation.
- The planning process is ad-hoc and subjective.

A NextGen Vision:

Performance-Based Air Traffic Management

Current Practice:

Expected Operating Environment → Planned Operational Response → Response Execution → Operational Outcome

NextGen Vision:

Expected Operating Environment → Service Expectations → Planned Operational Response → Response Execution → Operational Outcome

Philosophy:

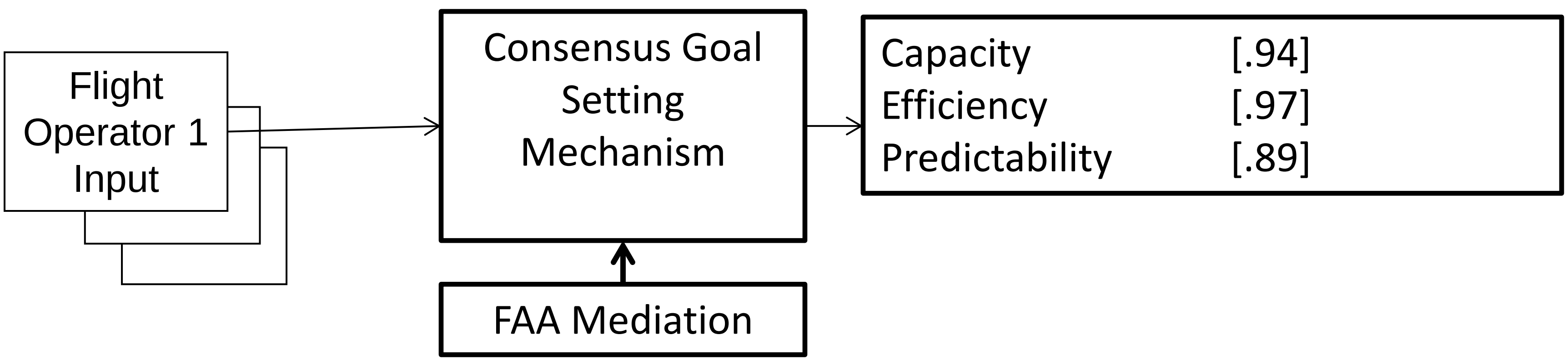
- Airlines provide “consensus” service expectations
- FAA develops operational plan to meet those expectations

COuNSEL: CONsensus Service Expectation Level setting

Broad concept/goal:

– Replace strategic planning teleconns, i.e.

formalize process for flight operators to input their preferences into daily TM decision making



COuNSEL Performance Goals

- **Capacity**: maximize throughput
  - Avoid underestimating capacity and encourage quick response if weather clears early
- **Efficiency**: minimize delay cost
  - Take delay on the ground instead of in the air
- **Predictability**: provide timely, accurate, information
  - Announce GDPs well ahead of start times
  - Avoid overestimating or underestimating capacity; make program revisions unlikely

Interpretation of Performance Goals

All metrics take on values between 0 and 1

1 ➔ perfect performance

0 ➔ worst possible performance

The system only allows goal vectors that are "feasible", e.g. even on a near-perfect day (1,1,1) would not be possible – perfect performance across all dimensions.

The system forces the flight operators to make tradeoffs:

(.91, .83, .85) → (.86, .89, .85)

***Reduce capacity goal*: .91 → .86**

***… in order to improve efficiency goal:* .83 → .89**

COuNSEL: Basic Concept

NEXTOR

Information to users:
candidate performance vectors

	Capacity	Efficiency	Predictability
V1:	0.9	0.8	0.5
V2:	0.7	0.7	0.9
V3:	0.8	0.6	0.8

Inputs from user 1:
Grades for vectors
and candidate vectors

Grades:

100%, 95%, 90%, 85% …

Consensus vector:
e.g. (.89 , .76 , .65)

Consensus Vector Chosen using *Majority Judgment (MJ)*

- Suppose:
  - 6 airlines (voters), voting on 3 candidates: m_1, m_2, m_3,
    e.g. (.90, .75, .80), (.85, .80, .83), (.85, .90, .79).
  - grades: 100%, 99%, 98%, 97%, 96%, 95%, 94%, …
- Grades sorted after voting from worst to best:

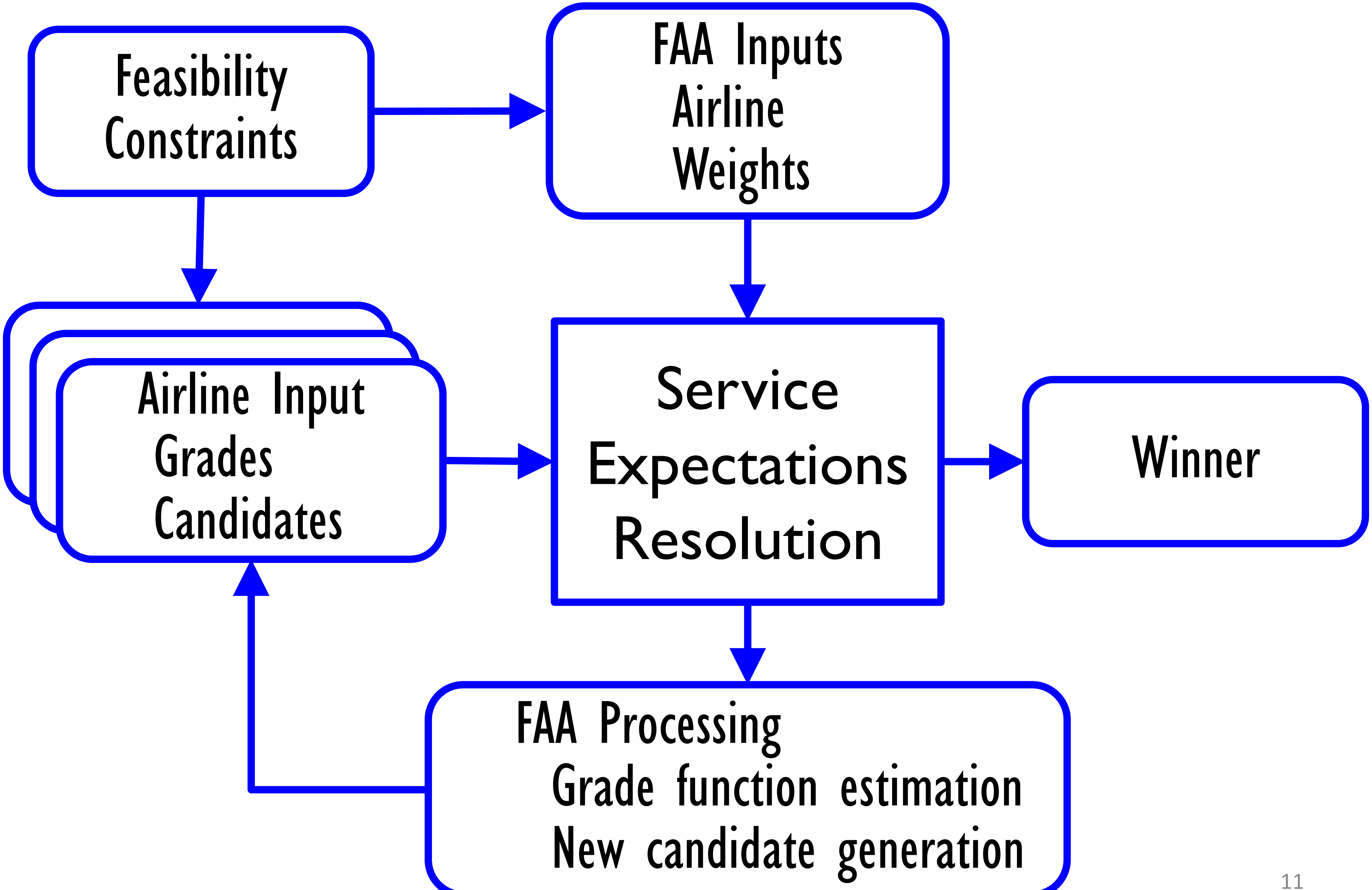
m_1	80%	80%	90%	94%	95%	100%
m_2	75%	83%	85%	87%	88%	90%
m_3	65%	70%	88%	90%	93%	95%

Majority grades: majority would give at least that grade.
…. in this example 4th grade from right.
Vector with highest majority grade will be selected.
There is a tie-breaking rule – not discussed here.

Challenge in Application of MJ to Service Level Expectation Setting

- The basic application of MJ allows flight operators to make a consensus choice among possible goal vectors.
- **Challenge 1:** given conditions on a particular day of operations what are appropriate "possible goal vectors" that should be presented to flight operators.
  - Partial Answer: In concept there will be many (an infinite number) of vectors that represent the possible tradeoffs among the performance vectors given the weather and traffic conditions for the scenario of interest. Thus, challenge 1, becomes the problem of representing the space of performance metric tradeoffs for the TMIs under consideration.
- **Challenge 2:** given some representation of the space of possible goal vectors, what is a process for choosing among these the ones that flight operators will grade as part of the MJ process?

COuNSEL Logic Flow



Goal vectors must satisfy constraints determined by daily conditions:

Bad weather day – sample vectors: (.90, .75, .80), (.85, .80, .83), (.85, .90, .79).

Good weather day – sample vectors: (.98, .95, .90), (.99, .92, .91), (.95, .97, .90).

$\mathbf{m}$ is possible metric vector :

$$\mathbf{m} \in FEAS_{METRIC}$$

COuNSEL Features

- Airline votes are weighted by number of flights involved in the TMI
- Voting process is iterative—new candidate vectors are determined by ratings of previous candidate vectors
- Only feasible candidate vectors are allowed — set of feasible vectors is based on conditions of the day
- Airlines may develop their own tools to assess how different candidate vectors affect their individual business objectives
- Multiple applications of COuNSEL might be used as conditions change; could be applied nationwide or to regional problem area

Significant Research Components

- **Generating candidate vectors, COuNSEL iteration mechanism:** must generate promising candidates for infinite space of possible vectors – employs optimization and statistical estimation models.
- **Definition of space of feasible candidate vectors:** analytic models of TMIs – relationship between parameter setting and performance metrics.
- **Understanding user impact and benefit mechanisms, gaining user acceptance:** outreach to flight operators; formal flight operator surveys; human-in-the-loop simulation, involving flight operators and FAA.
- **Modeling benefit mechanism and flight operator impact:** use of historical data analysis and simulation to relate flight operator performance to TMI parameter settings.
- **Modeling user voting/grading behavior:** game theory and related models to understand user payoff functions and incentives for good (and bad) voting behavior.

Evaluation

- COuNSEL was evaluated using multiple fast-time simulations: these employed historical GDP data and also a complex operational response model developed at MIT to support various airline studies.
- A Human-in-the-Loop (HITL) simulation was also run that included participants from FAA air traffic specialists and several airlines.
- The fast-time simulations were used to assess benefits and the HITL to gauge user response and acceptability.

COuNSEL Benefit Categories

- **Less time** spent by FAA and airlines **on SPTs** and related activities
- **Improved flight operator performance** on day-of-ops
  - Reduction in costs due to delay, cancellations, reroutes, etc.
  - General improvement in operational performance, e.g. smoother planning, better service levels, etc.
- **More equitable treatment of flight operators →** higher overall satisfaction, greater cooperation in ATM processes, e.g. info exchange.

Sample Result from Fast-Time Simulation (SFO GDP planning)

- COuNSEL reduced by 22.8% total ground delay, 13.7% total passenger delay, while only inducing an airborne delay of 1.46 minutes/flight.
- This corresponded to a 4.2% reduction in total airline operational costs.

Some Feedback from HITL

- The COuNSEL approach is valuable and brings several useful features
- Broader role for COuNSEL should be considered
- Need to insure all flight operators' voices are heard
- Multiple applications of COuNSEL for same TMI could be valuable
- Be cognizant of extra burden on flight operators caused by COuNSEL usage
- Consider alternate ways of determining flight operator weights

Benefits Summary

- Greater focus of TMI design on airline priorities and costs
- A fairer and more inclusive decision-making process where all the flight operators' voices will be heard
- A goal-oriented decision-making process where performance criteria are clear to the flight operators
- A more consistent decision-making process where decision are less dependent on managers' experience and personality