Service Level Expectation Setting for Air Traffic Management: Project Overview

September 12, 2014

Sponsors: FAA Air Traffic Organization – Mission Support Services: Rich Jehlen, Rob Hunt, Yong Li

NEXTOR-II Team: Mike Ball, Alex Estes, Prem Swaroop, U of Maryland

Cindy Barnhart, Chiwei Yan, MIT

Mark Hansen, Lei Kang, Yi Liu, UC Berkeley

Vikrant Vaze, Dartmouth

Current Practice on TMI Planning

Strategic planning telecons

TMI decisions

Operational Challenge

- Flight operators participate in strategic TMI 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.

SLE Concept

- The Service Level Expectation (SLE) setting project has produced a conceptual approach and prototype software tool designed to address the above deficiencies.
- The SLE concept takes into account the input of all involved flight operators and generates an output that represents a consensus of those flight operators in making Traffic Flow Management Initiative (TMI) decision.

SLE Concept

- The SLE mechanism allows operators to submit quantitative input that represent their preferred system performance goals (capacity, predictability and efficiency).
- It then appropriately weighs and aggregates operators' inputs to determine consensus performance goals.

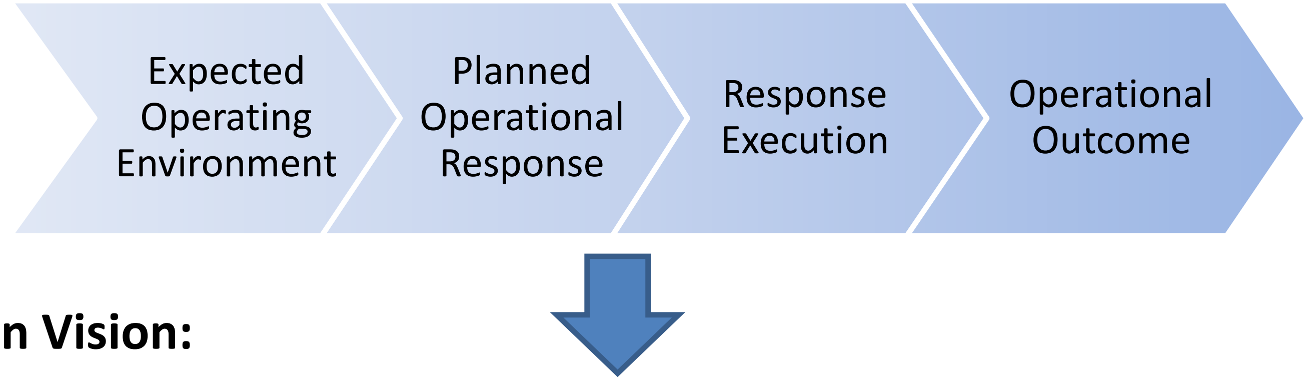
Underlying models, analysis and mechanisms are results of SLE project.

- These goals can then used to determine TMI parameters that are expected to best achieve the performance expectations.

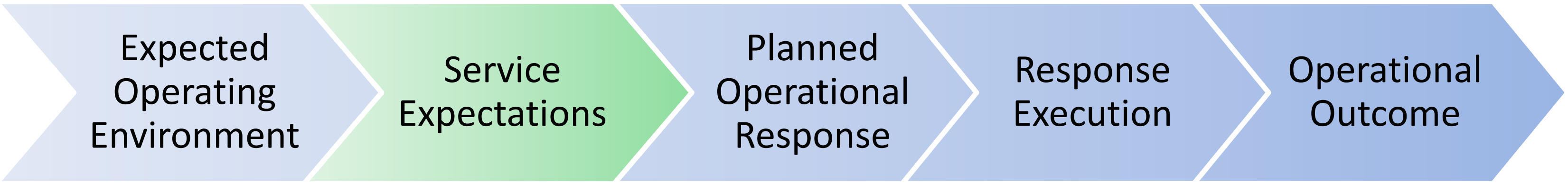
"Step 2": requires additional research – performance based TMI planning.

A NextGen Vision:
Performance-Based ATM

Current Practice:



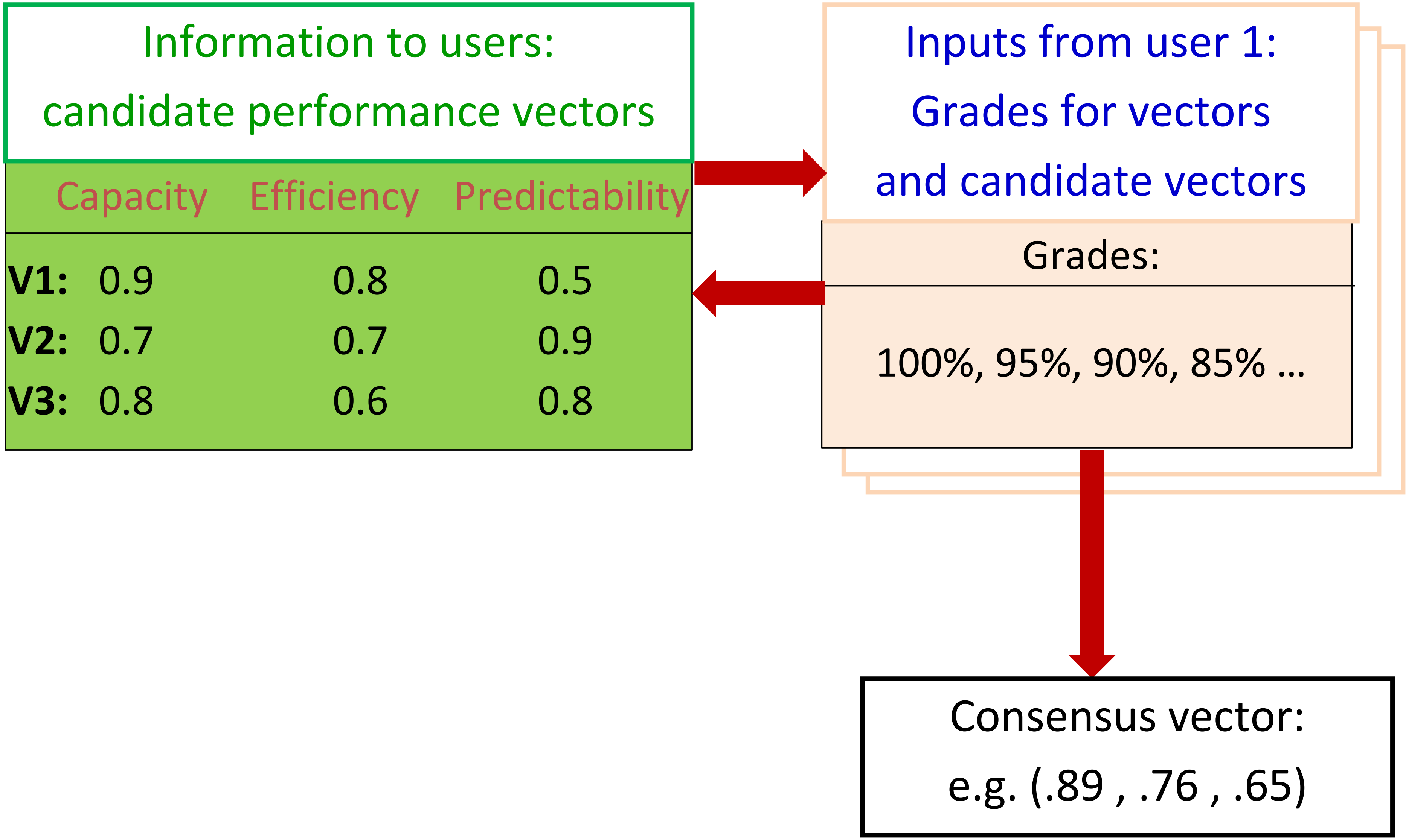
NextGen Vision:



Philosophy:

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

COuNSEL: CONsensus Service Expectation Level Planning



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*

- Suppose:
  - 6 airlines (voters), voting on 3 candidates: V_1, V_2, V_3
  - grades: 100%, 99%, 98%, 97%, 96%, 95%, 94%, …
- Grades sorted after voting from worst to best:

V_1	80%	80%	90%	94%	95%	100%
V_2	75%	83%	85%	87%	88%	90%
V_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.

Performance Goals in SLE

- **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**

Interpretation of Performance Goals

Capacity:

1 ➔ maximum airport throughput achieved (perfect weather day)

As metric decreases, flights will be delayed, cancellations may be necessary, diversions are a possibility, etc.

Interpretation of Performance Goals

Efficiency:

1 ➔ each flight will be executed in a minimum (user) cost manner: no airborne holding or vectoring, minimum taxi-in/out times, no diversions (note: an assigned ground delay is not counted against user cost as this cost is captured under capacity/throughput)

As metric decreases, airborne delays (and diversions) become more likely, the need to take suboptimal routes becomes more likely, etc.

Interpretation of Performance Goals

Predictability:

1 ➔ each flight's departure and arrival time known with perfect accuracy well in advance of flight

As metric decreases, flight departure time estimates will vary over course of day, enroute times will become less predictable, there will be less advance warning of FAA actions, TMI parameters will be more likely to change over time, etc.

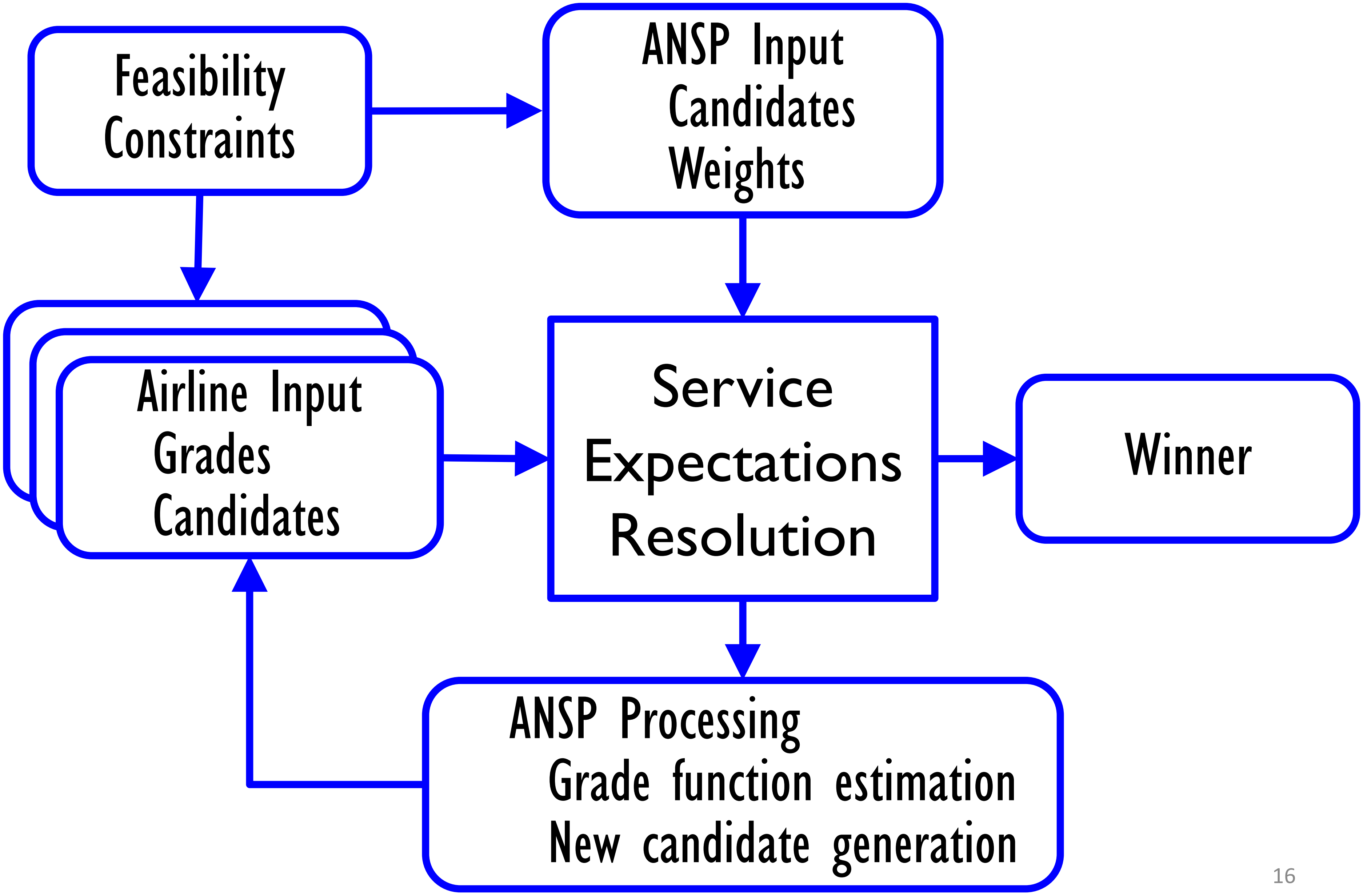
Design Tradeoffs

- SLE will enable flight operators to influence TMI design tradeoffs
- **Predictability vs. Throughput**
  - Predictability— assume lower rates and long duration so that initially assigned delays are unlikely to be extended
  - Throughput—assume higher rates and shorter duration in order to increase demand pressure
- **Efficiency vs. Throughput**
  - Efficiency—minimize airborne delay by imposing more ground delay
  - Throughput—employ higher arrival rates to increase demand pressure but (possibly) at the expense of more airborne delay
- **Predictability vs. Efficiency**
  - Predictability—make decisions well in advance, even though this increases the risk that they will be based on erroneous forecasts
  - Efficiency—make decisions later when better information is available, reducing the risk of airborne delay

SLE 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

COuNSEL Logic Flow



Feasibility Constraints

ANSP Input
- Candidates
- Weights

Airline Input
- Grades
- Candidates

Service Expectations Resolution

Winner

ANSP Processing
- Grade function estimation
- New candidate generation

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.

Benefits of SLE

- A more fair and 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

Topic 1: Choice of Performance Categories

NextGen: Performance-Based ATM

Expected Operating Environment

Service Expectations

Planned Operational Response

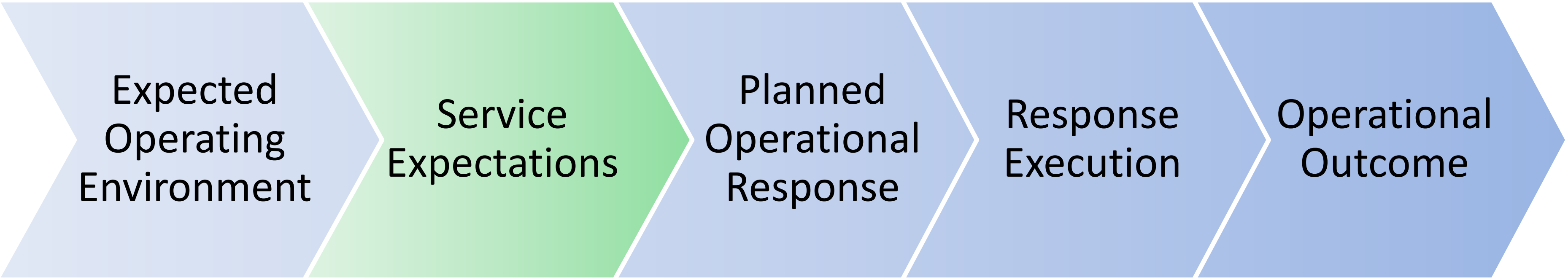
Response Execution

Operational Outcome

- “Performance based” ATM for National Air Space (NAS)
  - Support airline operators’ business objectives subject only to system-level objectives like safety and security
- Consistent with global and other regions’ visions of future ATM

1. Capacity
2. Cost-effectiveness
3. Efficiency
4. Flexibility
5. Predictability
6. Access & Equity
7. Environment
8. Global interoperability
9. Participation by the ATM Community
10. Security
11. Safety

NextGen: Performance-Based ATM

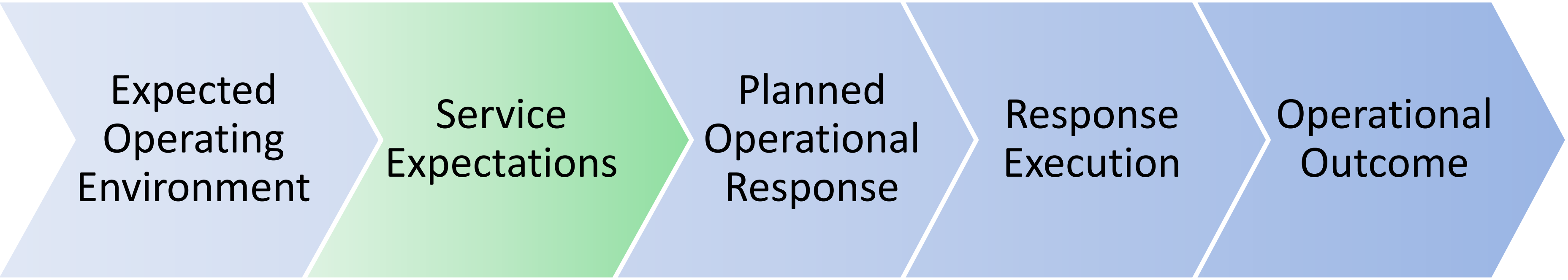


- “Performance based” ATM for National Air Space (NAS)
  - Support airline operators’ business objectives subject only to system-level objectives like safety and security
- Consistent with global and other regions’ visions of future ATM

1. Capacity
2. Cost-effectiveness
3. Efficiency
4. Flexibility
5. Predictability
6. Access & Equity
7. Environment
8. Global interoperability
9. Participation by the ATM Community
10. Security
11. Safety

Chosen

NextGen: Performance-Based ATM



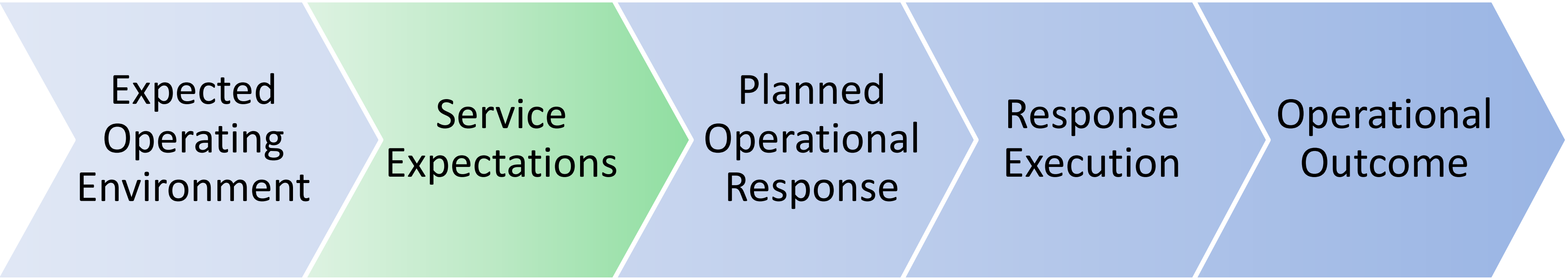
- “Performance based” ATM for National Air Space (NAS)
  - Support airline operators’ business objectives subject only to system-level objectives like safety and security
- Consistent with global and other regions’ visions of future ATM

1. Capacity

6. Access & Equity
7. Environment
8. Global interoperability
9. Participation by the ATM Community
10. Security
11. Safety

These would be set as global/strategic requirements and not manipulated on a day to day basis.

NextGen: Performance-Based ATM



Expected Operating Environment

Service Expectations

Planned Operational Response

Response Execution

Operational Outcome

- "Performance based" ATM for National Air Space (NAS)
  - – Support airline operators' business objectives subject only to system-level objectives like safety and security
- Consistent with global and other regions' visions of future ATM

1. Capacity
2. Cost-effectiveness
3. Efficiency
4. Flexibility
5. Predictability

Refers to ANSP cost effectiveness; not likely that flight operators would have incentive to reduce this.

ommunity

10. Security
11. Safety

NextGen: Performance-Based ATM

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

- “Performance based” ATM for National Air Space (NAS)
  - Support airline operators’ business objectives subject only to system-level objectives like safety and security
- Consistent with global and other regions’ visions of future ATM

1. Capacity
2. Cost-effectiveness
3. Efficiency
4. **Flexibility**
5. Predictability

There could be good arguments for including, e.g. TMI designs that allow flight operators greater ability to substitute and internally optimize would certainly be viewed positively.

ommunity

NextGen: Performance-Based ATM

Expected Operating Environment

Service Expectations

Planned Operational Response

Response Execution

Operational Outcome

- “Performance based” ATM for National Air Space (NAS)
  - Support airline operators’ business objectives subject only to system-level objectives like safety and security

l and other regions’ visions of future ATM

Important category; however, flight operators would vote based on whether they were currently getting good or bad end of inequitable treatment; perhaps ANSP should somehow control equity metric.

6. Access & Equity
7. Environment
8. Global interoperability
9. Participation by the ATM Community
10. Security
11. Safety

Specific Metrics

- The metrics used in each category were chosen for specific reasons related to status of research and prototype development:
  - ***We anticipate that these will change based on more research and priorities set by various other groups within the FAA.***

Topic 2: Choice of Underlying Mechanism

Research Problem

- Design a consensus-building mechanism, incorporating airline operators' preferences, for determining the levels of service expectations at NAS-level, usable by the Air Navigation Service Provider (ANSP), to design Planned Operational Response, for the day-of-operations

Desirable Properties

1. **single winner determination**.
   - Leads to a unique “winner”.
2. **confidentiality.**
   - Minimal private information requirements from the airlines.
3. **practicality.**
   - Easy to administer, not involving time-consuming information gathering and / or processing steps.
4. **consensus-building.**
   - Maximum acceptability among the airlines.
5. **equitability.**
   - Perceived to be fair to all parties involved from the outset.
6. **strategy-proof.**
   - As far as possible, encourage truth-telling behavior.

Mechanisms Considered

- “Investment” / Marketplace / Combinatorial Auction
  - Requires creation of artificial “currency”
  - Metrics are not really goods being split up
    - Strategic behavior unavoidable: free-rider problem
- Multi-player Non-cooperative Game
  - Useful in modeling the strategic behavior
  - Existence of unique Nash equilibrium established
  - Outcomes not “desirable”: extreme solutions, without desired tradeoffs
- Voting
  - Natural way to model the decision making paradigm
  - Challenges exist in modeling
  - Two alternatives considered:
    - Weighted Instant Runoff Voting
    - Majority Judgment
  - Game theory to be used for analysis

Majority Judgment

- Recently proposed procedure (Balinski and Laraki, ‘10)
- Bypasses Arrow’s Impossibility Theorem (1950)
  - when voters have three or more distinct alternatives, no voting system can convert the ranked preferences of individuals into a community-wide (complete and transitive) ranking while also meeting a certain set of criteria, namely: unrestricted domain, non-dictatorship, Pareto efficiency, and independence of irrelevant alternatives.
- Claimed by authors to be “a better alternative to all other known voting methods, in theory and in practice.”

Majority Judgment – Definition

Majority Judgment is a *social decision function*

- Grading of each candidate by all voters in a common language
  - instead of preference rankings
  - more natural, richer preference elicitation
- Many good properties: highly resistant to strategic voting

Consensus Vector Chosen using *Majority Judgment*

- Suppose:
  - 6 airlines (voters), voting on 3 candidates: V_1, V_2, V_3
  - grades: 100%, 99%, 98%, 97%, 96%, 95%, 94%, …
- Grades sorted after voting from worst to best:

V_1	80%	80%	90%	94%	95%	100%
V_2	75%	83%	85%	87%	88%	90%
V_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.

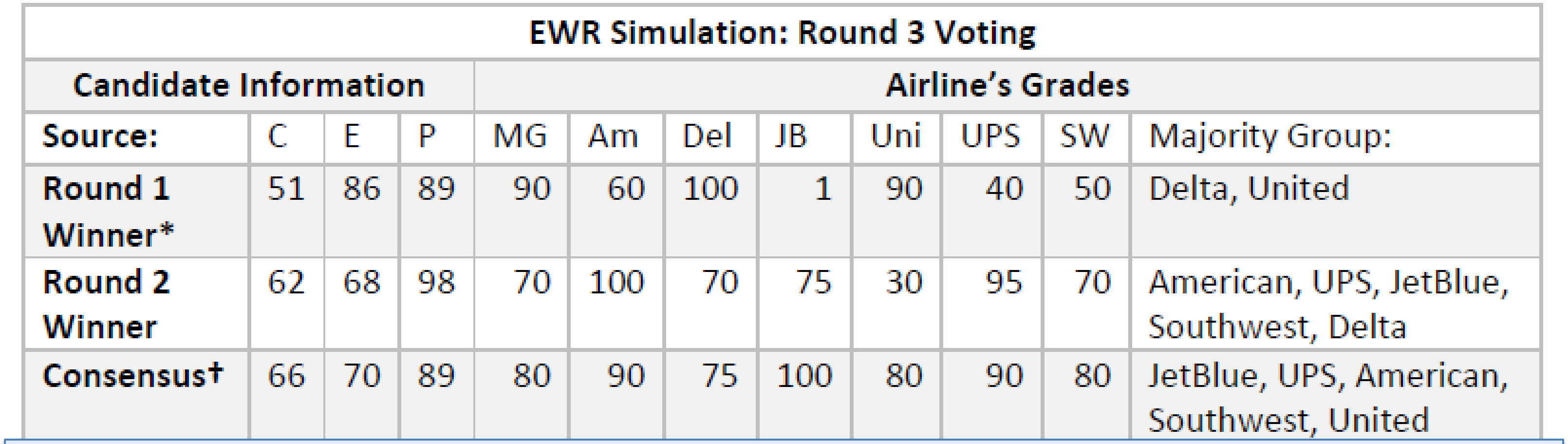
There is a tie-breaking rule – not discussed here.

MJ in Perspective

- The use of the median grade as the majority grade is key to the good properties of MJ, i.e. it greatly reduces the potential gain from “strategic” grading.

…. Yet, in terms of global welfare, one would prefer the average grade.

Even in the limited set of examples explored in the HITL, this issue was very notable to participants (and made some participants question the MJ criterion).



EWR Simulation: Round 3 Voting

Candidate Information				**Airline’s Grades**							
Source:	C	E	P	MG	Am	Del	JB	Uni	UPS	SW	Majority Group:
Round 1 Winner*	51	86	89	90	60	100	1	90	40	50	Delta, United
Round 2 Winner	62	68	98	70	100	70	75	30	95	70	American, UPS, JetBlue, Southwest, Delta
Consensus†	66	70	89	80	90	75	100	80	90	80	JetBlue, UPS, American, Southwest, United

Idea worth exploring: use median criterion to identify set of nearly equivalent vectors and allow ANSP to break near-ties using other criteria, e.g. average grade, equity, etc.

Idea worth exploring: use median criterion to identify set of nearly equivalent vectors and allow ANSP to break near-ties using other criteria, e.g. average grade, equity, etc.

Topic 3: Majority Judgment – Adaptation for Use in COuNSEL

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?

Solution to Challenge 1: *Set of constraints that define feasible vectors for particular day in the NAS.*

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 :

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

Majority Judgment

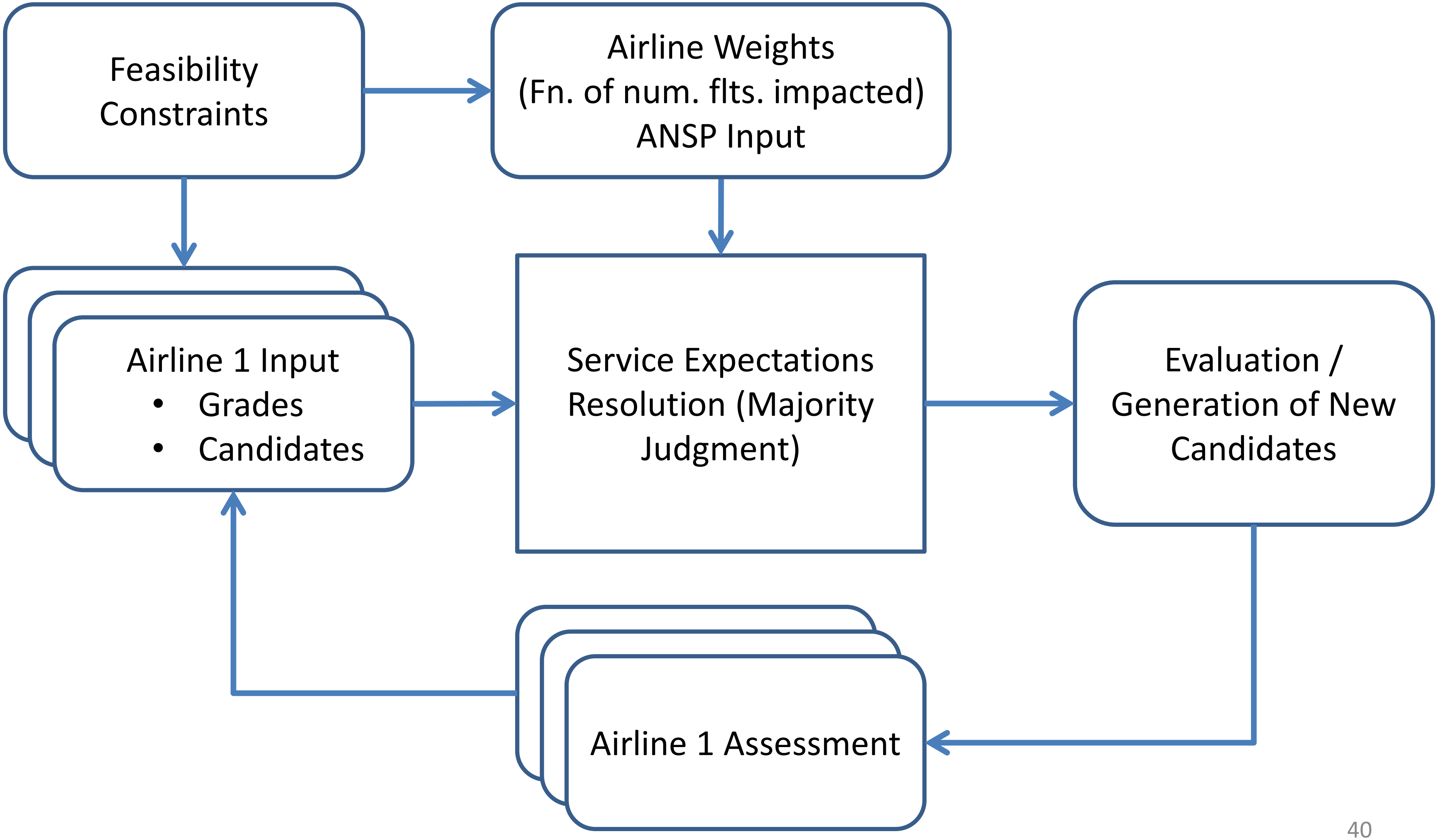
(with small set of vectors)

- Suppose:
  - 6 airlines (voters), voting on 3 candidates: V_1, V_2, V_3
  - grades: 100%, 99%, 98%, 97%, 96%, 95%, 94%, …
- Grades sorted after voting from worst to best:

V_1	80%	80%	90%	94%	95%	100%
V_2	75%	83%	85%	87%	88%	90%
V_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.

COuNSEL Architecture



Feasibility Constraints

Airline Weights
(Fn. of num. flts. impacted)
ANSP Input

Airline 1 Input
- Grades
- Candidates

Service Expectations Resolution (Majority Judgment)

Evaluation / Generation of New Candidates

Airline 1 Assessment

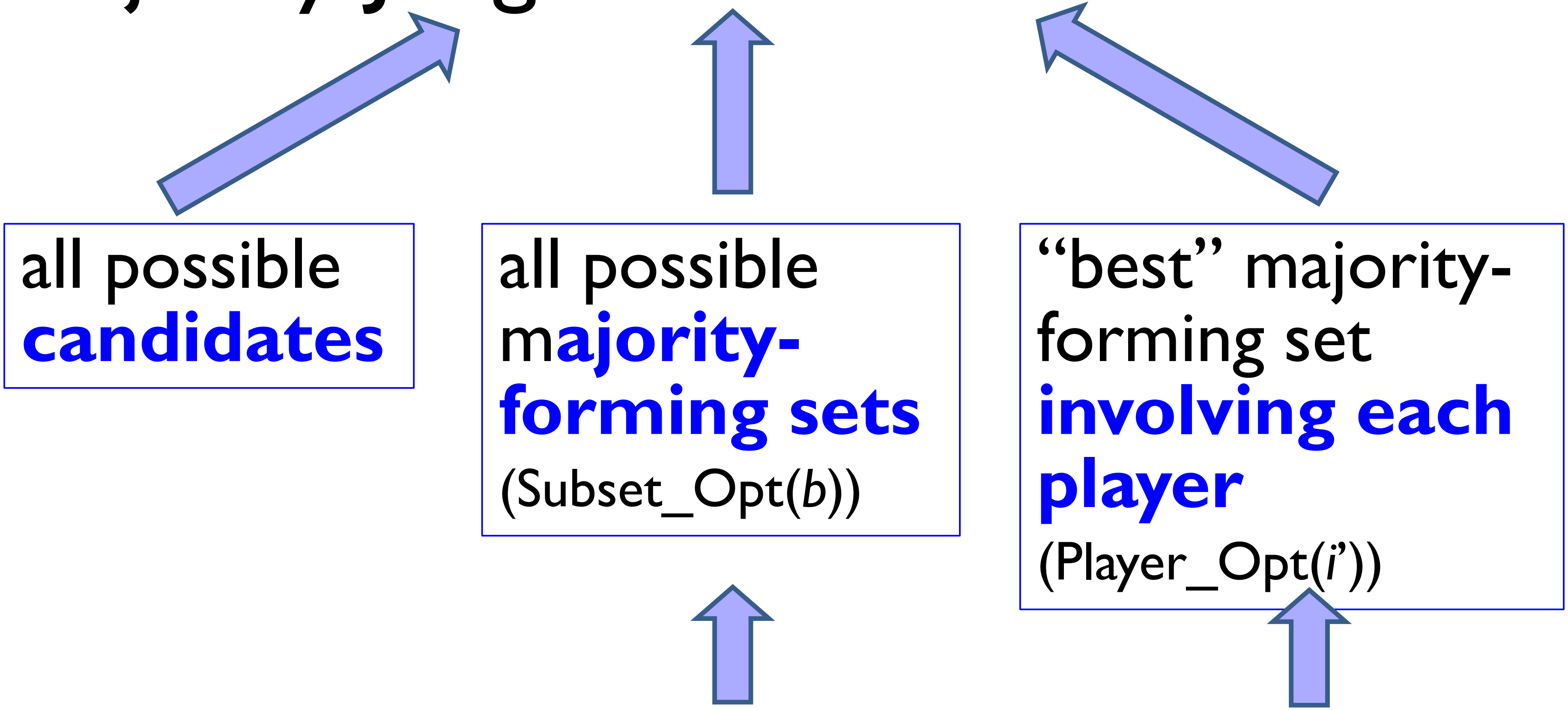
Applying MJ with infinite set of candidates:

1. Define optimization model (MJ-Opt) that finds Majority Judgment winner assuming each airline's grading function $g^a(\mathbf{m})$ is known.
2. Iteratively generate candidate vectors and based on airline grades use statistical methods to estimate $g^a(\mathbf{m})$
    - Candidate generation employs MJ-Opt to generate candidates likely to be close to MJ winner.

Also:

Allow flight operators to supply their own candidates.

Majority Judgment **Winner**



all possible **candidates**

all possible **majority-forming sets**
(Subset_Opt(*b*))

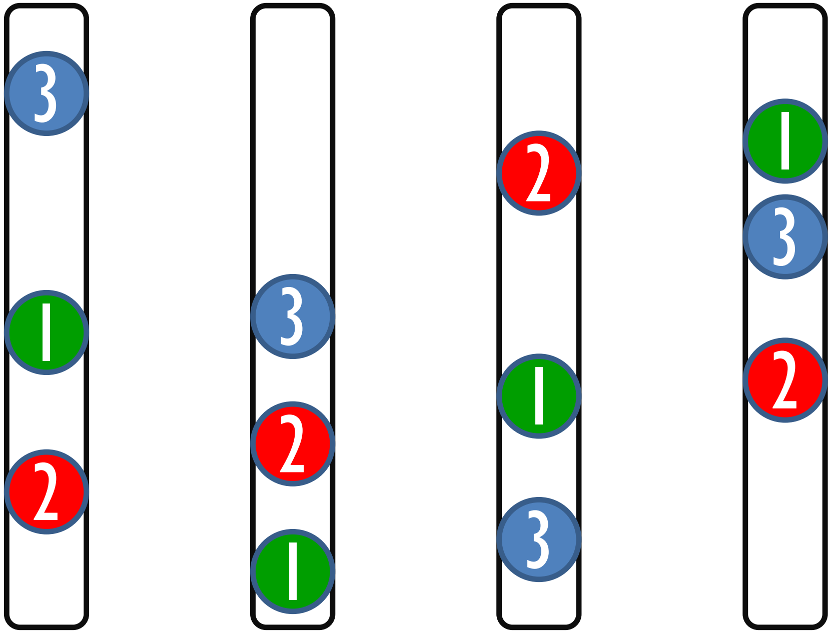
"best" majority-forming set **involving each player**
(Player_Opt(*i*'))

"Majoritarian Set": set of players that determine MG

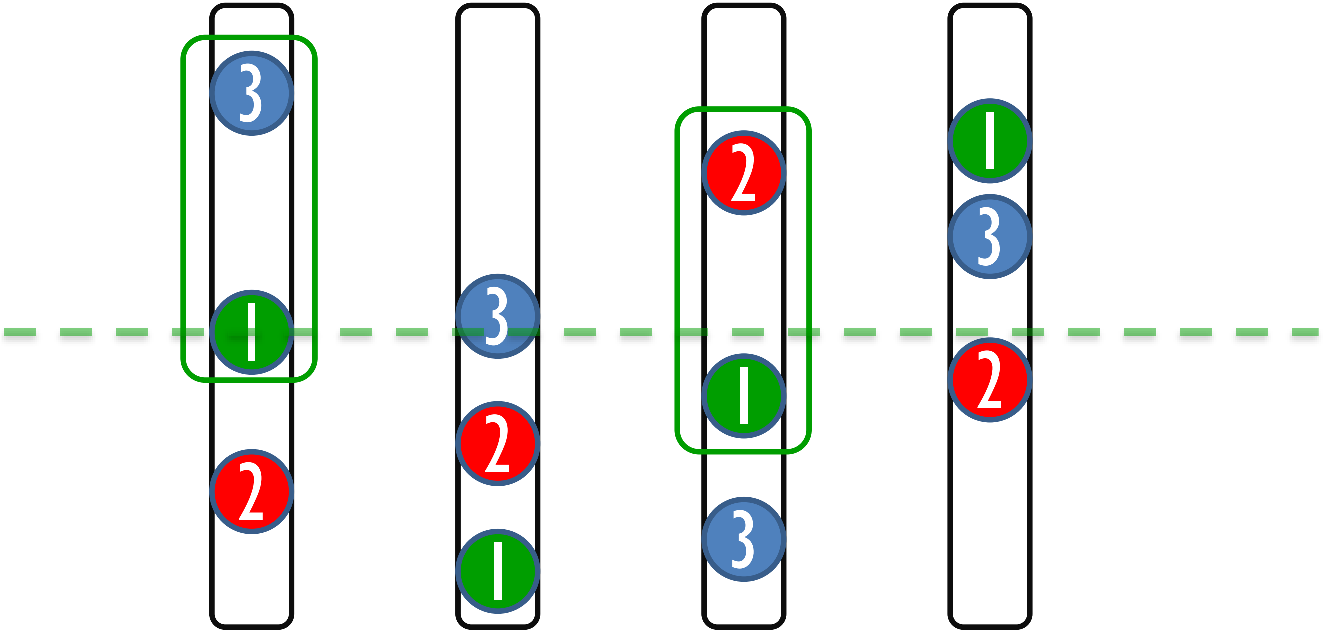
Player with the lowest grade in MS determines MG

Candidate with the highest MG wins

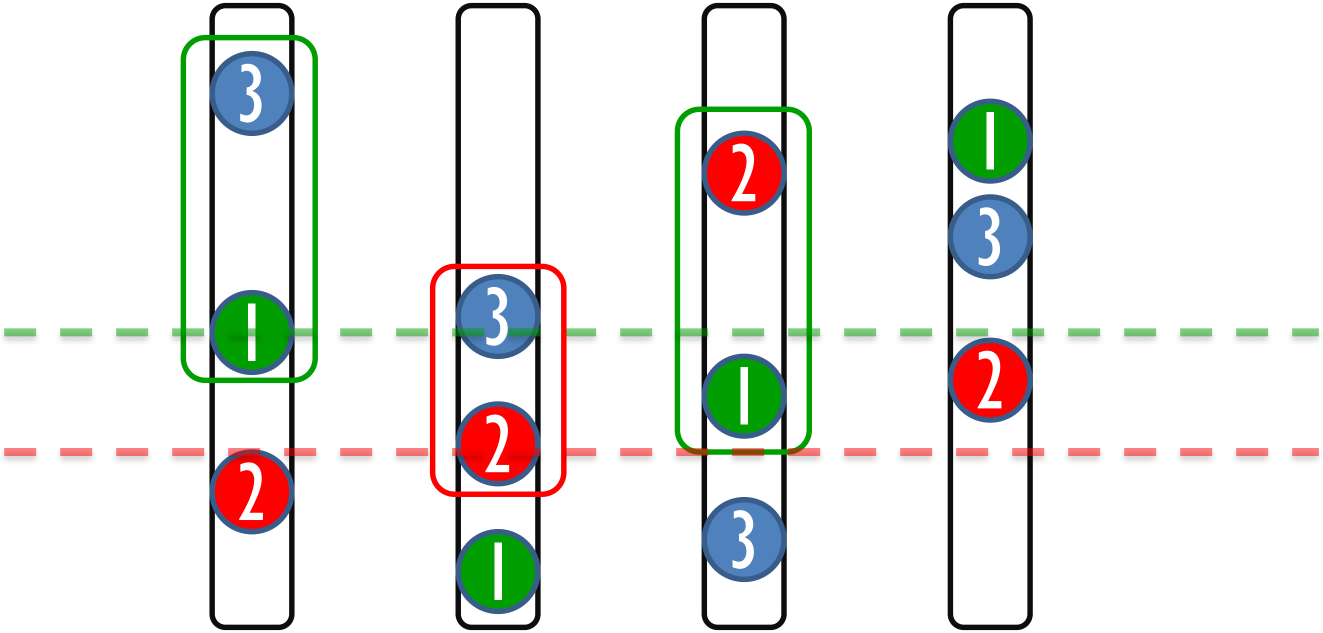
“**Best**” majority-forming set for a player



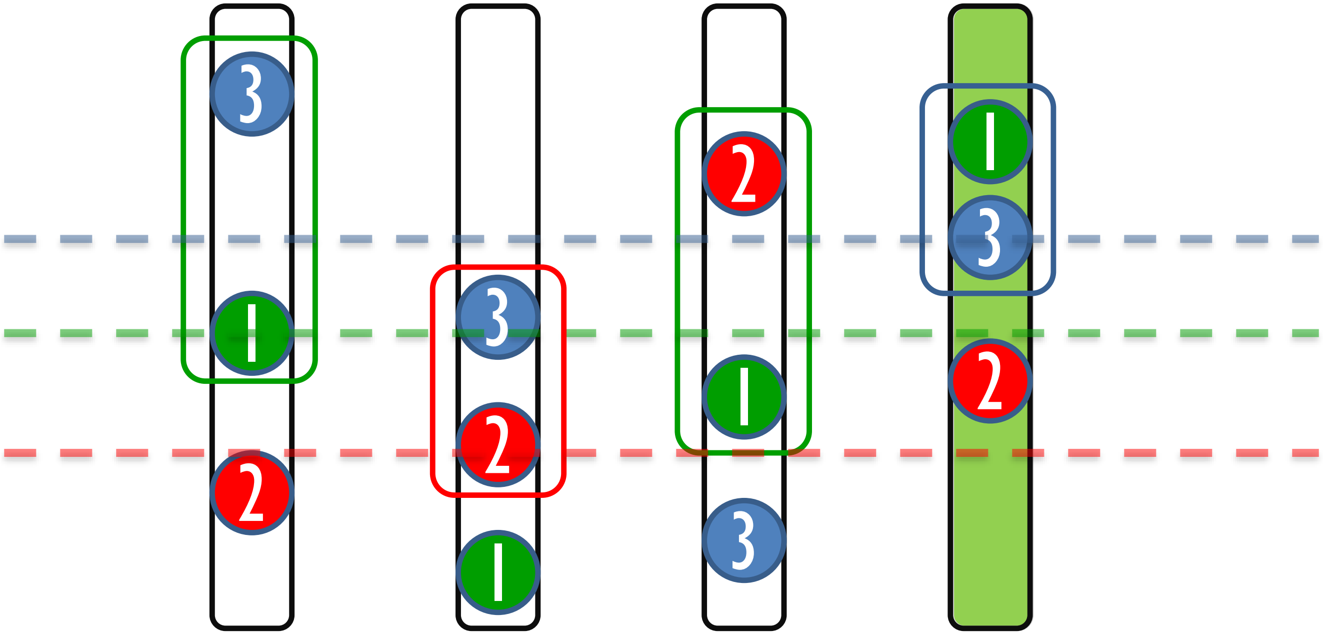
“**Best**” majority-forming set for 1



“**Best**” majority-forming set for 2



“**Best**” majority-forming set for 3



"**Best**" majority-forming set for player i'

$I_i = 1$ if $i \in M_{i'}$; 0 otherwise

$$
\begin{aligned}
\tilde{z}_{i'} = \max \quad & x_{i'} \\
s.t. \quad & x_{i'} \leq G^{max}(1 - I_i) + x_i && \forall \quad i \in N \\
& \sum_{i \in N} w_i I_i \geq \overline{W}' \\
& I_i \in \mathbb{B} && \forall \quad i \in N \\
& x_i = g_i(\mathbf{m}) && \forall \quad i \in N \\
& \mathbf{m} \in \mu
\end{aligned}
$$

This model can be solved efficiently with integer programming software.

Majority Judgment **Winner**

$$v^* = \max\nolimits_{i \in N} \tilde{z}_i$$

$$\Updownarrow$$

$$v^* = \max_{\mathbf{m} \in \mu} v(\mathbf{m})$$

"best" majority-forming set **involving each player**

(Player_Opt(*i'*))

Candidate with the highest MG wins

New Candidate Vectors

$I_i = 1$ if $i \in M_{i'}$; 0 otherwise

$$\begin{aligned} \tilde{z}_{i'} = \max \quad & x_{i'} & & \\ s.t. \quad & x_{i'} \leq G^{max}(1 - I_i) + x_i & \forall \quad & i \in N \\ & \sum_{i \in N} w_i I_i \geq \overline{W}' & & \\ & I_i \in \mathbb{B} & \forall \quad & i \in N \\ & x_i = \hat{g}_i(\mathbf{m}) & \forall \quad & i \in N \\ & \mathbf{m} \in \mu & & \end{aligned}$$

Estimate grade function

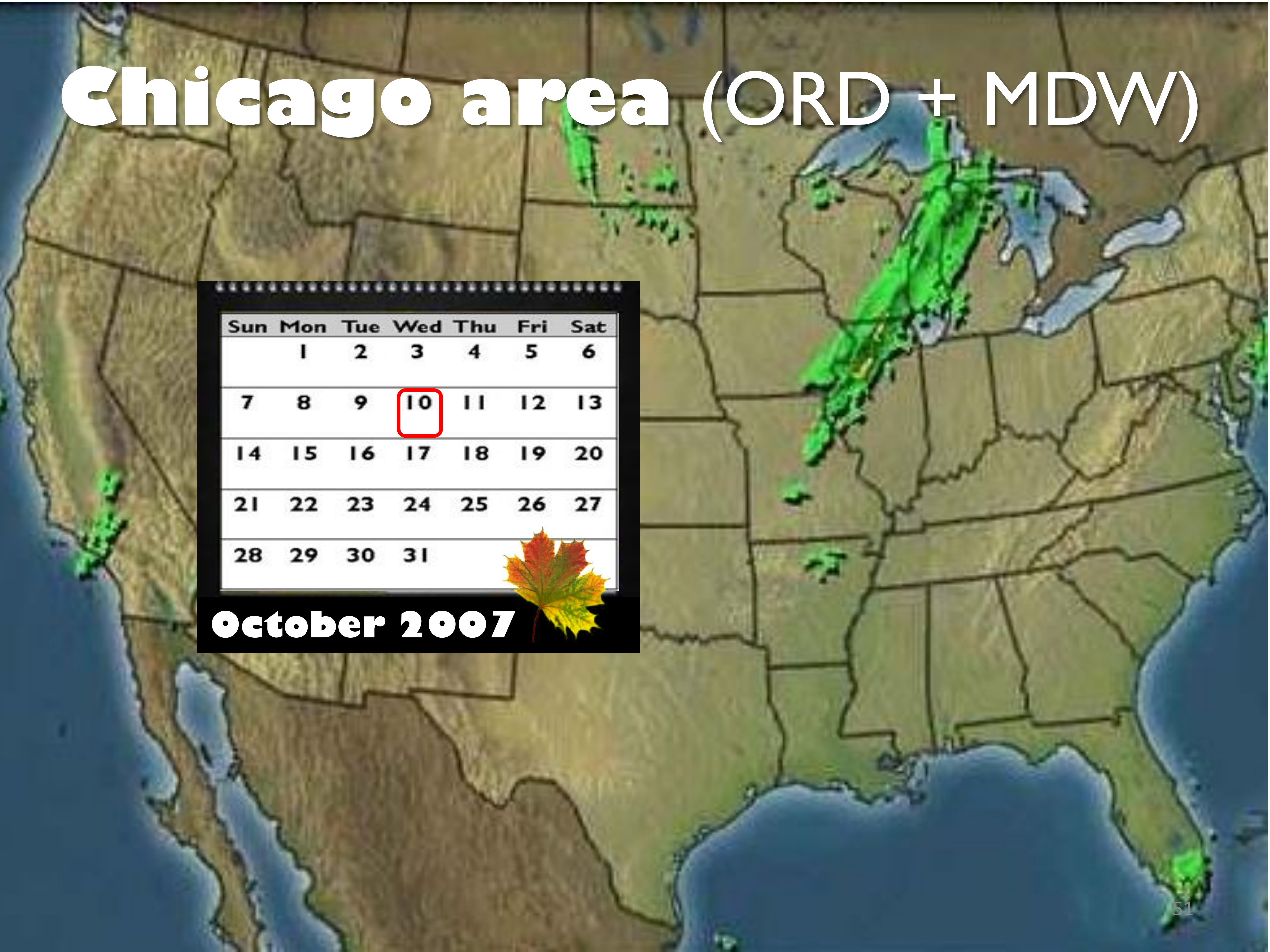
Constrained least-squares regression (for concavity)

Same formulation: **Two** Uses

1. Majority Judgment Winner determination over continuous candidate space
   Uses knowledge of grade functions
   Theoretical

2. New candidate generation
   Estimates grade functions (constrained least-squares)
   Practical

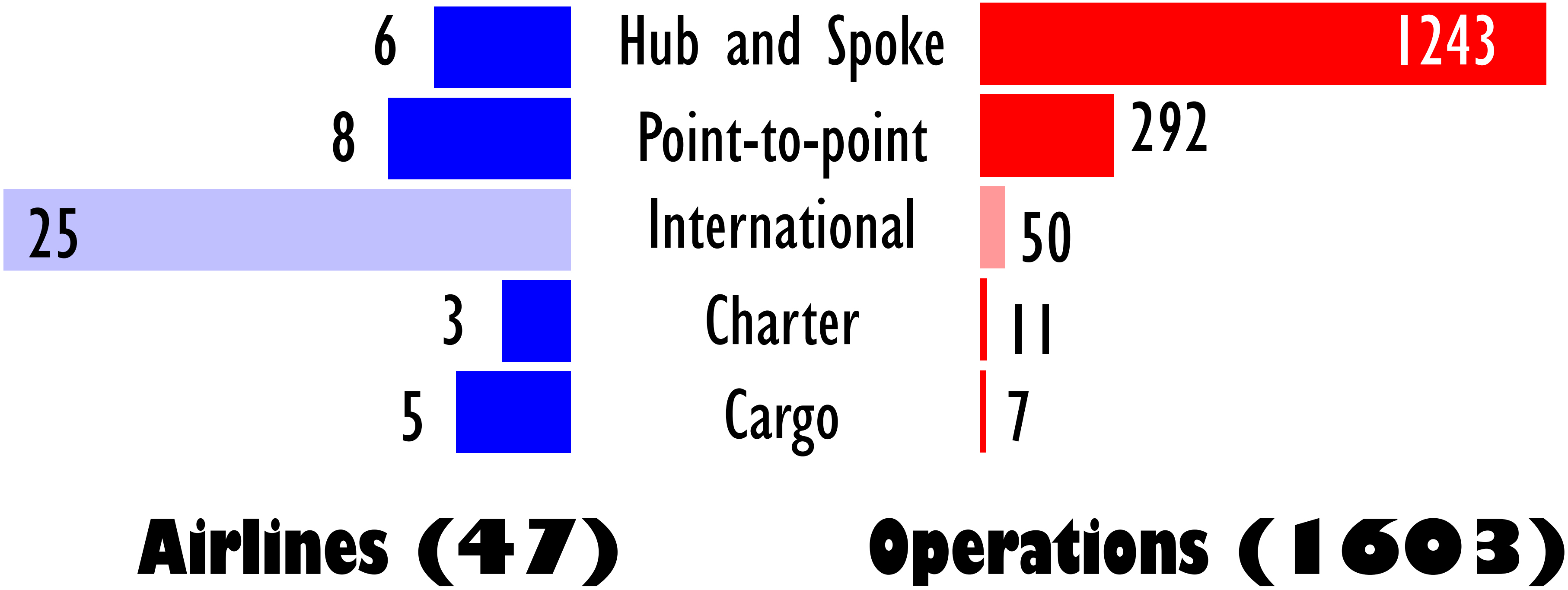
Chicago area (ORD + MDW)



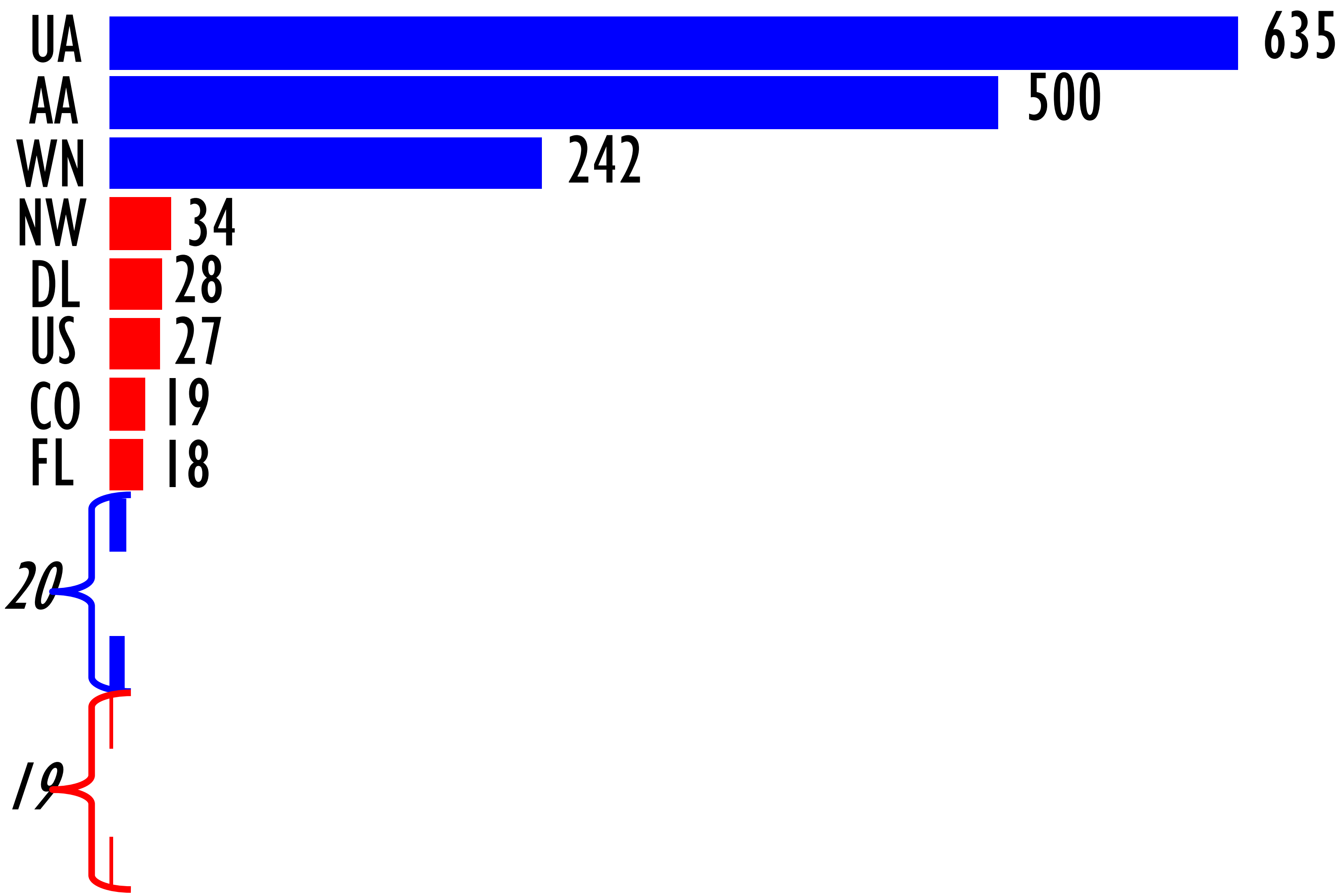
Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

October 2007

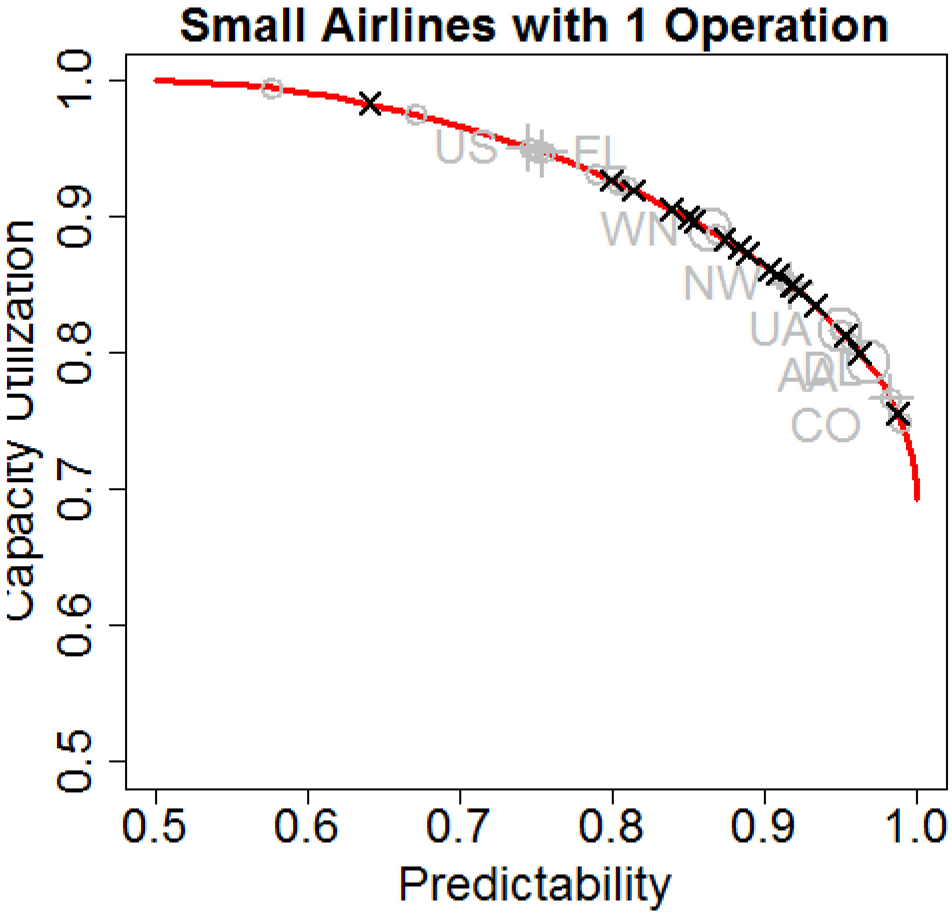
Heterogeneous airline operations



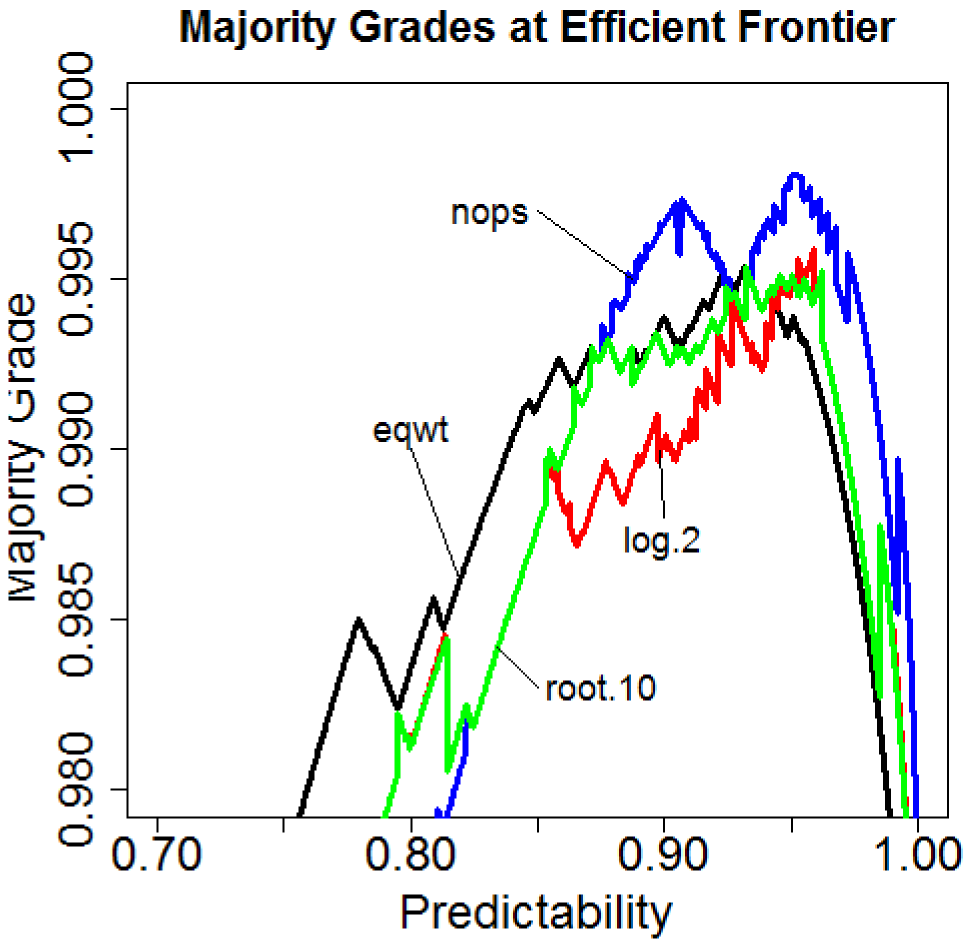
Long tail in distribution of operations



Airlines’ **best** vectors are **spread out**

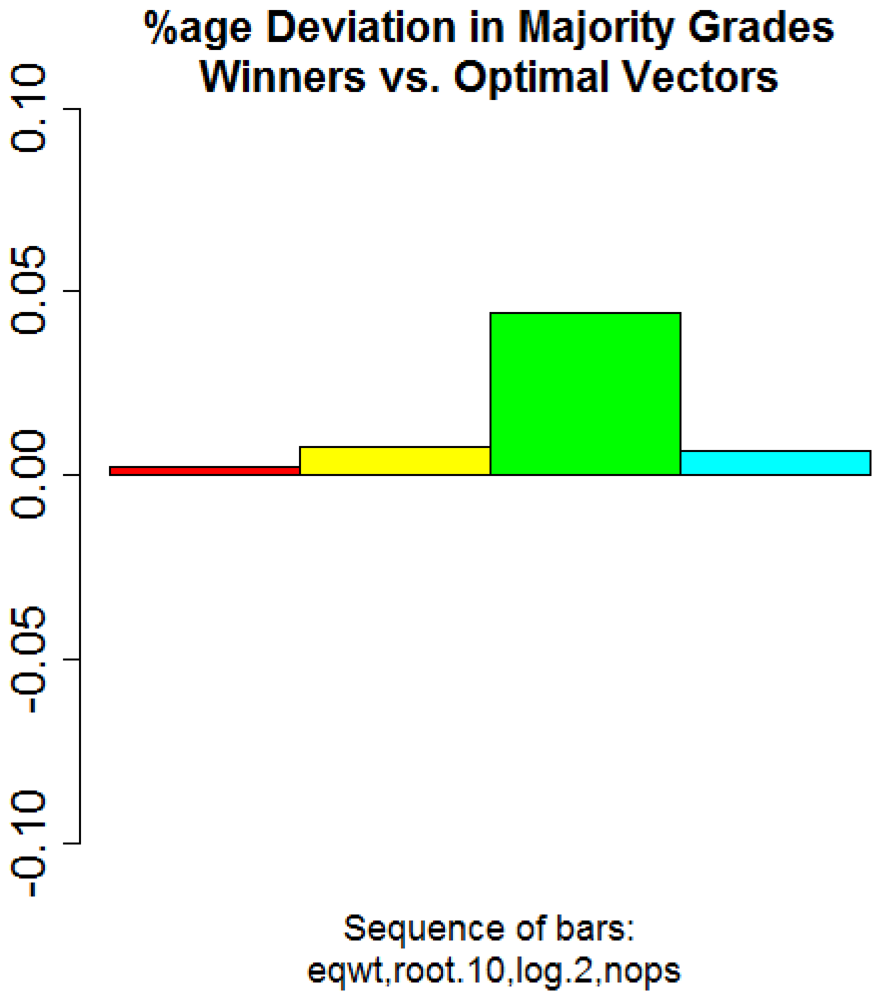


Optimal vectors are **hard** to find



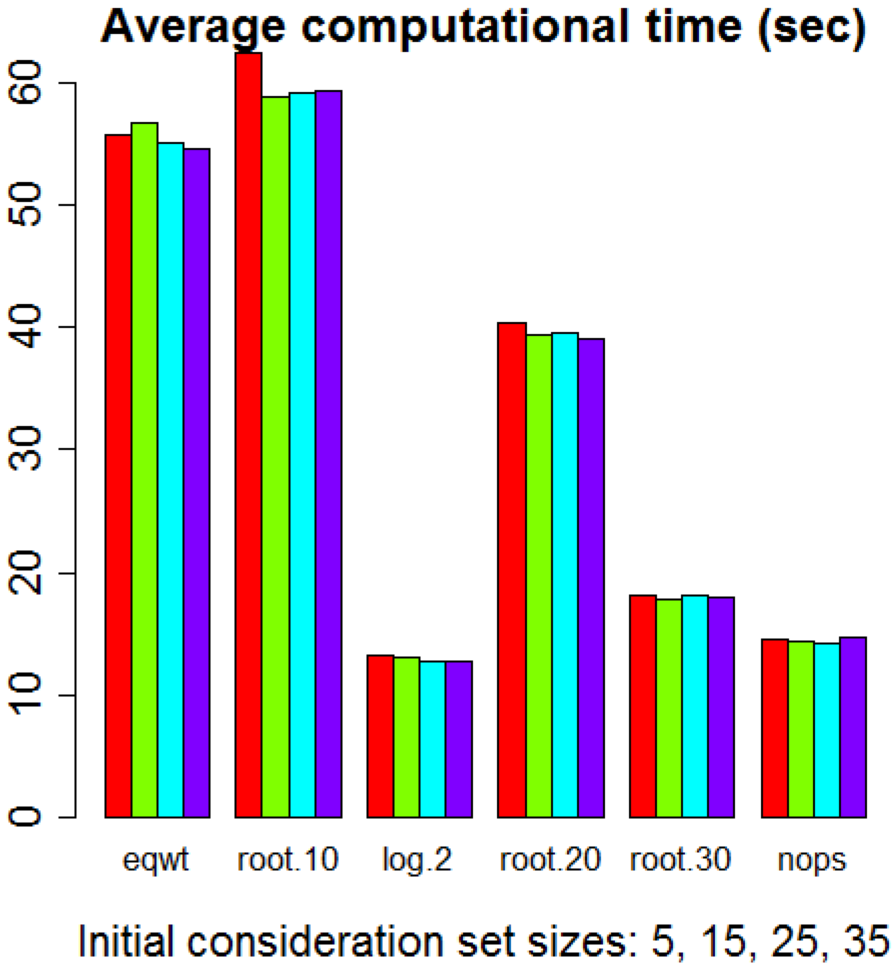
Wt Sch	UA's %age
nops	39.5
log.2	10.8
root.10	10
eqwt	2.1

Winning vectors are **close** to Optimal



Overall accuracy of procedure: **0.2%**

Computing times are **manageable**



Dell Inspiron 5520
Intel Core i7-3612 @2.10GHz,, 8GB RAM
Windows 7 Ultimate 64-bit

R 2.15.1 32-bit
CPLEX 12.4 via Rcplex 0.3-0
quadprog 1.5-4

Final Thoughts

- Simulation has shown approach to be computationally effective for 2-metric spaces – have not fully tested process for 3-dimensional vectors but looks quite doable.
- **Practical Perspective:** as was done in the HITL, the system can work quite well with "more modest" ways of generating candidate vectors, e.g. allowing flight operators to submit candidates, creating list ahead of time based on intuition, using various "heuristic" criteria.

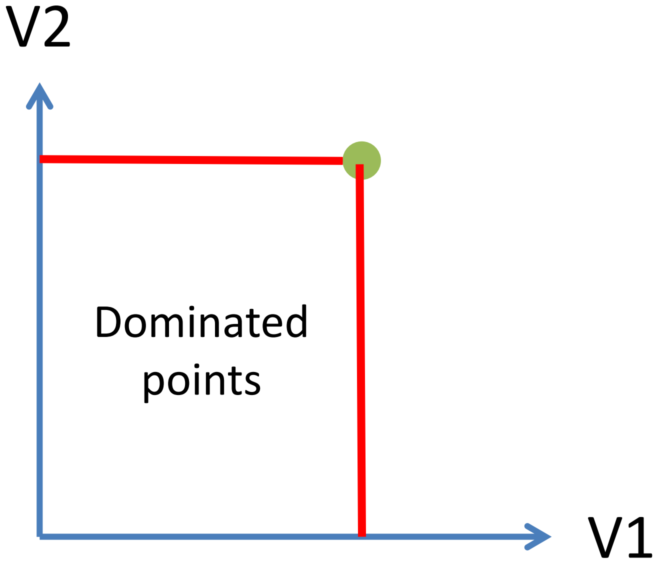
… the sophisticated integer programming approach to candidate generation may not be critical in practice (but determining this will require more experimentation).

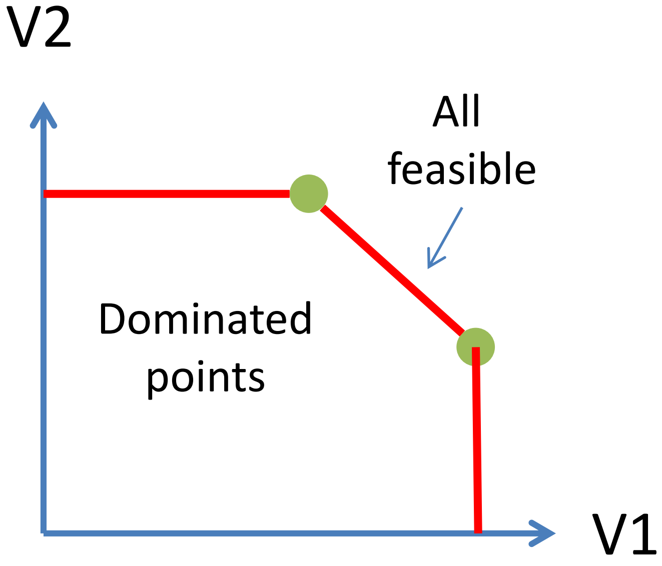
Topic 4: Definition of Space of Feasible Candidate Vectors

Characteristics of Space of Feasible Performance Goal Vectors:

- A basic assumption of the performance metrics is a higher value of any metric is preferred to a lower value (by any flight operator), e.g. any flight operator would prefer (.91, .88, .85) to (.91, .82, .85) since the first and last metric values are the same but the 2nd is higher in the first vector (we say the 1st point dominates the 2nd).

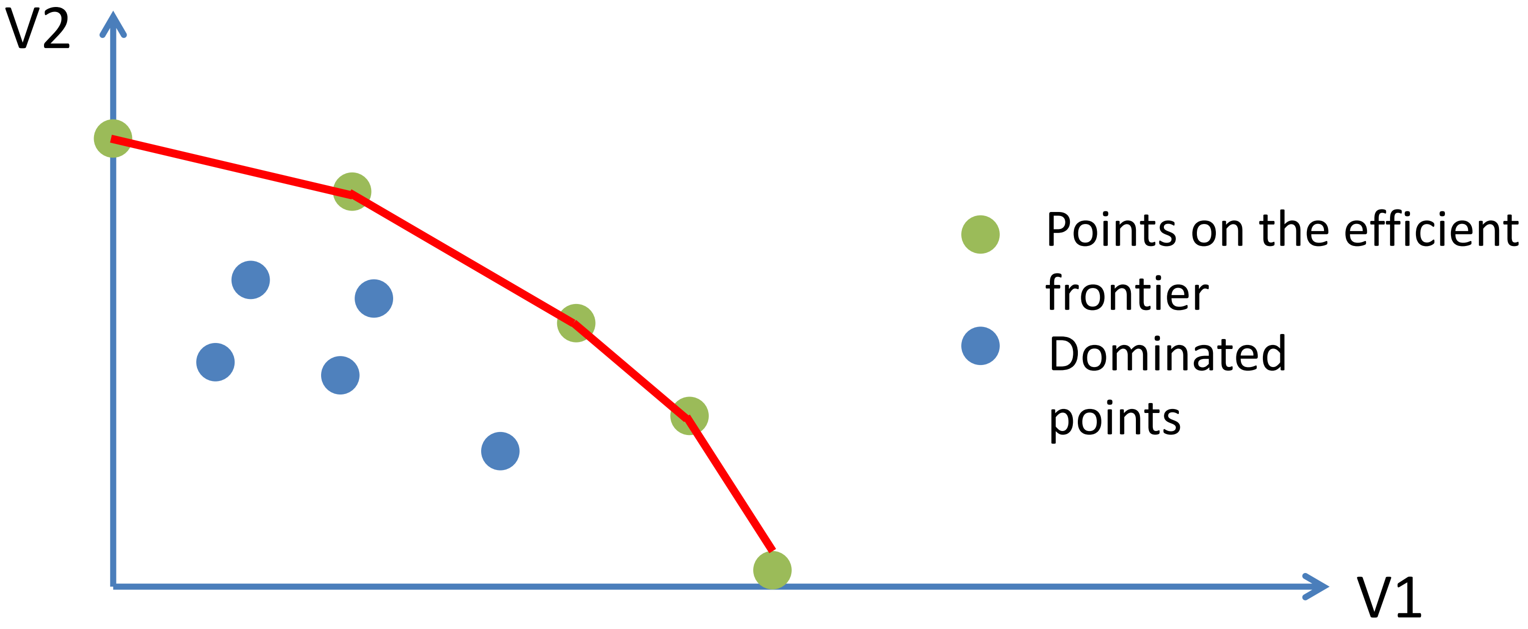
- Also, it is assumed (somewhat for conceptual and mathematical convenience) that if two vectors are possible/feasible then any vector on the line segment between them is feasible, e.g. if (.91, .88, .87) and (.91, .82, .91) are both feasible then a point in between, e.g. ½ (.91, .88, .87) + ½ (.91, .82, .91) = (.91, .85, .89) is also feasible.





Characteristics of Space of Feasible Performance Goal Vectors

- Thus we can define the space of feasible vectors by a set of linear constraints with the structure illustrated below
- Only the points of the efficient frontier are of interest as possible goal vector



Format of Constraints Defining Space of Performance Goal Vectors

- Based on the previous discussion, if performance vectors are denoted by (V1, V2, V3) then any constraint defining the region of feasible performance goal vectors has the form:

$$A1\ V2 + A2\ V2 + A3\ V3 <= B$$

where A1, A2, A3 >= 0 and B > 0

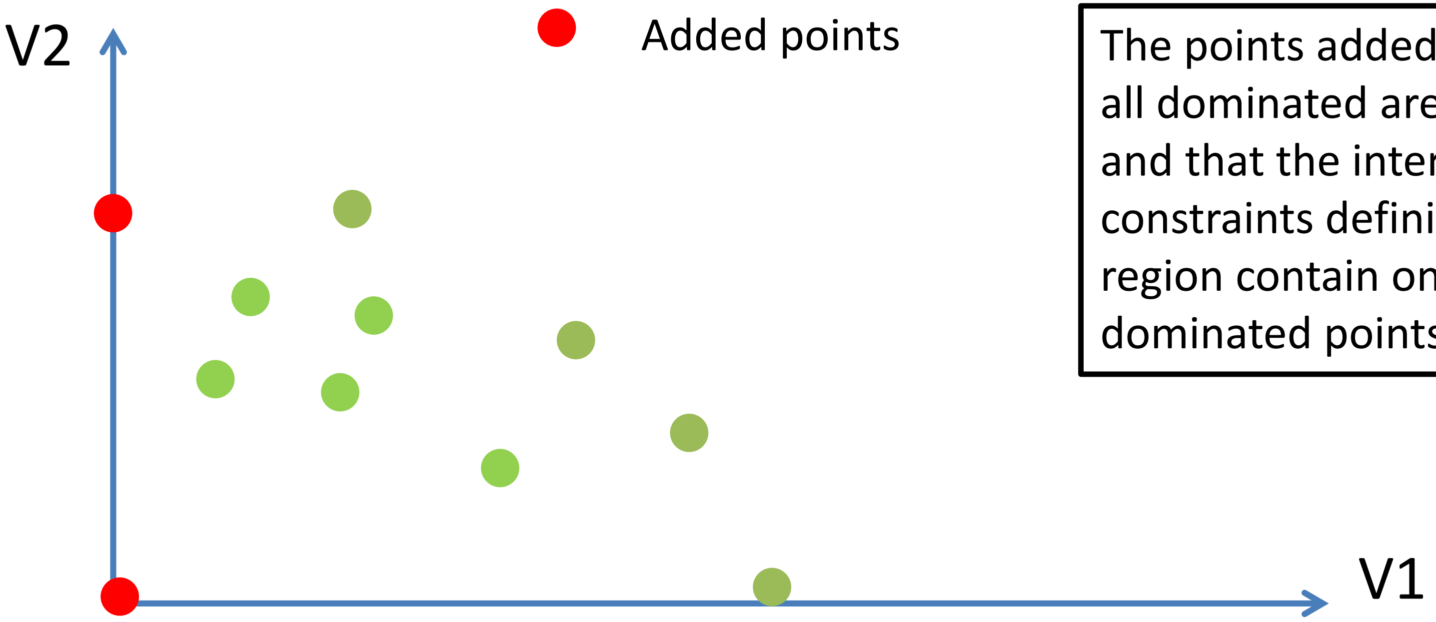
- The COuNSEL software tool accepts a list of constraints in this format.

Generating Constraints

- Approach to generating constraints defining space of feasible performance vectors:
  - Step 1: generate set of possible performance vectors given the weather and demand conditions of the day.
  - Step 2: find set of constraints that encloses the points generated in step 1, in a feasible region with the appropriate properties.

Solution to Step 2

- There are well known methods that find a set of constraints defining the convex hull of a set of given points – such methods can be accessed as functions in various computational toolkits
- This “almost” provides a solution to Step 2: before applying such a method, it may be necessary to add some points to insure the set of points have the structured described earlier.
- The figure below illustrates the points that may need to be added.



The points added insure that all dominated are feasible and that the interior constraints defining the region contain only non-dominated points

Solution to Step 1:
Performance Vector Generation for GDPs Based on Analysis of Historical Days

- Research carried out so far assumes a GDP plan is characterized (only) by the planned airport arrival rate vector (PAAR)
- The performance achieved by choosing a particular PAAR is determined by the actual airport arrival capacity profile that occurs (AAAR)
- The conditions on a particular day (weather forecast) will determine an AAAR distribution for that day, i.e. a list of possible AAAR together with associated probabilities
- Performance vectors can be enumerated by enumerating possible PAARs and computing an associated performance vector for each PAAR by applying the AAAR distribution

The Logic

- Identify a set of possible capacity profiles for the given day-of-operation
- Each possible capacity profile may be selected as the planned capacity profile

The Logic (II)

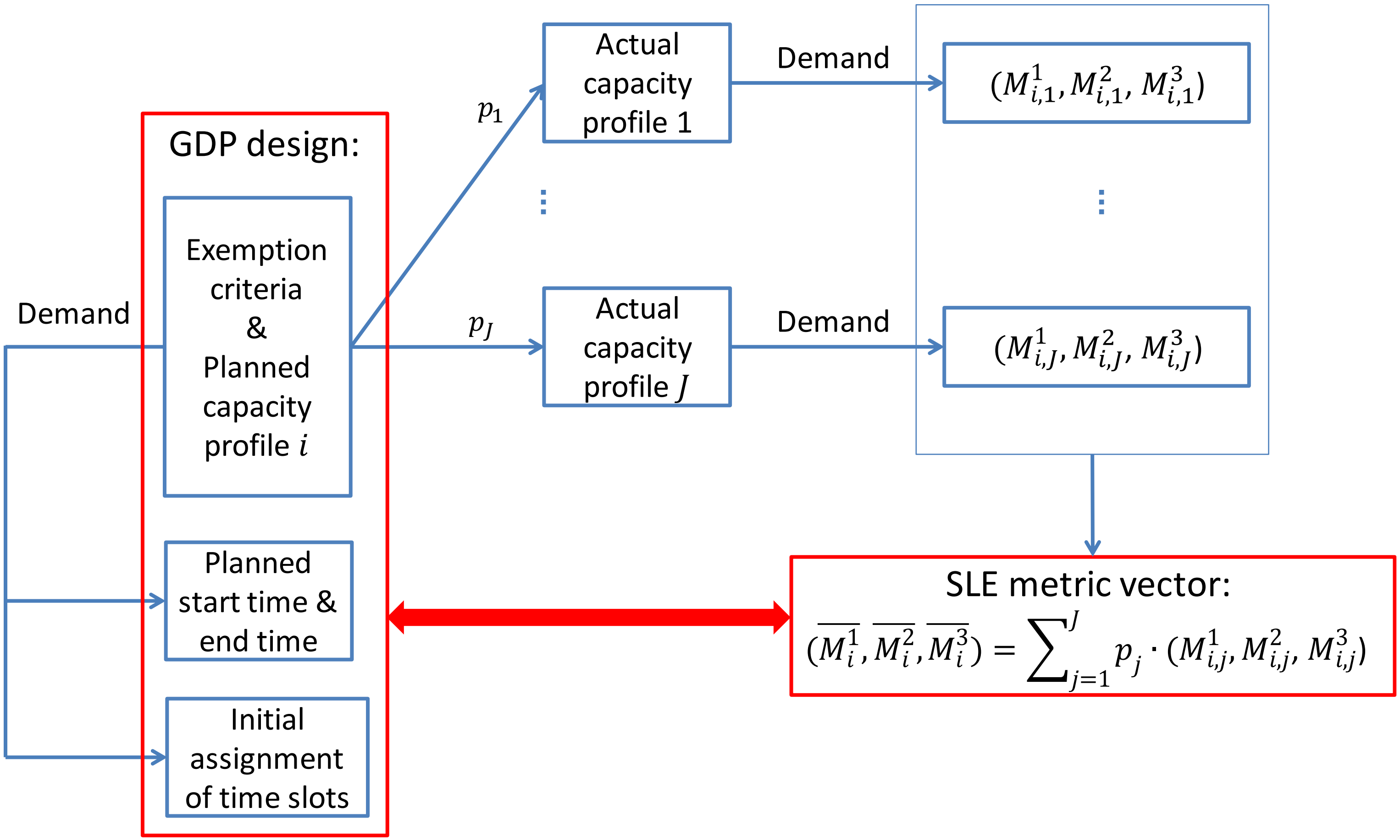
- For each planned capacity profile, the feasible candidate vector (SLE metric) is estimated as an average of the realized system performances over all the possible capacity profiles that may realize:

$$\overline{M_i^k} = \frac{\sum_{j=1}^{J} M_{i,j}^k}{J}$$

where, $\overline{M_i^k}$ is SLE metric for performance goal k with planned capacity profile i;

$M_{i,j}^k$ is the realized performance for performance goal k if capacity profile i is planned and capacity profile j is the actual capacity profile.

Flowchart



Currently, all the profiles are assumed to be equally likely.

Performance Goals

- Currently, we are considering the following performance criteria:
    - Capacity utilization
    - Efficiency
    - Predictability
- More criteria could be considered upon users' request

Capacity Utilization

This metric is defined to measure how much capacity is planned when the GDP is first implemented against the capacity under VMC condition:

$$M_{i,j}^{1} = \alpha_{cu,i,j} = \frac{N_{R,i,j}}{N_{VMC,i,j}}$$

where,

$\alpha_{cu,i,j}$ is the capacity utilization metric with planned capacity profile i and actual capacity profile j;

$N_{R,i,j}$ is the count of realized arrivals between GDP start time and end time when capacity profile i is planned and profile j is realized;

$N_{VMC,i,j}$ is the count of arrivals that could have been landed assuming VMC capacity and infinite demand during the same period for the same pair of profiles.

Efficiency

Efficiency is defined referring to the motivation of GDP: transforming airborne delay to cheaper ground delay:

$$M_{i,j}^{2} = \alpha_{e,i,j} = \frac{\sum_k GD_{i,j,k}}{\sum_k TD_{i,j,k}}$$

where,

$\alpha_{e,i,j}$ is the efficiency metric with planned capacity profile i and actual capacity profile j;

$GD_{i,j,k}$ is the ground delay incurred by flight k for the same pair of capacity profiles;

$TD_{i,j,k}$ is the total delay incurred by flight k, equal to realized ground delay plus realized airborne delay.

Predictability

- Predictability is defined to capture the accuracy in estimating capacity rates. In the strategic planning telecons, most of the debate is on setting capacity rates.
- On one hand, we want to make sure available capacity will be effectively utilized. On the other hand, we also appreciate the accuracy of the guess on capacity rates. The former is considered in the capacity utilization and the latter is considered by predictability metric.

Predictability (II)

$$M_{i,j}^{3} = \alpha_{p,i,j} = \frac{1}{T}\sum_{t=1}^{T} \frac{min(PAAR_{i,t}, AAAR_{j,t})}{max(PAAR_{i,t}, AAAR_{j,t})}$$

where,

$\alpha_{p,i,j}$ is the predictability metric with planned capacity profile i and actual capacity profile j;

t is the index for the 15-minute interval and T is the total number of intervals;

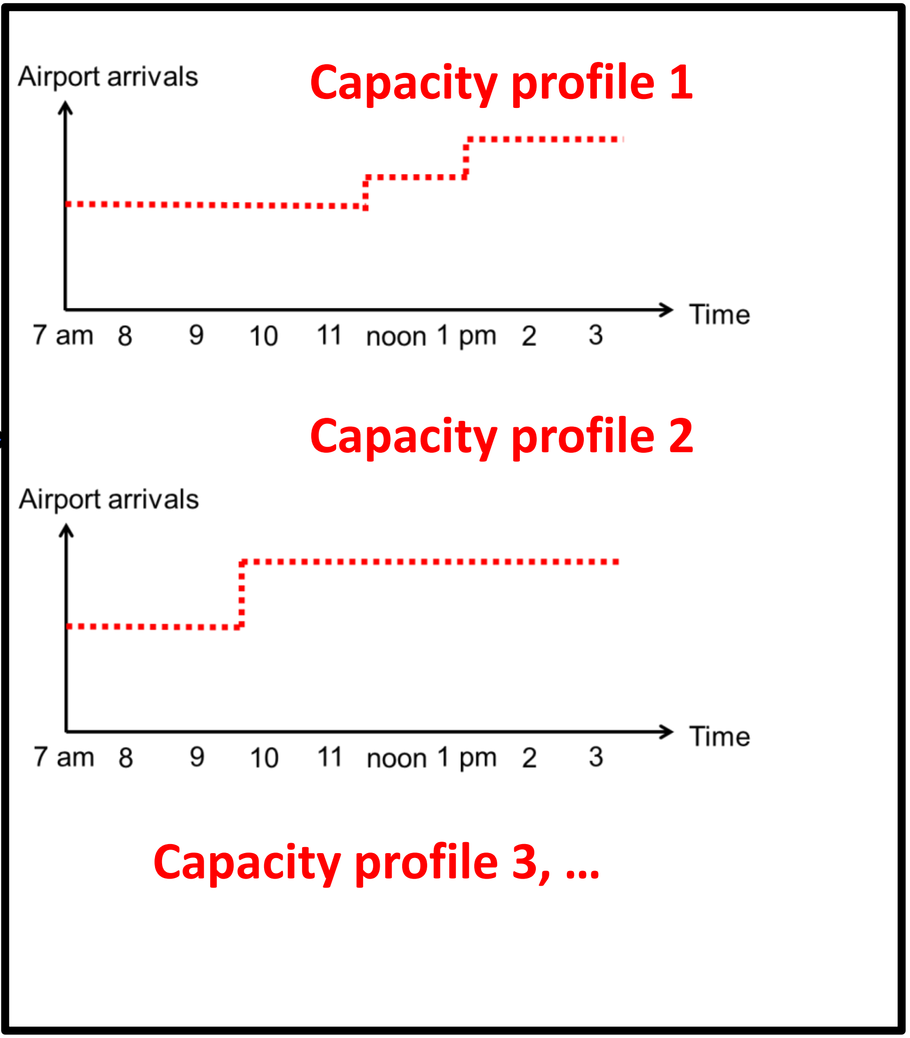
$PAAR_{i,t}$ is the planned airport acceptance rate for interval t given plan capacity profile as i;

$AAAR_{j,t}$ is the actual airport acceptance rate for interval t when the actual capacity profile is j.

How to
Generate the Set of Possible Capacity Profiles?

Weather forecast
For a given day:

- Ceiling
- Visibility
- Wind
- Thunderstorm
- Snow



Capacity profile 1

Capacity profile 2

Capacity profile 3, …

(Ref: Liu et al., Icrat 2014)

Methodology:
learn from history

Logic in the Method

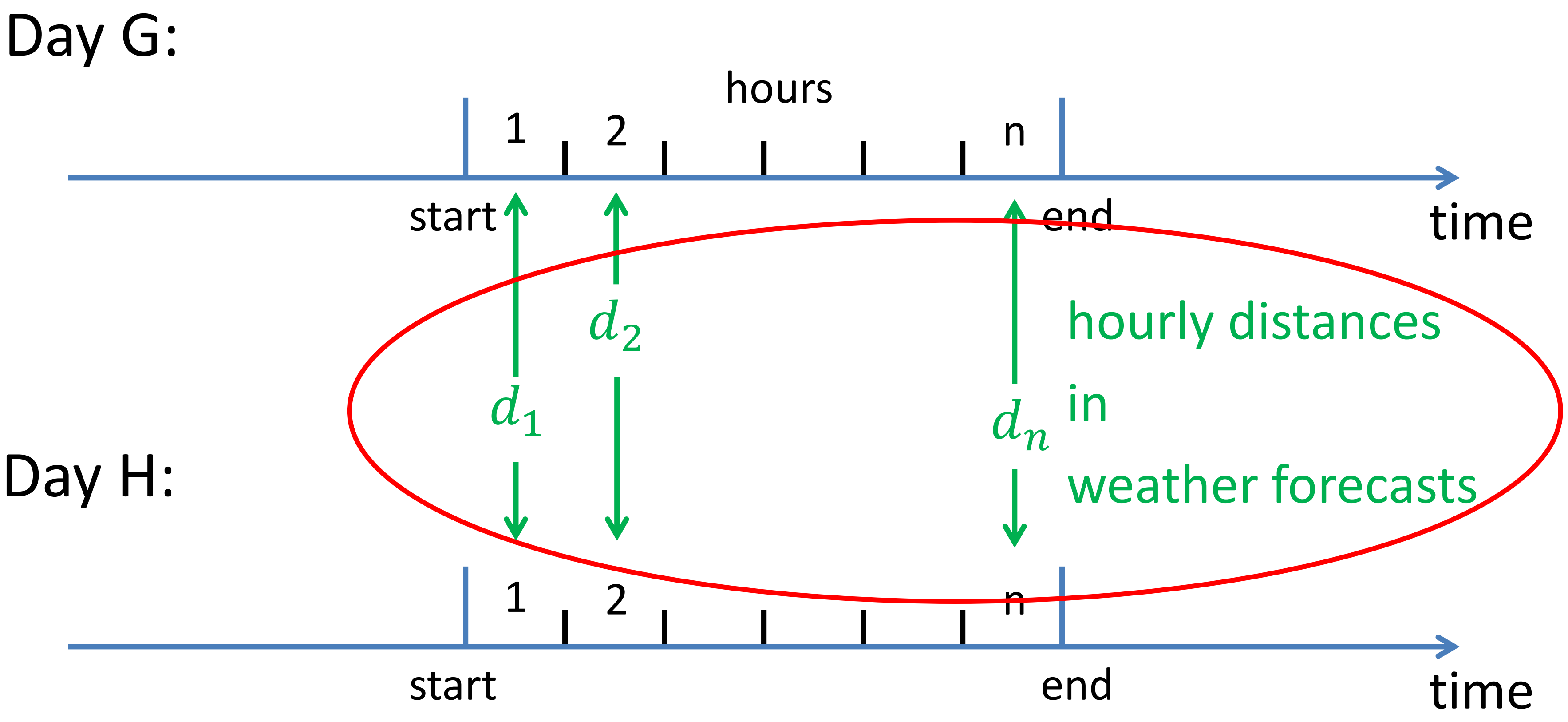
Given day	Day G
Historical days	Day H_1 Day H_2 … Day H_m
Capacity profiles	Profile 1 √ Profile 2 √ … Profile m ×
Total distances	$TD_{G,H_1} < TD_{G,H_2} < \dots < TD_{G,H_m}$ Closest → Furthest
Similarity	Highest → Lowest

TD_{G,H_i} :Total distance in weather forecast

between Day G and Day H_i

Total distance between Days G and H

$$TD_{G,H} = \sum_{i=1}^{n}(d_i)^2$$



Hourly Distance between Hours j and k

$$d_{j,k}(A) = \sqrt{(WF_j - WF_k)^T \cdot \boxed{A} \cdot (WF_j - WF_k)}$$

⇧ Weather Forecast vector

$[x_1, x_2, x_3]$

⇧ Matrix of distance coefficients

Δ's: difference between
the weather variables
from hour i and hour j

$$\begin{array}{c|ccc|} & \Delta x_1 & \Delta x_2 & \Delta x_3 \\ \Delta x_1 & a_{1,1} & a_{1,2} & a_{1,3} \\ \Delta x_2 & a_{2,1} & a_{2,2} & a_{2,3} \\ \Delta x_3 & a_{3,1} & a_{3,2} & a_{3,3} \end{array} \;?$$

$$d_{j,k}(A) = \sqrt{\boxed{a_{11}} \cdot \Delta_{x1}^2 + \boxed{a_{12}} \cdot \Delta_{x_1} \cdot \Delta_{x_2} + \boxed{a_{13}} \cdot \Delta_{x_1} \cdot \Delta_{13} + \cdots}$$

Weather forecast distance between two hours depends on difference in capacity between these two hours

Similarity/Dissimilarity Sets

- A pair of hourly weather forecasts, (WF_j, WF_k)
  - belongs to the similarity set, S, if difference in realized capacity rates is small
  - belongs to the dissimilarity set, D, if difference in realized capacity rates is large

The objective here is to predict hourly capacity

Matrix of Distance Coefficients, A

Objective: $\min_{A} \sum_{(WF_j, WF_k) \in S} [d_{j,k}(\mathrm{A})]^2$

Minimize the weather forecast distances for the hour pairs in the similarity set

Constraints:

$$\sum_{(WF_j, WF_k) \in D} \left\| WF_j - WF_k \right\|_A \geq 1$$

So A ≠ 0

and

$$A \succcurlyeq 0$$

A is positive and semi-definite, so $d_{j,k}(\mathrm{A})$ is satisfying non-negativity

(Eric et al., 2012)

Distance Matrix, A

In the literature

$$\begin{array}{c|ccc} & \Delta x_1 & \Delta x_2 & \Delta x_3 \\ \hline \Delta x_1 & 1 & 0 & 0 \\ \Delta x_2 & 0 & 1 & 0 \\ \Delta x_3 & 0 & 0 & 1 \end{array}$$

$$d_{j,k} = \sqrt{\Delta_{x1}^2 + \Delta_{x_2}^2 + \Delta_{x_3}^2}$$

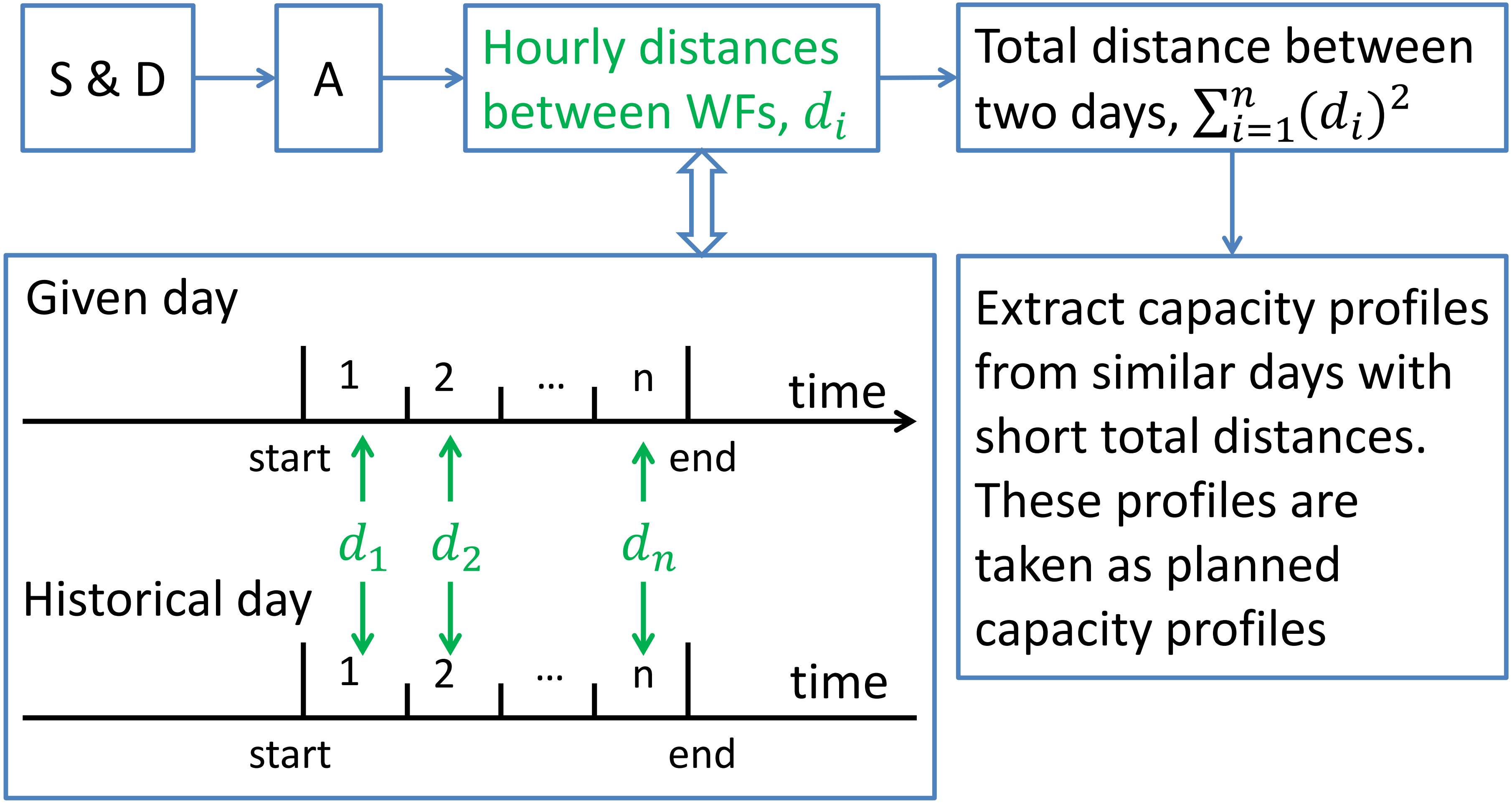
VS.

In the proposed work

$$\begin{array}{c|ccc} & \Delta x_1 & \Delta x_2 & \Delta x_3 \\ \hline \Delta x_1 & a_{1,1} & a_{1,2} & a_{1,3} \\ \Delta x_2 & a_{2,1} & a_{2,2} & a_{2,3} \\ \Delta x_3 & a_{3,1} & a_{3,2} & a_{3,3} \end{array}$$

- Different weights for different weather variables
- Weights for the interactions between weather variables

Recipe



S & D

A

Hourly distances between WFs, d_i

Total distance between two days, $\sum_{i=1}^{n}(d_i)^2$

Extract capacity profiles from similar days with short total distances. These profiles are taken as planned capacity profiles

Topic 5: Benefit Mechanisms and User Grading Models

Benefits of SLE

- 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
- Reduction in NAS-wide operating (delay and disruption) cost via better support of airlines' business objectives
- A more fair and inclusive decision-making process where all the flight operators' voices will be heard

This set of slides focus on the last two

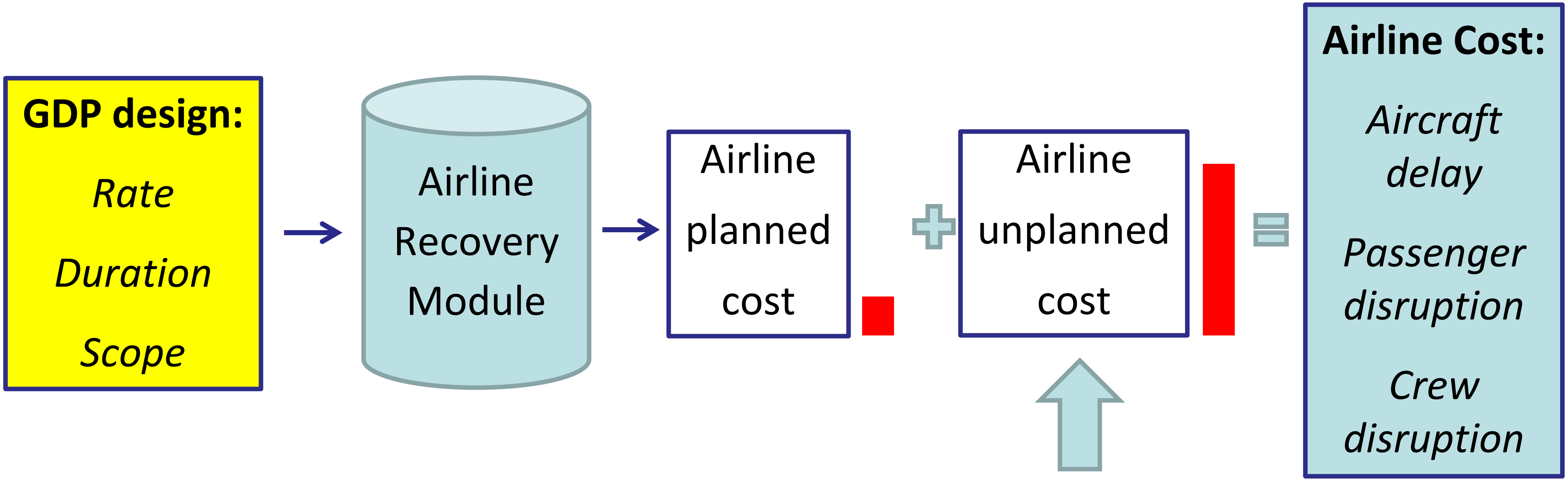
Assessment Methods

- **CoUNSEL Design**
  - COuNSEL design is informed by assuming airlines vote according to the value functions computed by our modeling approach. (Aside from modeling approach, we also conducted a Human-In-The-Loop (HITL) experiment to get airline inputs)
- **Benchmarks**, compare COuNSEL design to
  - *Centralized (state-of-research) design:* the design which has the least total aircraft delay cost (sum of ground delay and airborne delay cost) for all GDP-impacted incoming flights
  - *System-optimal design:* the design which has the least total delay and disruption cost (both aircraft and passenger delay/disruption) by summing over the delay cost of each airline. This approach accounts for airline recovery actions.
- **Notes**
  - FAA traffic managers make decisions in designing GDPs and these decisions impact airlines' operating bottom lines. COuNSEL design most likely will not necessarily lead to an improvement in traditional system performance metrics, e.g. overall throughput or delay. Rather it will lead to a better economic performance for the airlines and fairer distribution of outcomes among different airlines.

Core Modeling Approaches

- In order to assess airline's value function of different GDP designs, we built…
  - An integrated simulation platform
    - Generate different GDP designs (rate, duration and scope).
    - An integrated recovery module for each airline to simulate airline response to GDP programs.
    - Evaluate under capacity uncertainty.
  - An airline recovery module
    - Given disruptions, how to swap fleet, cancel flights, re-accommodate passengers to minimize total delay cost.

Assessment Flowchart



GDP design:

Rate

Duration

Scope

Airline Recovery Module

Airline planned cost

+

Airline unplanned cost

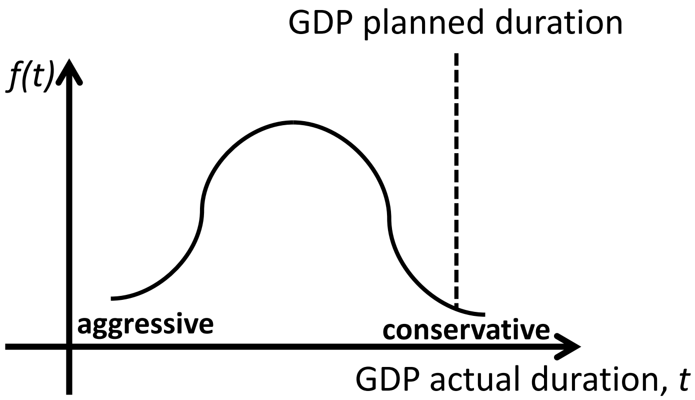
=

Airline Cost:

Aircraft delay

Passenger disruption

Crew disruption



Capacity is uncertain…

GDP rate may be under/over-estimated

GDP duration may be too long/short

…leads to early cancellation and late extension

Unplanned cost: Additional airborne delay, passengers disruptions, fleet disruptions due to inaccurate delay information provided by FAA

Experimental Setup

- **mm/dd/yy:** 6/16/2007
- **Airport:** SFO
- **Actual duration:** Uniform[3 hrs, 9 hrs]
- **14 candidate designs for evaluation:**
  planned duration: 3-9 hours, with an increment of 0.5 hour
- **Program arrival rate:**
  outside GDP duration: VFR rate
  inside GDP duration: IFR rate
- **Airline Itinerary data source:**
  Generated by Barnhart et al., 2011.

- **Delay cost coefficient estimation:**
  BTS Form 41 financial data. Estimated separately for different airlines and different fleet types.
- **Carriers involved:**

	# Impacted Operations	# Fleet Types (# Aircraft in Each Category)	# Impacted Passengers	% Connecting Passengers
United & SkyWest	359	10 (17,4,8,3,9,1,3,7,5,27)	24236	32.33%
American & American Eagle	70	5 (4,2,4,3,9)	7678	27.39%
US Airways	40	4 (1,4,1,4)	4007	31.57%
Continental & ExpressJet	30	5 (1,1,3,1,2)	3244	20.43%
Delta Airlines	26	4 (1,1,2,2)	3750	30.29%
Alaska Airlines	25	2 (4,3)	2461	9.47%
Northwest Airlines	23	4 (2,2,2,1)	3232	25.46%
Frontier Airlines	15	2 (2,2)	1351	31.68%
JetBlue Airways	9	1 (2)	1180	8.05%
AirTran Airways	8	1 (4)	973	32.58%

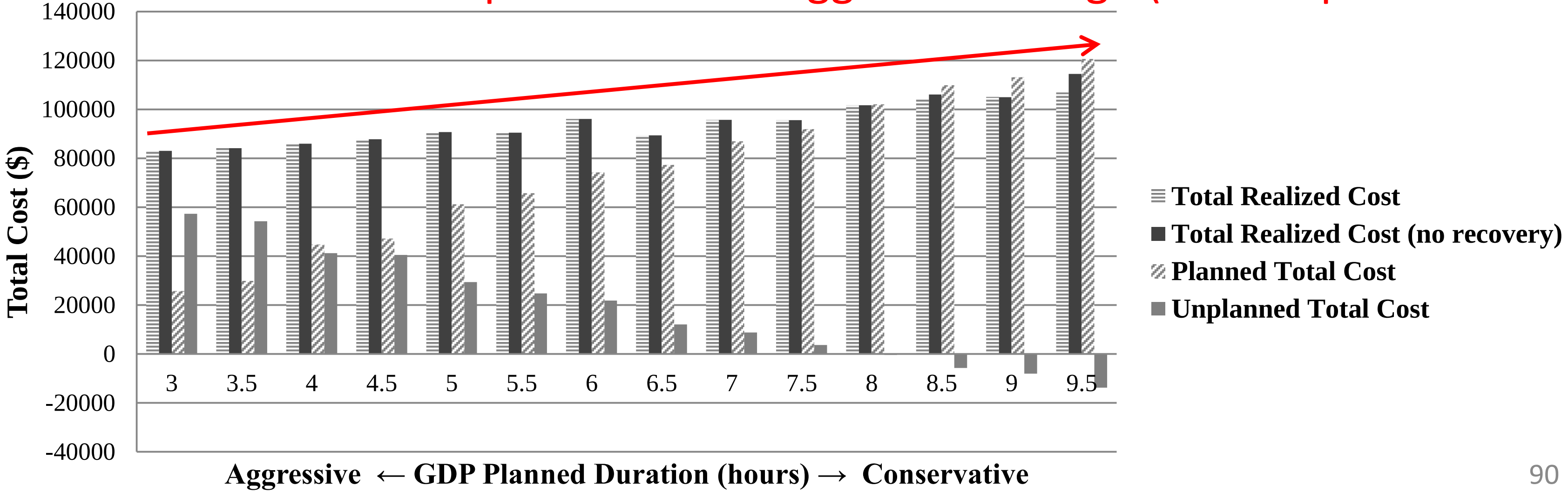
Revealing Airline's Preference

Airline	# Impacted Operations	# Fleet Types (# Aircraft in Each Category)	# Impacted Passengers	% Connecting Passengers	Average Load Factor
US Airways	40	4 (1,4,1,4)	4007	31.57%	80.43%

small number of total operations, multiple different fleet type

little flexibility for recovery
(reduces 6.6% cost through recovery at most)

total cost trend: preference for aggressive design (shorter planned duration



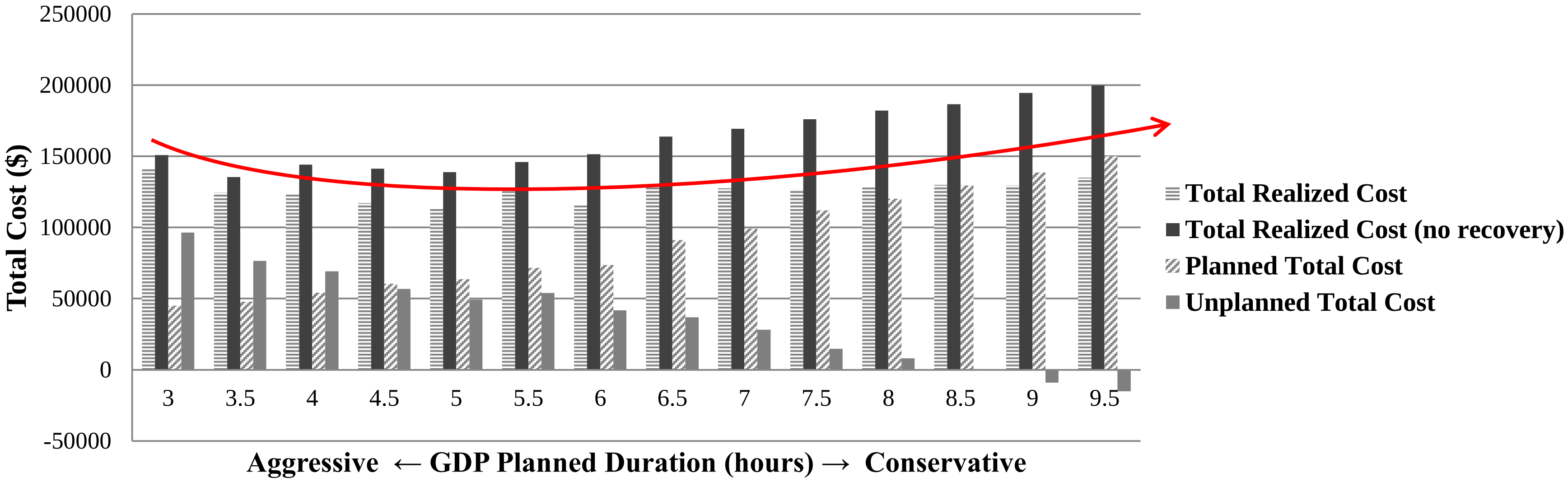
Revealing Airline’s Preference

Airline	# Impacted Operations	# Fleet Types (# Aircraft in Each Category)	# Impacted Passengers	% Connecting Passengers	Average Load Factor
American & American Eagle	70	5 (4,2,4,3,9)	7678	27.39%	75.53%

medium number of total operations, multiple different fleet type

medium flexibility for recovery
(reduces 32.4% cost through recovery at most)

total cost trend: preference for moderate design (intermediate planned duration)



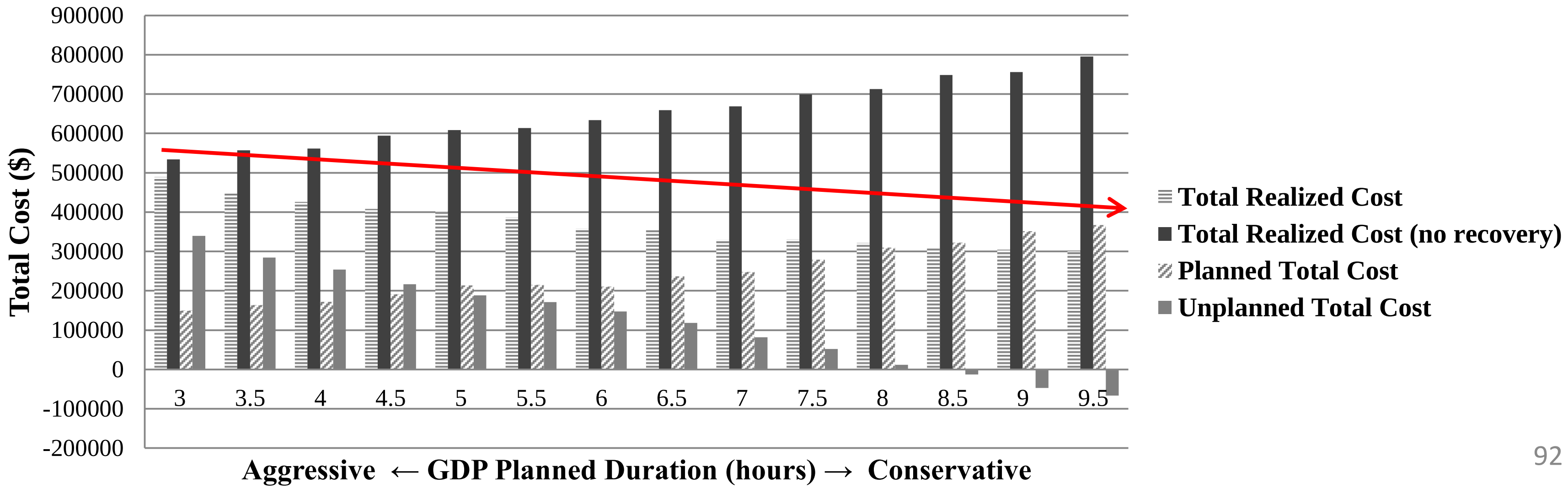
Revealing Airline's Preference

Airline	# Impacted Operations	# Fleet Types (# Aircraft in Each Category)	# Impacted Passengers	% Connecting Passengers	Average Load Factor
United & SkyWest	359	10 (17,4,8,3,9,1,3,7,5,27)	24236	32.33%	75.29%

extremely large number of total operations, multiple different fleet type

great flexibility for recovery
(reduces 62.3% cost through recovery at most)

total cost trend: preference for conservative design (longer planned duration)



Revealing Airline's Preference

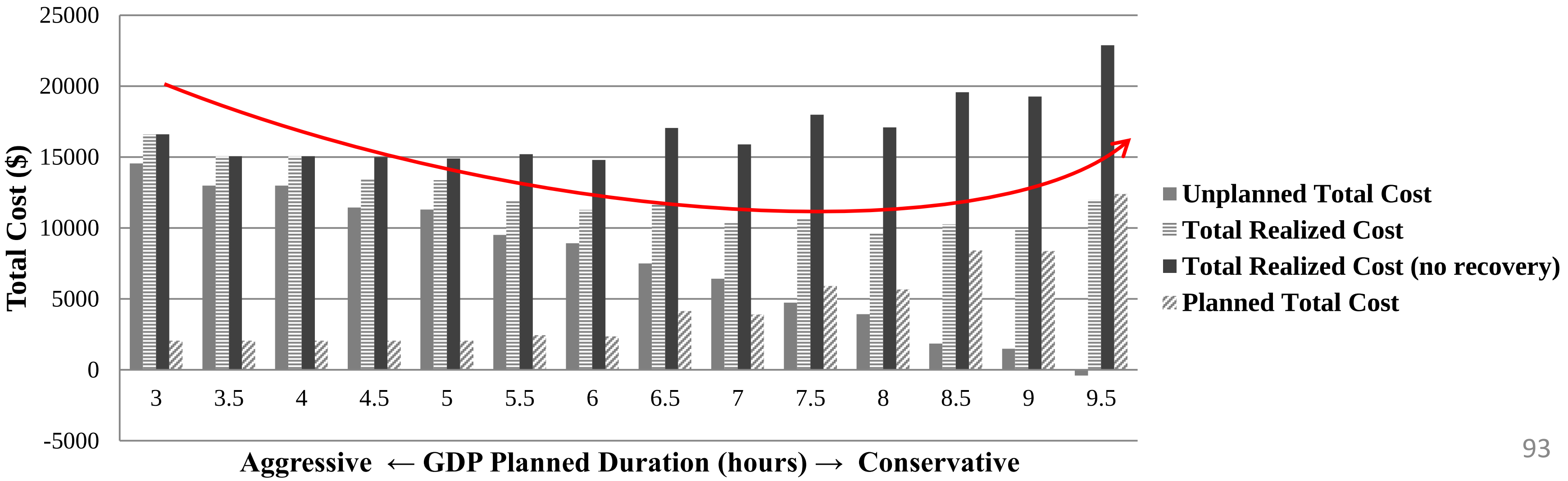
Airline	# Impacted Operations	# Fleet Types (# Aircraft in Each Category)	# Impacted Passengers	% Connecting Passengers	Average Load Factor
AirTran Airways	8	1 (4)	973	32.58%	82.32%

small number of total operations, single fleet type

⇩

great flexibility for recovery
(reduces 47.6% cost through recovery at most)

total cost trend: preference for conservative design (longer planned duration)



NAS-wide Benefits Assessment

Preference Category	Airline - GDP Cost Matrix	Aggressive Design ← GDP Planned Duration (hours) → Conservative Design													
		3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5
Moderate	**American & American Eagle**	141340	124389	123490	117142	***112998***	125420	115407	128040	127462	126762	128174	130014	129585	134946
Aggressive	**Frontier**	***60362***	76148	66946	81898	82396	83363	85580	88988	91783	89850	101507	94825	106871	105891
Aggressive	**US Airways**	***83058***	84186	85994	87735	90695	90418	96115	89400	95663	95637	101711	104089	105107	106905
Aggressive	**Continental & ExpressJet**	34152	37247	37844	***33511***	36526	33968	39176	37459	39935	40162	41300	43174	44005	47296
Moderate	**JetBlue**	9705	9849	10766	8939	8252	7983	***7577***	8367	7707	8563	9446	10863	13090	15468
Moderate	**Delta**	36256	35408	34897	34846	34860	***34132***	35880	34732	35531	35773	38467	39139	41918	43874
Conservative	**AirTran**	16600	15049	15050	13499	13363	11954	11280	11651	10338	10645	***9592***	10268	9864	12001
Aggressive	**Northwest**	***22247***	36705	32657	31738	31265	34185	34704	32411	36074	36831	36690	40855	40764	40228
Conservative	**United & SkyWest**	489250	448340	426198	408230	402122	386515	357885	354516	330232	330824	322038	309187	304852	***300218***
Moderate	**Alaska**	41167	35758	35713	***32724***	35337	37002	34810	36539	34573	36305	36882	37731	38215	38301
Moderate	**NAS wide**	934137	903079	869554	850262	847815	844941	818413	822104	***809297***	811352	825808	820144	834271	845128
Conservative	**Centralized Objective**	244986	235343	226604	221638	214614	210056	202624	201951	196292	189613	***188450***	195662	209204	220389

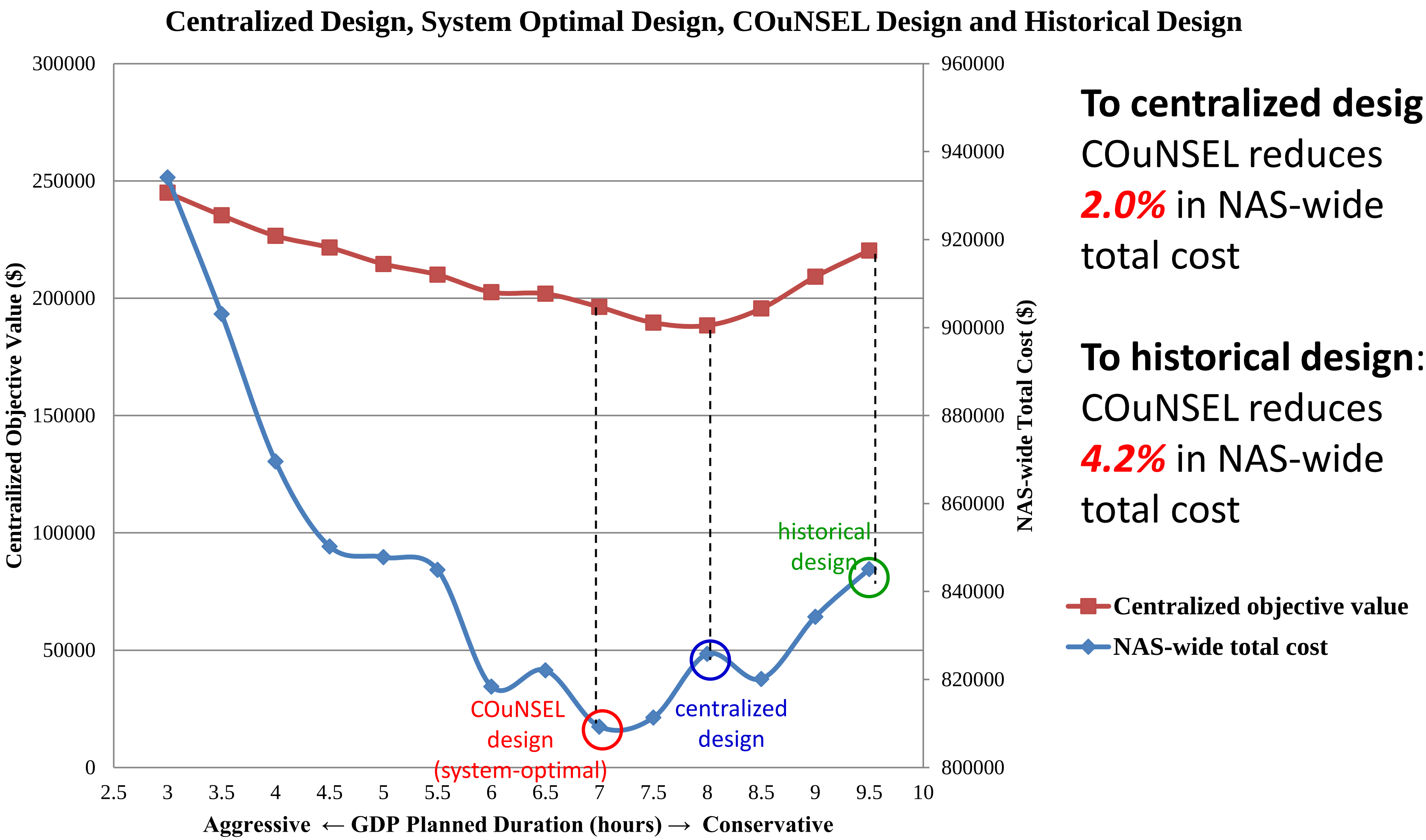
NAS-wide Benefits Assessment

Linearly transform costs into 100-scale grades…

Airline - GDP Grade Matrix	**# impacted operation**	**weights**	**Aggressive Design ← GDP Planned Duration (hours) → Conservative Design**													
			3	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	7	**7.5**	**8**	**8.5**	**9**	**9.5**
American & American Eagle	70	17.97	80	91	92	96	100	90	98	88	89	89	88	***87***	***87***	***84***
Frontier	15	6.30	100	79	90	74	73	72	71	68	66	67	59	64	56	57
US Airways	40	12.28	100	99	97	95	92	92	86	93	87	87	82	80	79	78
Continental & ExpressJet	30	10.1	98	90	89	100	92	99	86	89	84	83	81	78	76	71
JetBlue	9	4.45	78	***77***	***70***	85	92	95	100	91	98	88	80	70	58	49
Delta	26	9.16	94	96	98	98	98	100	95	98	96	95	***89***	87	81	78
AirTran	8	4.11	58	64	64	71	72	80	85	82	93	***90***	100	93	97	80
Northwest	23	8.43	100	61	68	70	71	65	64	69	62	60	61	54	55	55
United & SkyWest	359	54.63	61	67	70	***74***	***75***	***78***	***84***	***85***	***91***	91	93	97	98	100
Alaska	25	8.92	***79***	92	92	100	93	88	94	90	95	90	89	87	86	85

Majority judgement winner coincides with system-optimal design!!

NAS-wide Benefits Assessment



To centralized design: COuNSEL reduces ***2.0%*** in NAS-wide total cost

To historical design: COuNSEL reduces ***4.2%*** in NAS-wide total cost

NAS-wide Benefits Assessment

To centralized design: COuNSEL reduces total ground delay by ***9.8%***, total passenger delay by ***3.3%***. It increases total airborne delay from 214 minutes to 318 minutes. On a per flight basis, from 0.95 minutes/flight to 1.46 minutes/flight.

To historical design: COuNSEL reduces ***22.8%*** total ground delay, ***13.7%*** total passenger delay, while only inducing an airborne delay of 1.46 minutes/flight

NAS performance is improved by being operated slightly aggressive!

	GDP Planned Duration (hours)	NAS wide Total Cost ($)	Total Ground Delays (minutes)	Total Airborne Delay (minutes)	Average Ground Delay per Flight (minutes)	Average Airborne Delay per Flight (minutes)	# Disrupted Passengers	Total Passenger Delay (minutes)
	3	934137	2337	422	10.40	1.87	674	480618
	3.5	903079	2835	432	12.62	1.92	725	469141
	4	869554	3012	403	13.41	1.79	679	467044
	4.5	850262	3269	386	14.56	1.71	681	456964
	5	847815	3589	382	15.98	1.70	685	453177
	5.5	844941	3857	376	17.18	1.67	674	458074
	6	818413	4090	371	18.21	1.65	671	459613
	6.5	822104	4429	358	19.72	1.59	673	472420
COuNSEL design	7	809297	4607	328	20.52	1.46	668	480232
	7.5	811352	4748	257	21.14	1.14	678	485759
centralized design	8	825808	5105	214	22.73	0.95	673	496769
	8.5	820144	5546	123	24.70	0.54	646	520816
	9	834271	5690	85	25.34	0.37	667	531846
historical design	9.5	845128	5970	0	26.59	0	662	556366

Assessment Results

- Compared to centralized design COuNSEL produces more equitable GDP design.
- Compared to system optimal design COuNSEL produces the same level of equity.

Airline	Cost under Preferred Design	Cost under COuNSEL Design	Percentage Increment (COuNSEL)	Cost under Centralized Design	Percentage Increment (Centralized)
American & American Eagle	112998	127462	11.35%	128174	11.84%
Frontier	60362	91783	34.23%	101507	40.53%
US Airways	83058	95663	13.18%	101711	18.34%
Continental & ExpressJet	33511	39935	16.09%	41300	18.86%
JetBlue	7577	7707	1.69%	9446	19.79%
Delta	34132	35531	3.94%	38467	11.27%
AirTran	9592	10338	7.22%	9592	0.00%
Northwest	22247	36074	38.33%	36690	39.36%
United & SkyWest	300218	330232	9.09%	322038	6.78%
Alaska	32724	34573	5.35%	36882	11.27%
		Standard Deviation	11.88%	**Standard Deviation**	12.44%

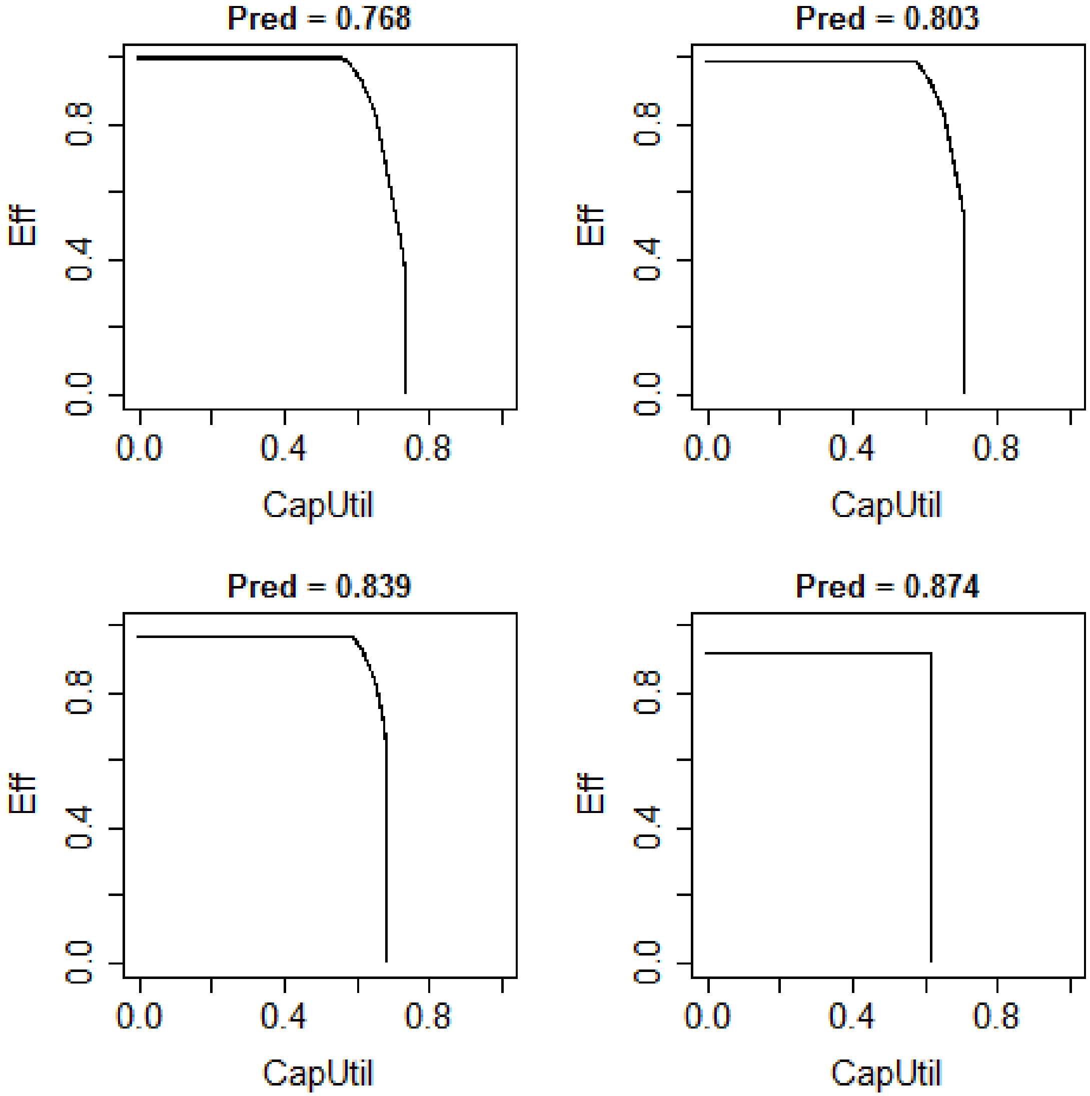
User Support Tools

- Various user support tools are developed to help airlines and FAA make corresponding decisions under SLE framework.
  - SLE metrics tradeoff curves
  - SLE metrics to TMI parameters mapping
  - SLE metrics to airline performance mapping

User Support Tool #1: SLE Metric Tradeoff Curves

- Each slide gives four tradeoff curves showing the tradeoff between two SLE metrics for four values of the third SLE metric.

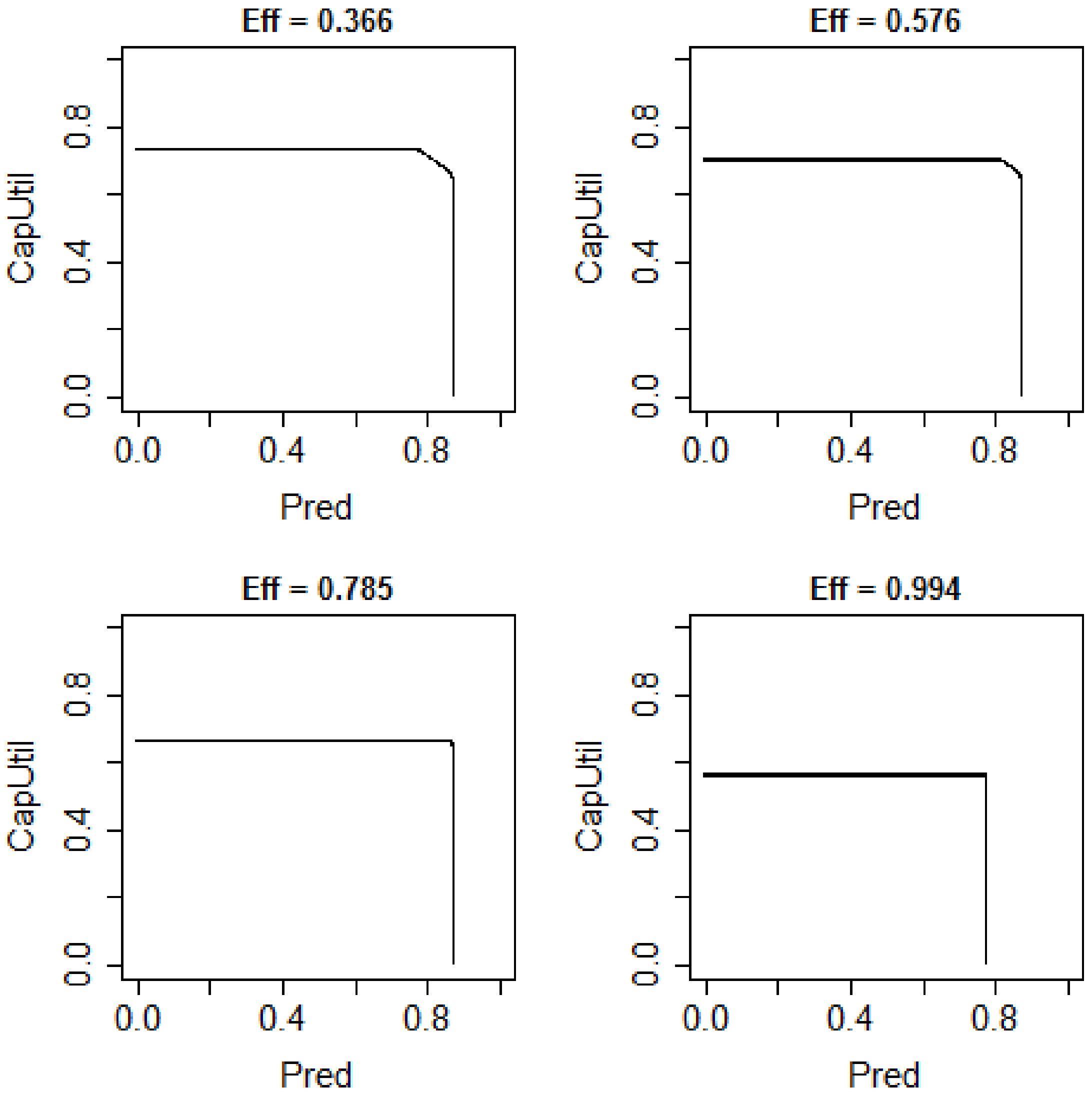
Efficiency vs Capacity Utilization Tradeoff



Eff vs CapUtil
for Pred =

.768
.803
.839
.874

Capacity Utilization vs Predictability Tradeoff



CapUtil vs Pred for Eff =

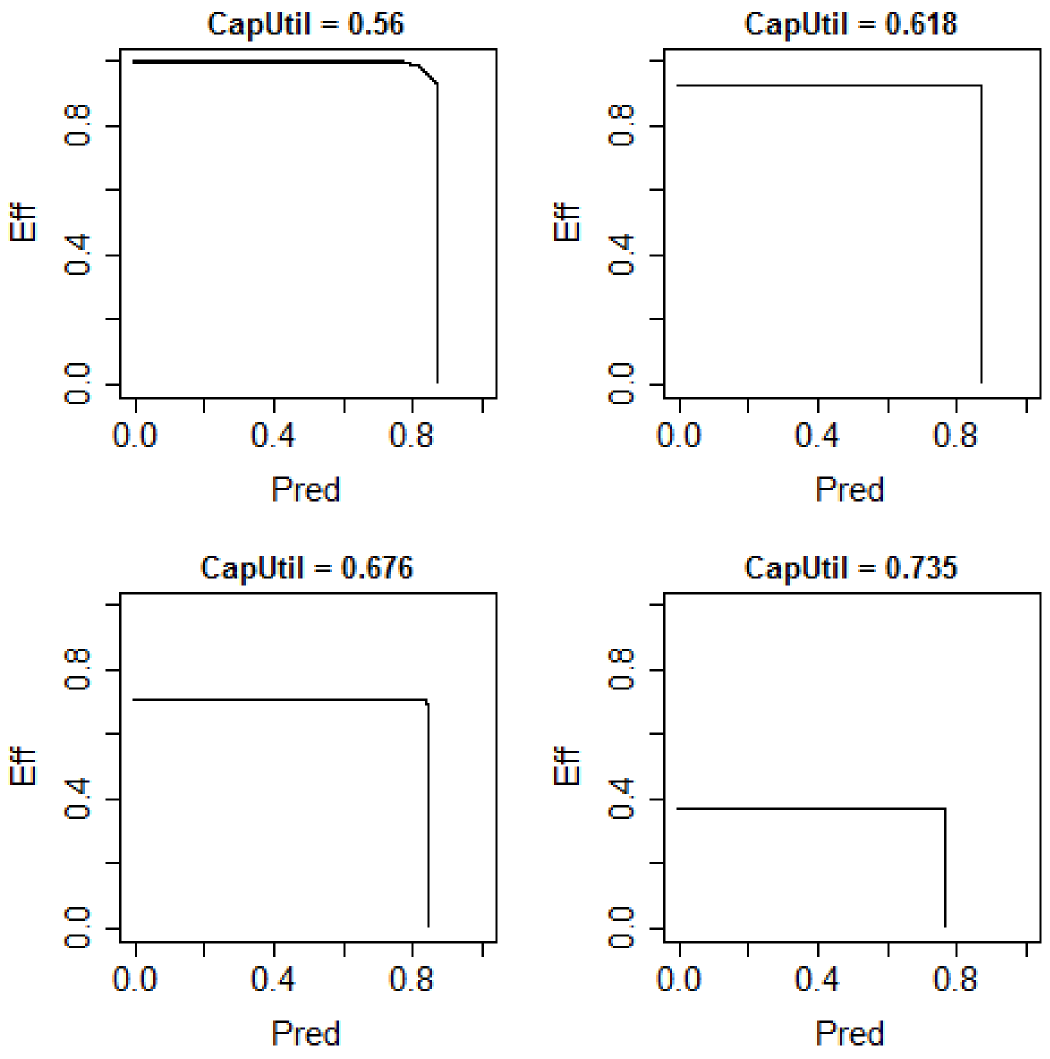
.366

.576

.785

.994

Efficiency vs Predictability Tradeoff



Eff vs Pred for CapUtil =

.56

.618

.676

.735

User Support Tool #2: SLE Vectors to TMI Parameters Mapping

- For the FAA traffic managers and for each scenario a mapping is given from a set of SLE metric vectors to corresponding TMI plans/parameters.

Goal Vectors to TMI Parameters Mapping (Use GDP as an example)

- Goals: capacity utilization, efficiency, predictability
- GDP parameters: start time, end time, planned called rates

Goal vectors			**TMI parameters**						
			Planned start time	**planned end time**	**Called rates(arrivals per quarter hour)**				
Capacity utilization	**Efficiency**	**Predictability**			11:00-11:15	11:15-11:30	11:30-11:45	…	22:45-23:00
0.651	0.839	0.869	11:15:00	0:45:00	8	8	8	…	8
0.614	0.894	0.836	13:04:00	1:31:40	10	10	9	…	7
0.668	0.665	0.854	13:05:00	0:23:20	9	9	8	…	8
0.617	0.934	0.875	11:30:00	1:26:40	8	8	8	…	8
0.615	0.927	0.880	11:15:00	1:28:07	8	8	8	…	8
0.582	0.982	0.822	11:15:00	2:18:45	8	8	8	…	8
0.647	0.770	0.843	12:56:00	0:25:30	9	9	9	…	9
0.560	0.994	0.769	10:30:00	3:01:52	8	7	7	…	7
0.735	0.349	0.765	13:37:00	22:06:00	10	13	13	…	9
0.610	0.943	0.867	11:45:00	1:35:37	9	9	8	…	8
0.718	0.471	0.795	13:20:00	22:36:40	10	10	9	…	9
0.671	0.629	0.840	11:15:00	0:16:52	8	8	8	…	8
0.617	0.918	0.873	12:20:00	1:25:00	9	9	8	…	8
0.658	0.777	0.865	11:45:00	0:36:00	9	9	8	…	8

User Support Tool #3: SLE Vectors to User Performance Indicator Mapping

- For each flight operator and for each scenario a mapping is given from a sample of SLE metric vectors to user performance indicators.

SLE Vectors to User Performance Indicator Mapping: American Airlines

- American Airline: with 89 total impacted flights, 9863 impacted passengers
- With great recovery capability, it prefers low capacity-high efficiency GDP design
- Total operating cost includes: 1) flight delay cost (fuel and other aircraft operating cost)
  2) passenger delay cost

Cap.	Eff.	Pred.	Expected Total Operating Cost ($1,000)	Num of Cancellations	Expected Ground Delay Minute	Expected Airborne Delay Minute	Expected Passenger Total Delay Minute	Expected Delay Minute per Nondisrupted Passenger	Expected Num of Disrupted Passengers
0.996	0.484	0.791	727	0	2,852	320	451,228	47.3	261
0.992	0.529	0.796	748	0	3,073	337	462,632	48.5	267
0.989	0.571	0.798	754	0	3,011	345	485,702	50.8	245
0.984	0.610	0.798	730	0	3,013	217	471,783	49.4	254
0.970	0.705	0.789	726	0	3,708	295	430,993	45.2	290
0.964	0.731	0.784	744	0	3,794	288	466,915	48.9	275
0.959	0.753	0.777	669	2	3,395	221	382,214	40.0	276
0.942	0.798	0.752	695	2	3,780	261	418,667	43.8	270
0.931	0.812	0.731	621	0	4,869	265	487,811	50.6	209
0.926	0.814	0.720	603	0	4,810	255	479,422	49.6	190
0.921	0.813	0.708	600	0	4,820	239	463,497	48.1	205
0.917	0.814	0.696	571	0	4,970	120	461,740	47.8	187
0.912	0.814	0.683	611	2	3,972	155	379,071	39.5	264
0.908	0.815	0.670	576	2	4,273	128	386,789	40.1	226
0.904	0.815	0.656	566	2	4,250	91	382,581	39.8	250
0.900	0.816	0.643	528	0	5,102	50	440,946	45.5	174
0.899	0.816	0.639	570	2	4,809	20	397,665	41.3	231

Conclusion

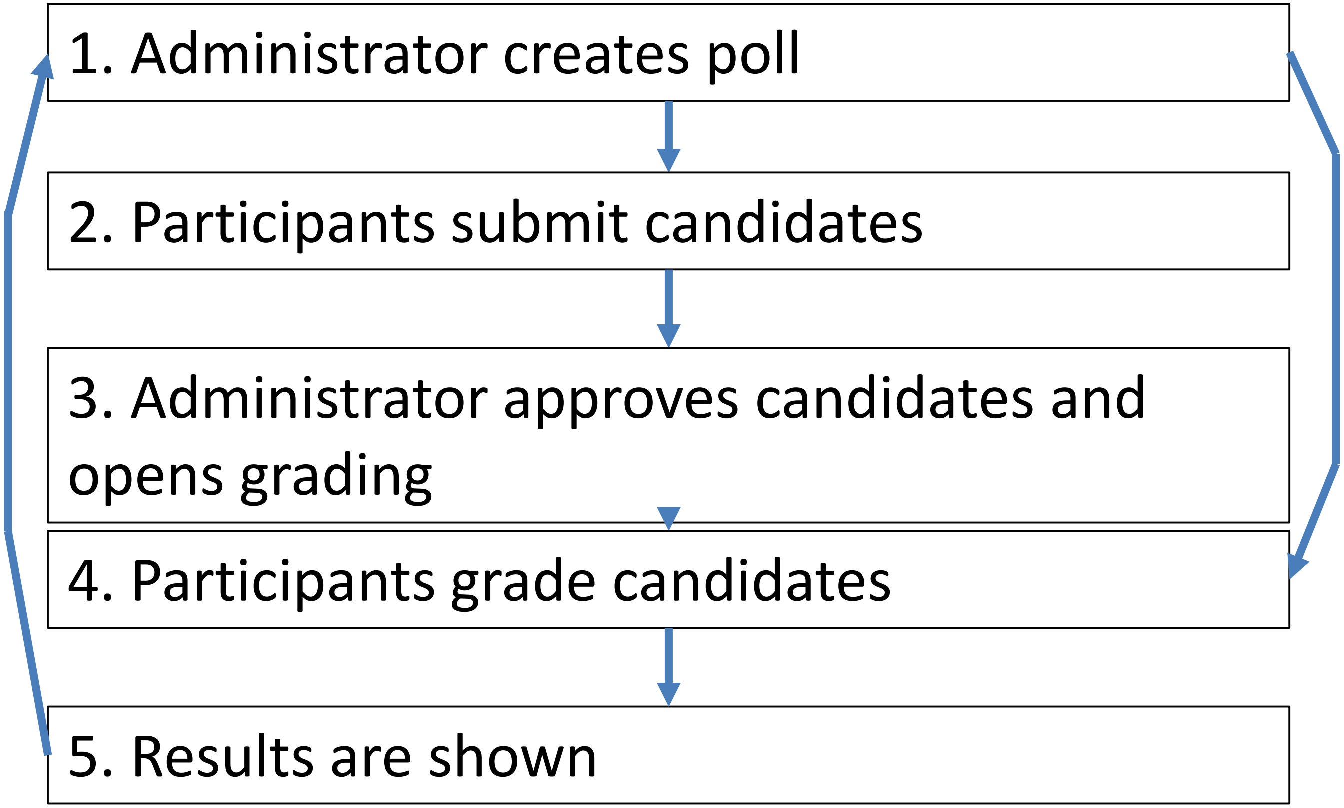
- In most of the cases, COuNSEL has the capability to reduce system-wide total delay cost, and produce more equitable design.
- COuNSEL leads to a better economic performance for the airlines and fairer distribution of outcomes among different airlines.

Topic 6: COuNSEL Software Tool

Software Tool

- Users are divided into administrators and participants
- Administrators create polls, approve submissions and can view detailed submission results
- Participants submit candidates, rank candidates and can view only the winning vector

Process



1. Administrator creates poll

2. Participants submit candidates

3. Administrator approves candidates and opens grading

4. Participants grade candidates

5. Results are shown

Necessary Inputs

- The following inputs will be required for each poll:
  - User Accounts: each participants must have an account
  - Group: participants are organized into groups
  - Metric table: a table of constraints defining the feasible set of candidates
  - Weight set: an assignment of weights to the participants

Groups

- Individuals are organized into groups
- When you make a poll, you need to create a group for that poll which contains the users that will vote in that poll
- Individuals may belong to more than one group

Metric Table

- The metric table is a list of constraints which describe the feasible set of candidates.
- These constraints take the form

$$A1 * capacity + A2 * efficiency + A3 * predictability \ \leq B$$

where $A1, A2, A3$ and *B* are all positive numbers.

- This tool requires that these numbers be at least 0.0001

Weight Sets

- Weight sets describe how much weight is given to each user during voting
- Weights can be any positive number with at most two decimal place

Candidate Format

- In the software, candidates are represented as a three dimensional vector:

$$(capacity, efficiency, predictability)$$

- Each element of a candidate is usually represented as an integer percentage from 0 to 100
- Example: the candidate which achieves 50% capacity, 70% efficiency and 70% predictability is represented as

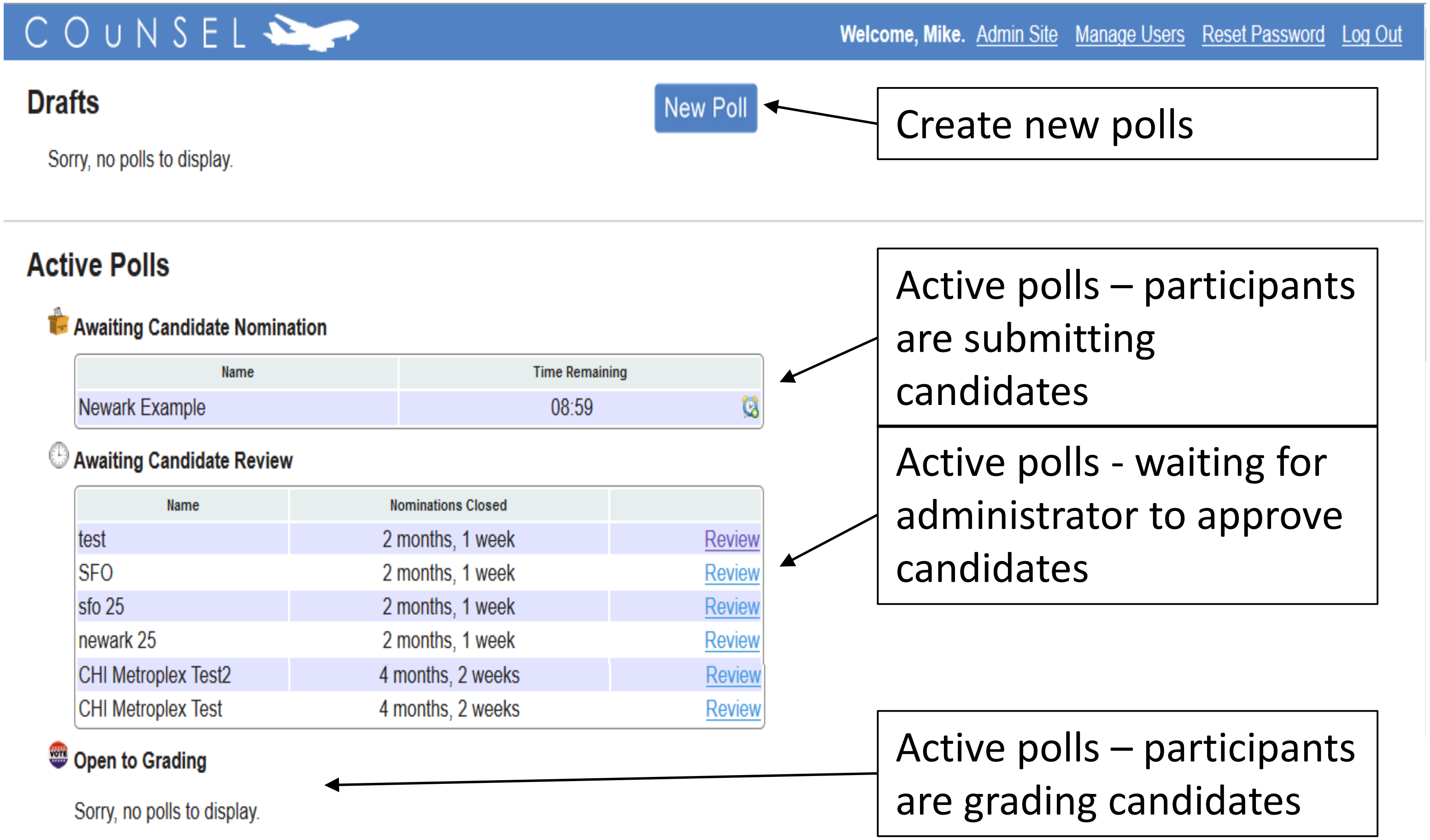
$$(50,70,70)$$

Candidate Format

- However, metric constraints are written in terms of decimal values instead of percentages
- Example: the constraint that the sum of the three metrics is no more than 200% for any candidate would be:

$$1 * capacity + 1 * efficiency + 1 * predictability \leq 2$$

Administrator Home Page



COUNSEL

Welcome, Mike. Admin Site Manage Users Reset Password Log Out

Drafts

Sorry, no polls to display.

Active Polls

Awaiting Candidate Nomination

Name	Time Remaining
Newark Example	08:59

Awaiting Candidate Review

Name	Nominations Closed	
test	2 months, 1 week	Review
SFO	2 months, 1 week	Review
sfo 25	2 months, 1 week	Review
newark 25	2 months, 1 week	Review
CHI Metroplex Test2	4 months, 2 weeks	Review
CHI Metroplex Test	4 months, 2 weeks	Review

Open to Grading

Sorry, no polls to display.

Create new polls

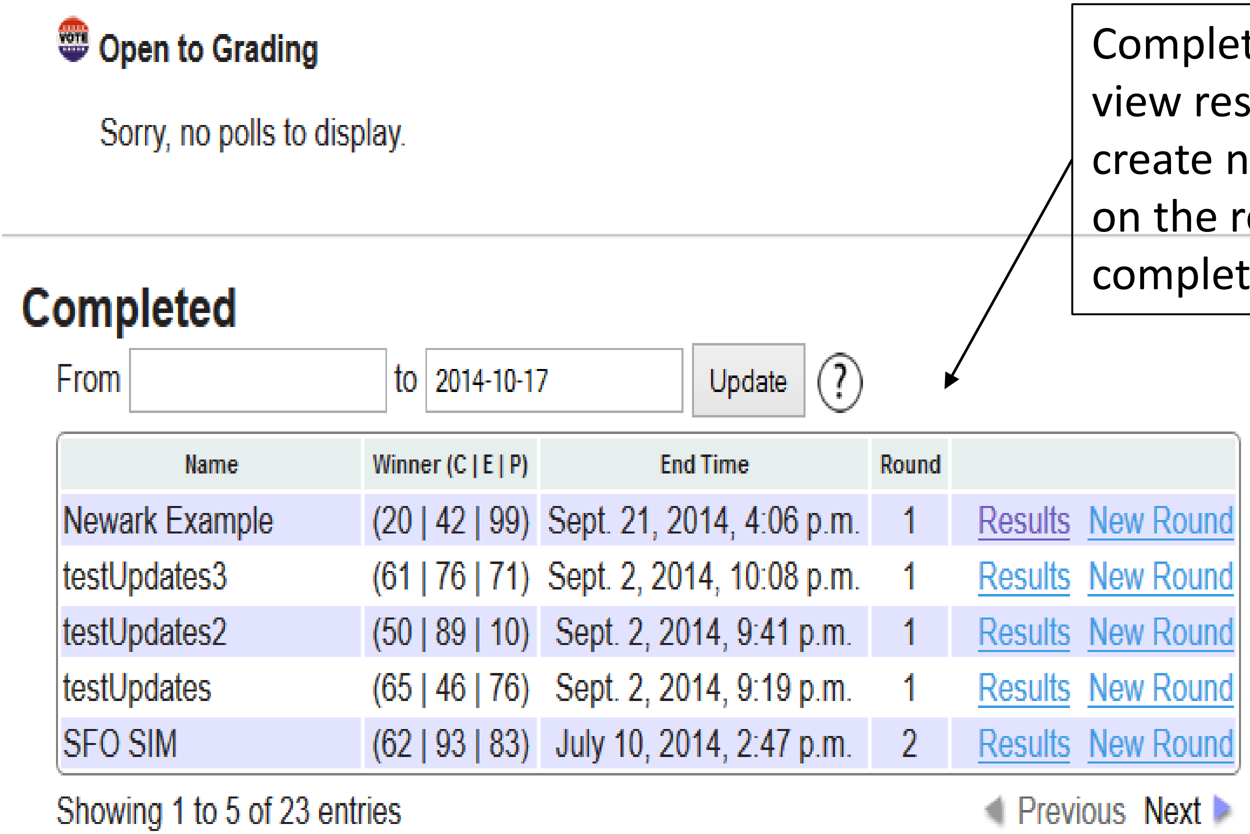
Active polls – participants are submitting candidates

Active polls - waiting for administrator to approve candidates

Active polls – participants are grading candidates

Administrator Home Page

Completed polls – can view results, or can create new polls based on the results of the completed poll



Open to Grading

Sorry, no polls to display.

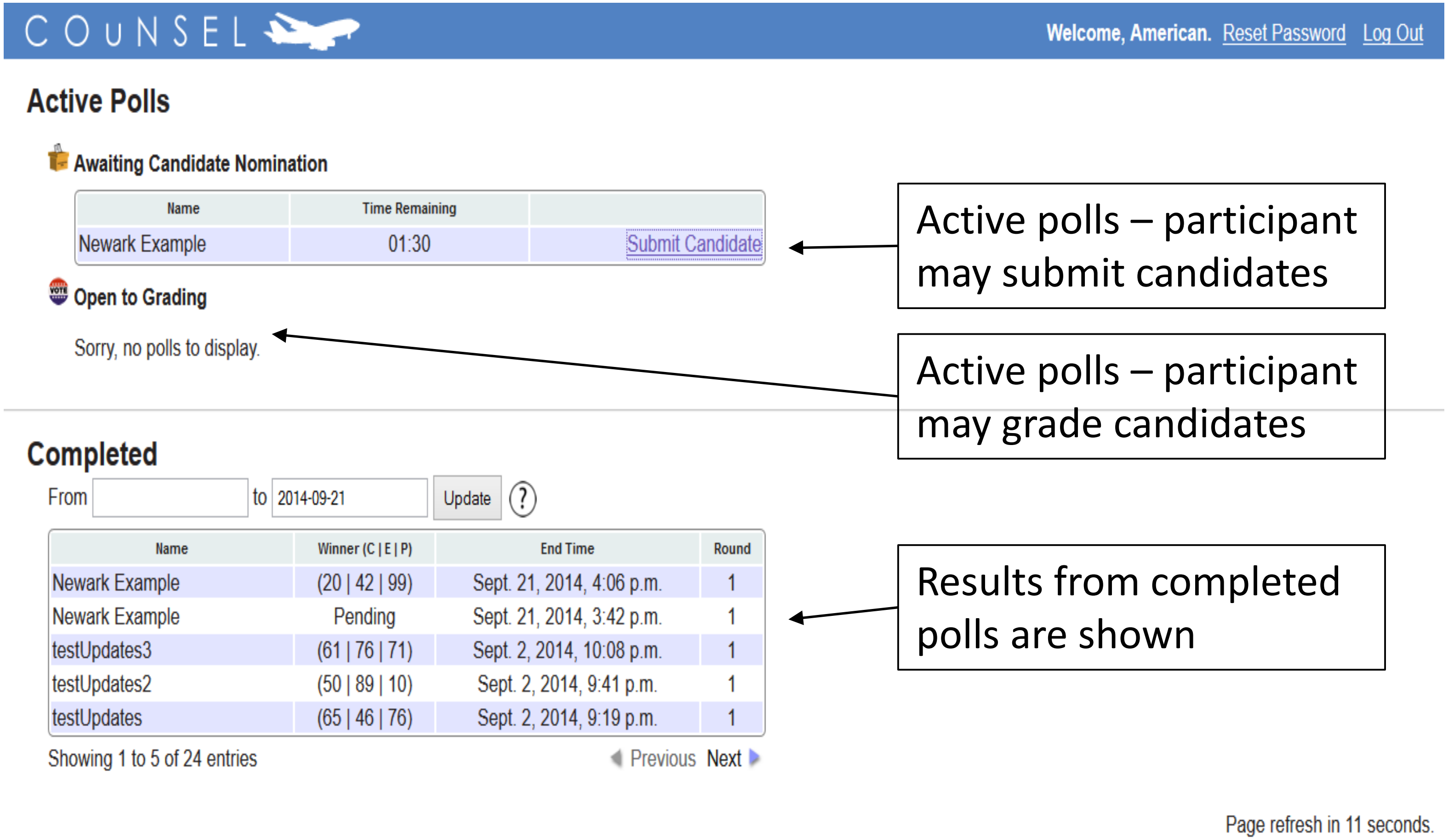
Completed

From ☐ to 2014-10-17 [Update] (?)

Name	Winner (C | E | P)	End Time	Round	
Newark Example	(20 | 42 | 99)	Sept. 21, 2014, 4:06 p.m.	1	Results New Round
testUpdates3	(61 | 76 | 71)	Sept. 2, 2014, 10:08 p.m.	1	Results New Round
testUpdates2	(50 | 89 | 10)	Sept. 2, 2014, 9:41 p.m.	1	Results New Round
testUpdates	(65 | 46 | 76)	Sept. 2, 2014, 9:19 p.m.	1	Results New Round
SFO SIM	(62 | 93 | 83)	July 10, 2014, 2:47 p.m.	2	Results New Round

Showing 1 to 5 of 23 entries

Participant home page



Active Polls

Awaiting Candidate Nomination

Name	Time Remaining	
Newark Example	01:30	Submit Candidate

Open to Grading

Sorry, no polls to display.

Completed

From ____ to 2014-09-21 Update ?

Name	Winner (C | E | P)	End Time	Round
Newark Example	(20 | 42 | 99)	Sept. 21, 2014, 4:06 p.m.	1
Newark Example	Pending	Sept. 21, 2014, 3:42 p.m.	1
testUpdates3	(61 | 76 | 71)	Sept. 2, 2014, 10:08 p.m.	1
testUpdates2	(50 | 89 | 10)	Sept. 2, 2014, 9:41 p.m.	1
testUpdates	(65 | 46 | 76)	Sept. 2, 2014, 9:19 p.m.	1

Showing 1 to 5 of 24 entries

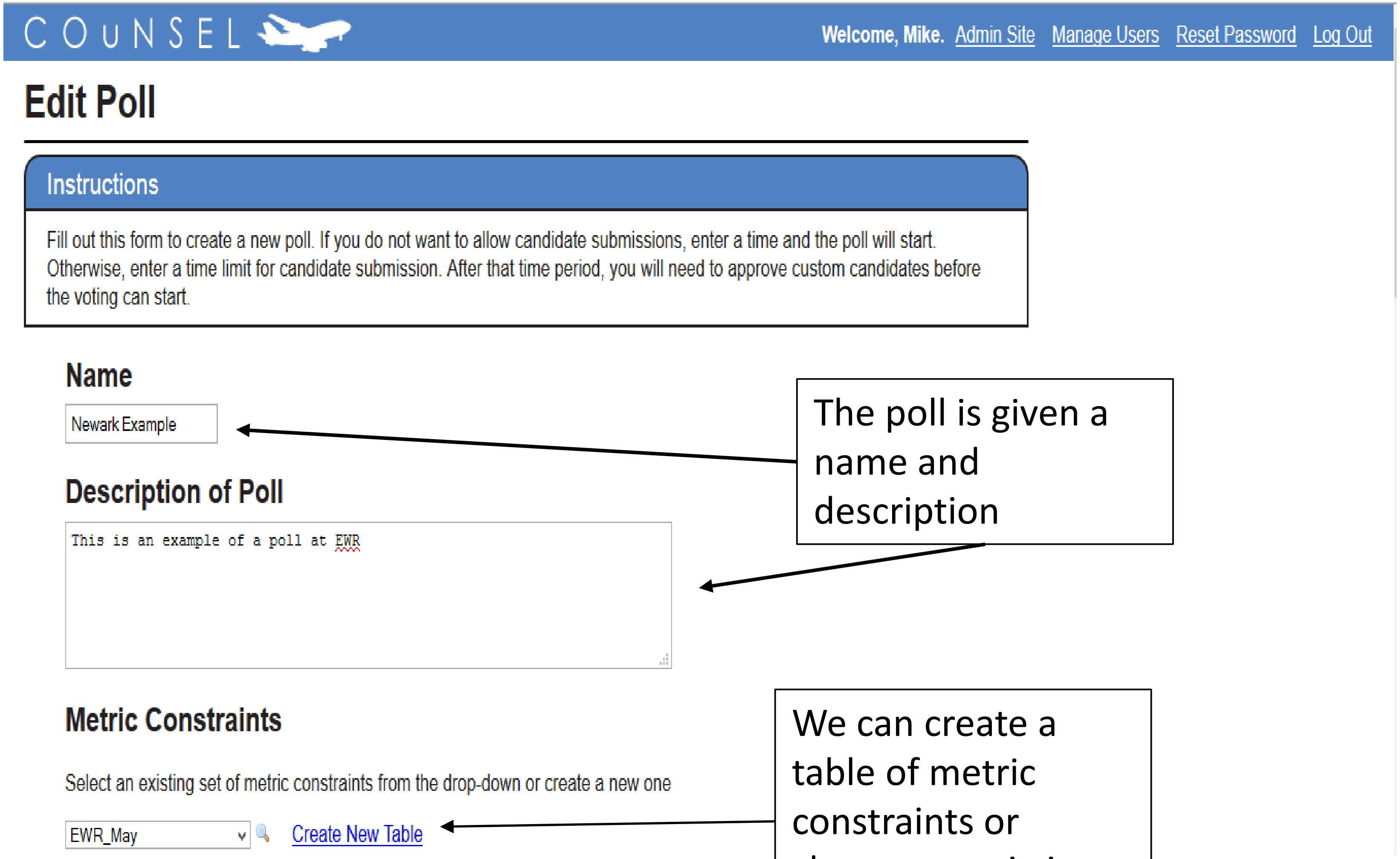
Page refresh in 11 seconds.

Active polls – participant may submit candidates

Active polls – participant may grade candidates

Results from completed polls are shown

Poll Creation - Administrator



Edit Poll

Instructions

Fill out this form to create a new poll. If you do not want to allow candidate submissions, enter a time and the poll will start. Otherwise, enter a time limit for candidate submission. After that time period, you will need to approve custom candidates before the voting can start.

Name

Newark Example

Description of Poll

This is an example of a poll at EWR

Metric Constraints

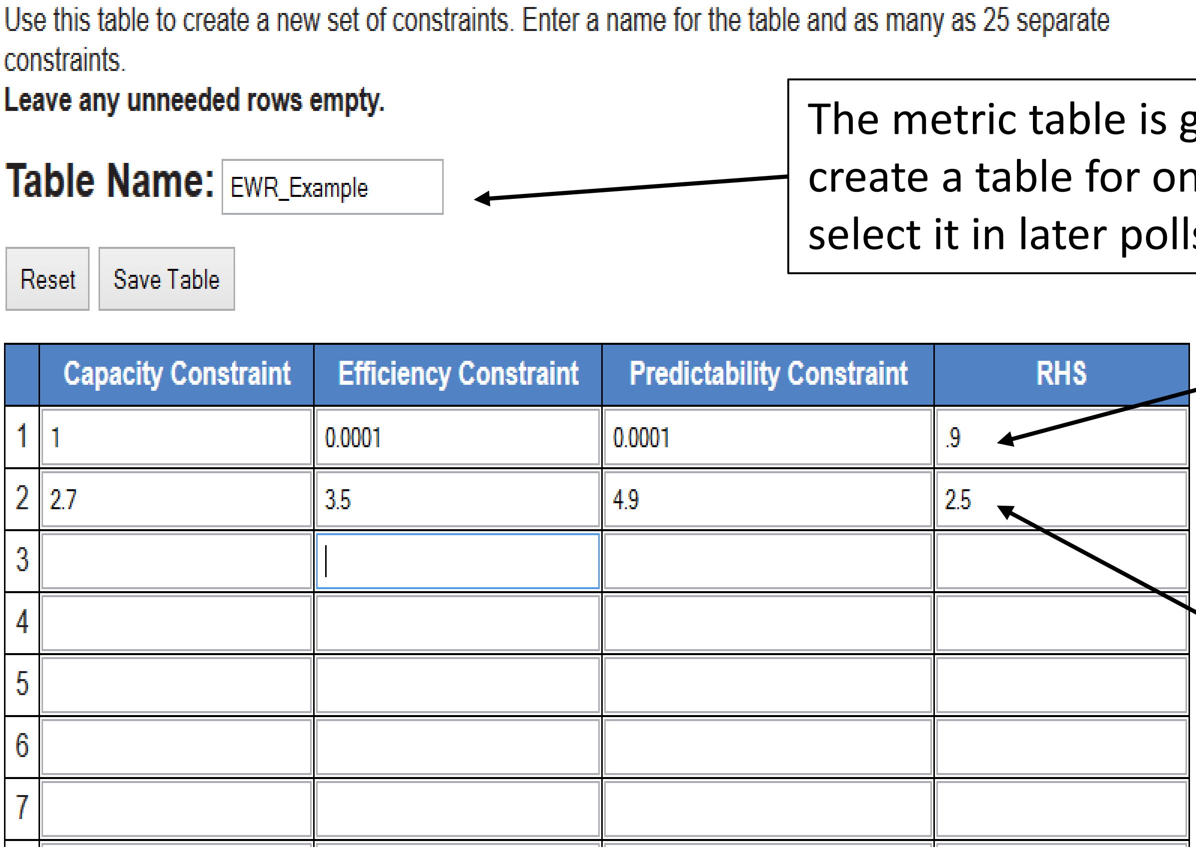
Select an existing set of metric constraints from the drop-down or create a new one

EWR_May

The poll is given a name and description

We can create a table of metric constraints or choose an existing table

Poll Creation - Administrator



Use this table to create a new set of constraints. Enter a name for the table and as many as 25 separate constraints.

Leave any unneeded rows empty.

Table Name: EWR_Example

	Capacity Constraint	Efficiency Constraint	Predictability Constraint	RHS
1	1	0.0001	0.0001	.9
2	2.7	3.5	4.9	2.5
3				
4				
5				
6				
7				

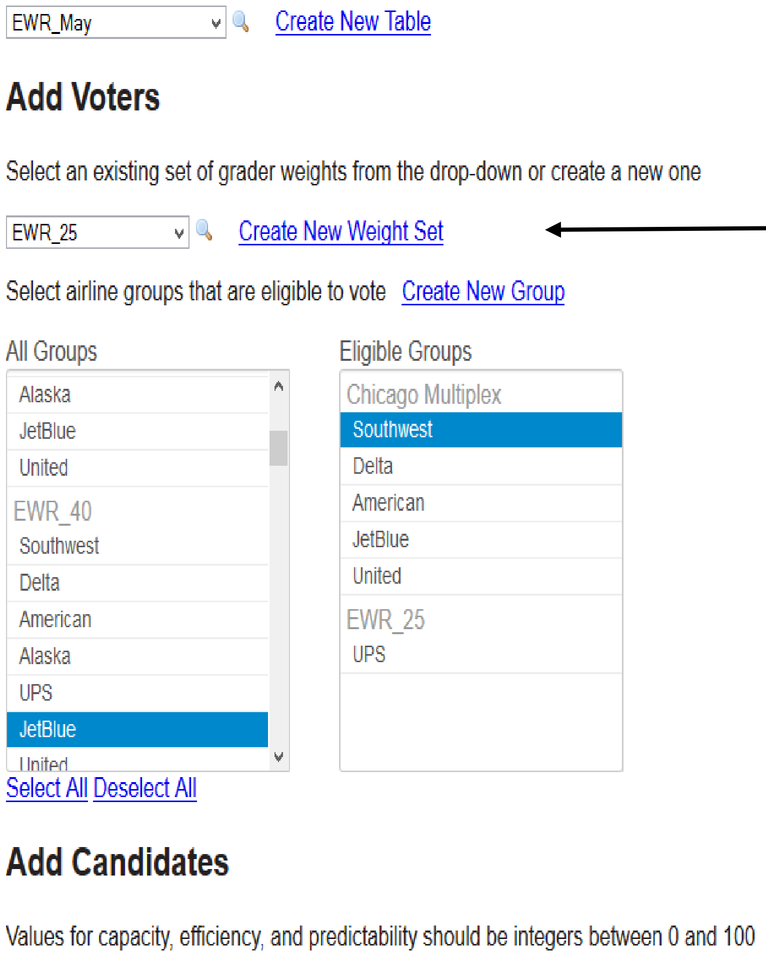
The metric table is given a name. After we create a table for one poll, we will be able to select it in later polls

Each line in this table is a constraint of the form

$$A * cap. + B * eff. + C * pred. = D$$

Every entry must have a value of at least 0.0001

Poll Creation - Administrator



EWR_May

Add Voters

Select an existing set of grader weights from the drop-down or create a new one

EWR_25

Select airline groups that are eligible to vote

All Groups
Alaska
JetBlue
United
EWR_40
Southwest
Delta
American
Alaska
UPS
JetBlue
United

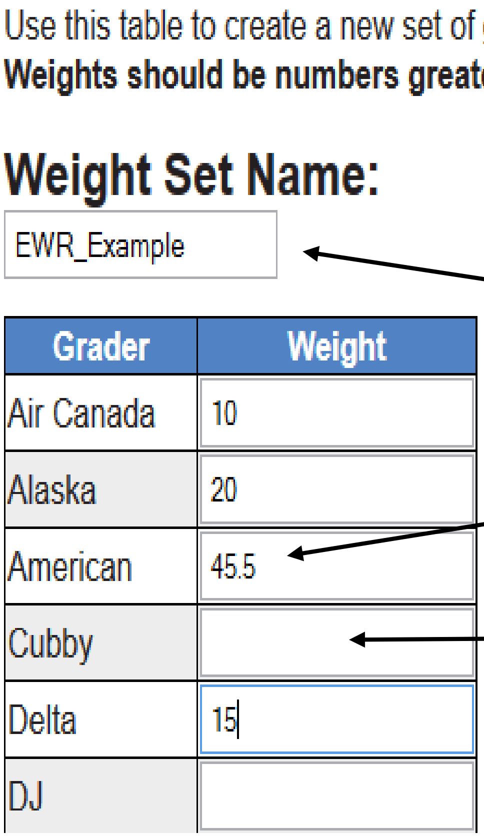
Eligible Groups
Chicago Multiplex
Southwest
Delta
American
JetBlue
United
EWR_25
UPS

Add Candidates

Values for capacity, efficiency, and predictability should be integers between 0 and 100

The set of weights of voters is specified

Poll Creation - Administrator



Use this table to create a new set of grader weights. Enter a name for the table and a weight for each grader.
Weights should be numbers greater than zero with up to two decimal places.

Weight Set Name:

EWR_Example

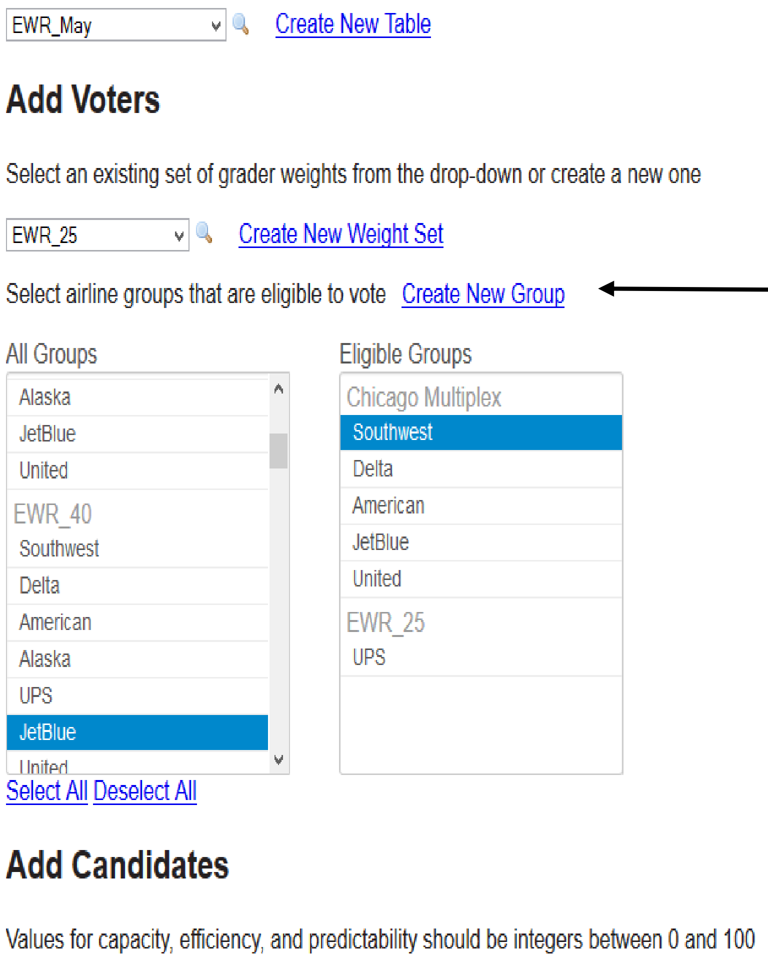
Grader	Weight
Air Canada	10
Alaska	20
American	45.5
Cubby	
Delta	15
DJ	

The set of weights is given a name. We will be able to select this set in future polls.

Weights can be any positive number with up to two decimal places

If a user is not voting in our poll, we leave the entry blank

Poll Creation - Administrator



EWR_May ⌄ 🔍 Create New Table

Add Voters

Select an existing set of grader weights from the drop-down or create a new one

EWR_25 ⌄ 🔍 Create New Weight Set

Select airline groups that are eligible to vote Create New Group

All Groups	Eligible Groups
Alaska	Chicago Multiplex
JetBlue	Southwest
United	Delta
EWR_40	American
Southwest	JetBlue
Delta	United
American	EWR_25
Alaska	UPS
UPS	
JetBlue	
United	

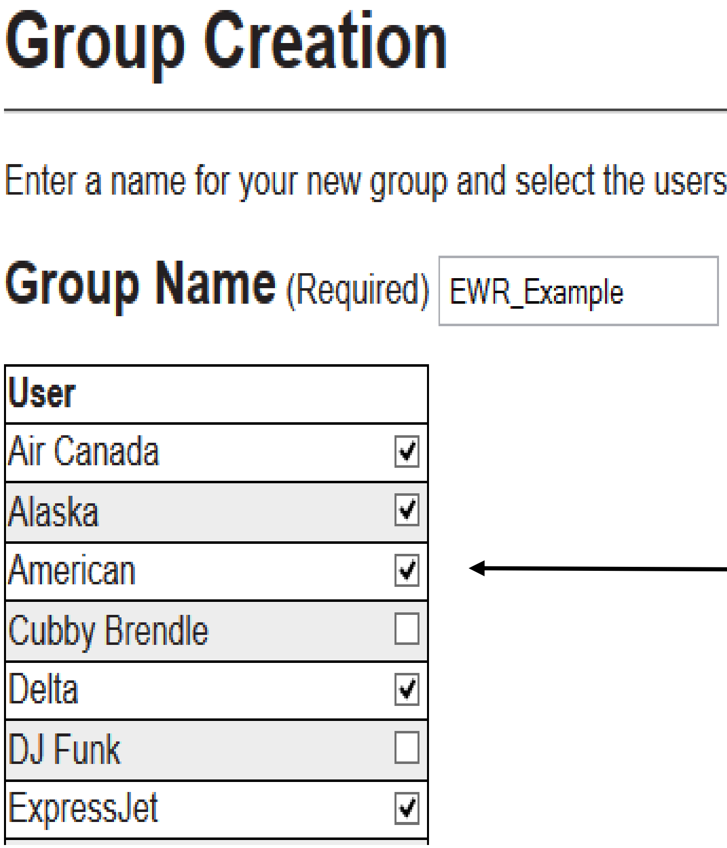
Select All Deselect All

Add Candidates

Values for capacity, efficiency, and predictability should be integers between 0 and 100

We create a group of users for the poll or select an existing group

Poll Creation - Administrator



Group Creation

Enter a name for your new group and select the users you wish to add.

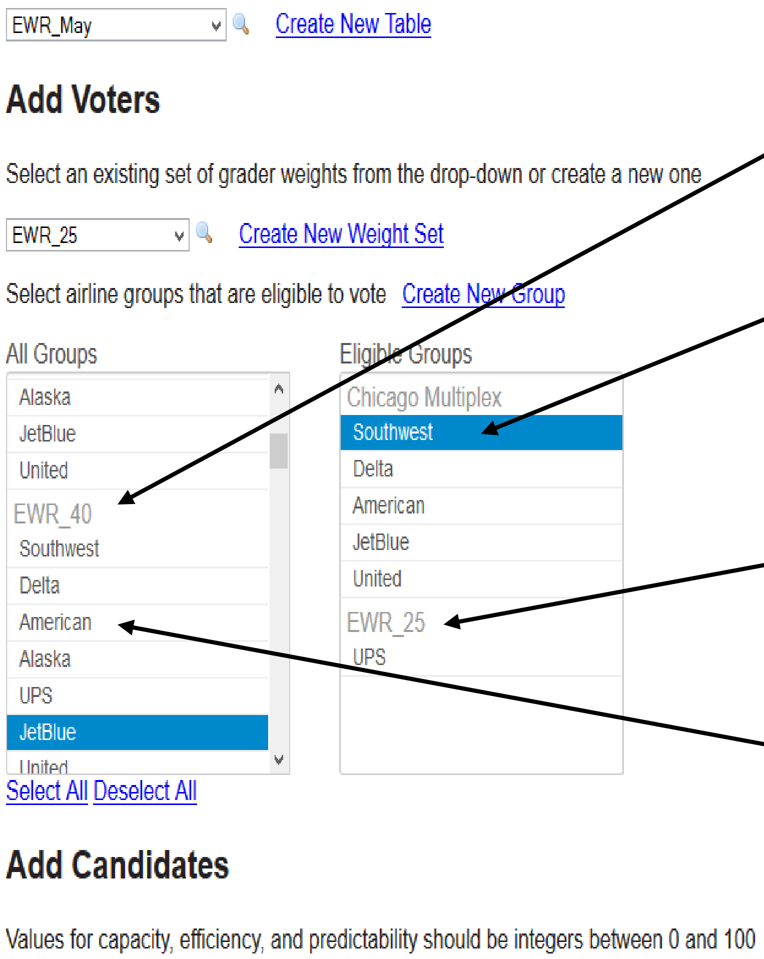
Group Name (Required) EWR_Example

User	
Air Canada	☑
Alaska	☑
American	☑
Cubby Brendle	☐
Delta	☑
DJ Funk	☐
ExpressJet	☑

The group is given a name. We will be able to select this group in future polls.

We select which users will be able to participate in our poll

Poll Creation - Administrator



EWR_May
Create New Table

Add Voters

Select an existing set of grader weights from the drop-down or create a new one

EWR_25
Create New Weight Set

Select airline groups that are eligible to vote Create New Group

Add Candidates

Values for capacity, efficiency, and predictability should be integers between 0 and 100

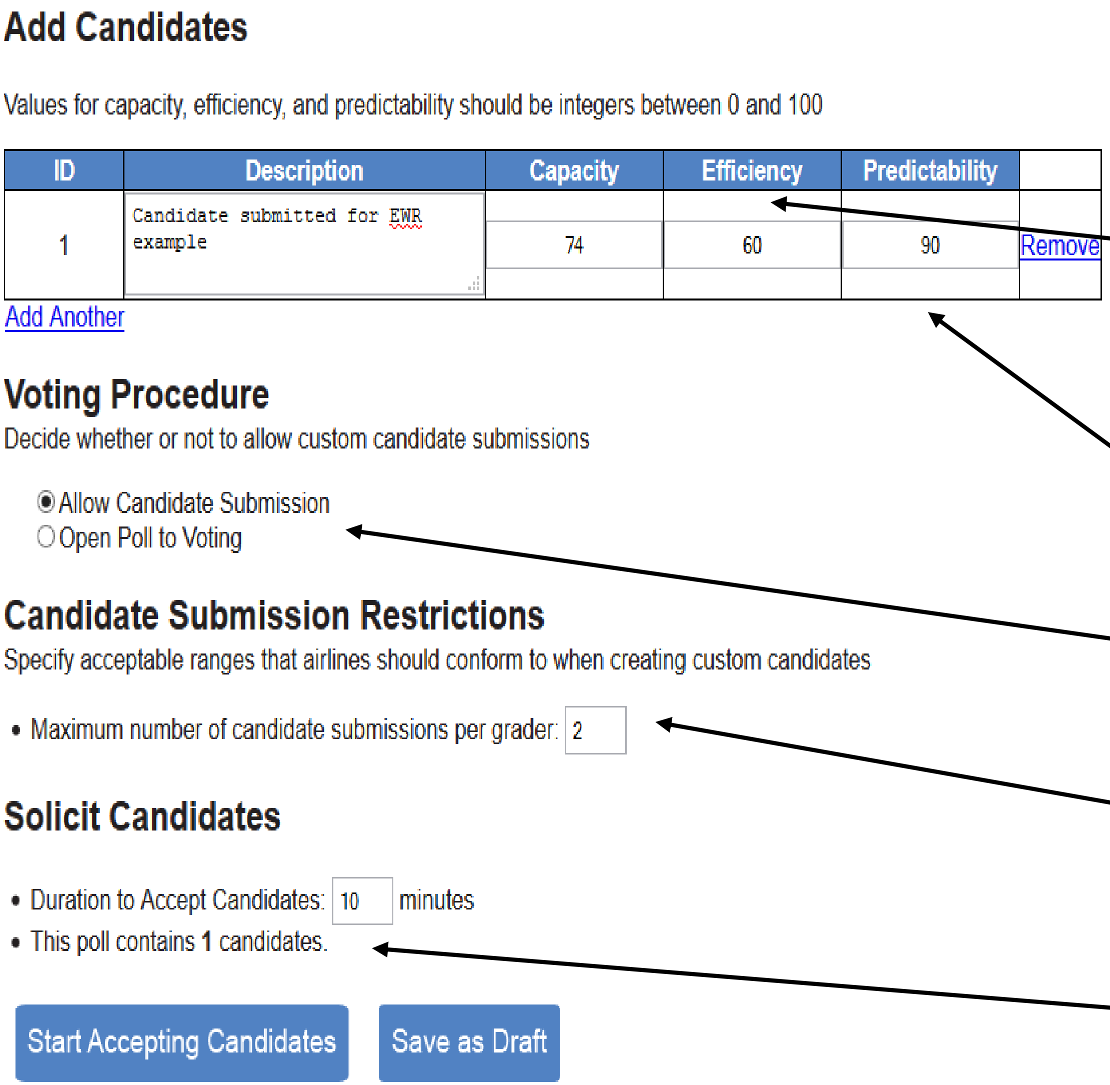
We click on a group to add the users in that group to our poll.

Eligible users will appear in the "Eligible Groups" section

Note: if an individual is in several groups, then they might be appear under a group other than the one we selected. This does not affect the functionality of the poll.

We can also select individuals one at a time

Poll Creation - Administrator



Add Candidates

Values for capacity, efficiency, and predictability should be integers between 0 and 100

ID	Description	Capacity	Efficiency	Predictability	
1	Candidate submitted for EWR example	74	60	90	Remove

Add Another

Voting Procedure

Decide whether or not to allow custom candidate submissions

● Allow Candidate Submission
○ Open Poll to Voting

Candidate Submission Restrictions

Specify acceptable ranges that airlines should conform to when creating custom candidates

- Maximum number of candidate submissions per grader: 2

Solicit Candidates

- Duration to Accept Candidates: 10 minutes
- This poll contains **1** candidates.

The administrator can choose to submit some candidates for grading. These should be feasible, but the software allows infeasible ones.

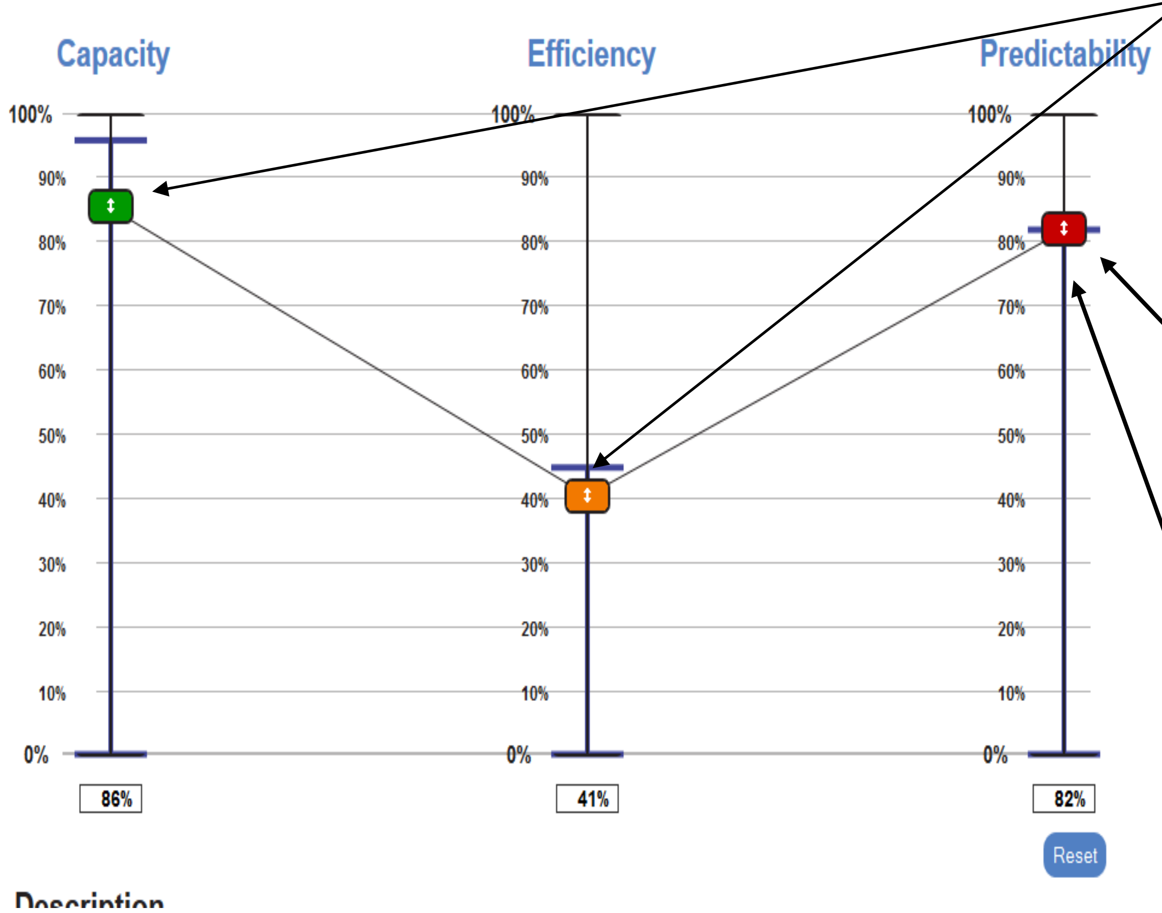
Each element of the candidate is an integer between 0-100

Choose whether to also allow participants submit candidates

Choose how many candidates each user may submit

Choose a time duration and then click the button to start accepting candidates

Candidate Submission - Participant

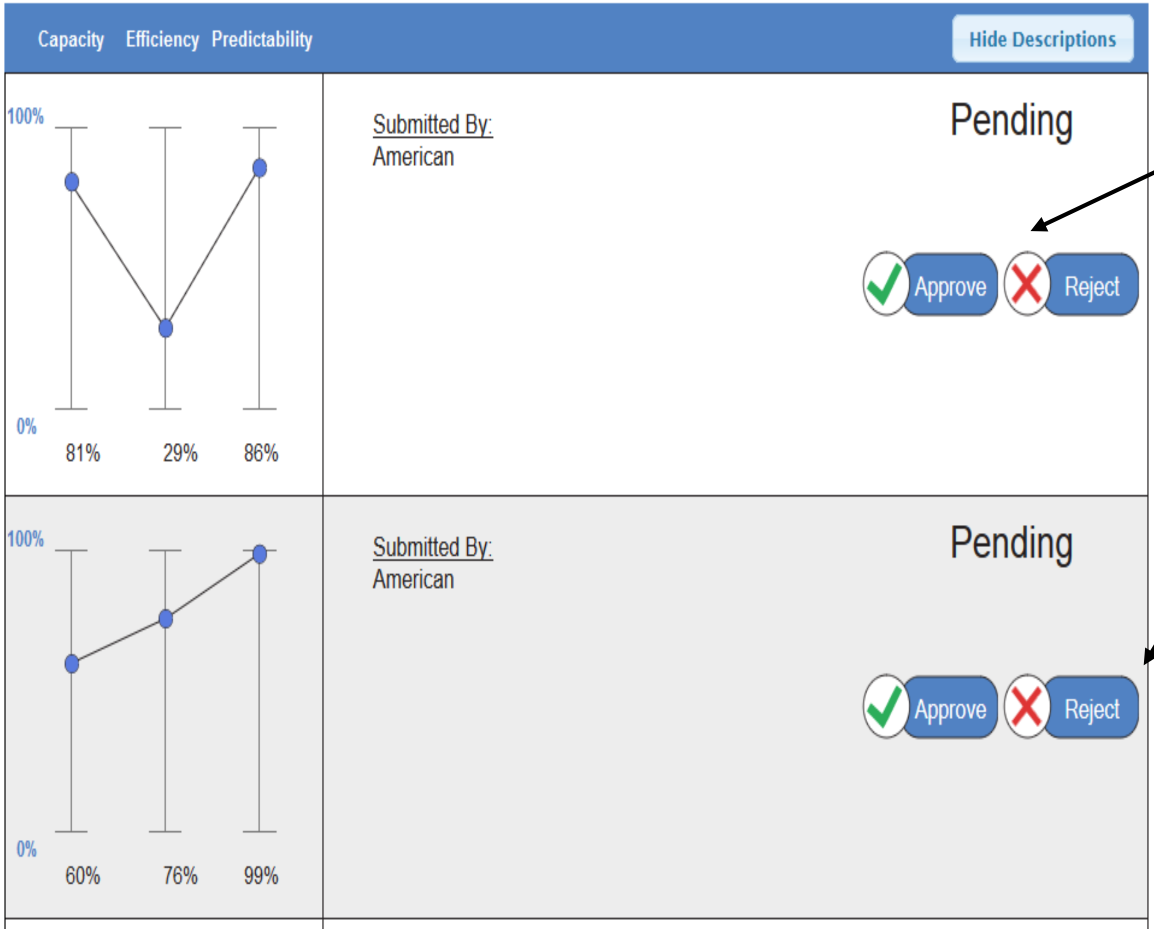


User uses sliders to set values of two parameters

Third slider set automatically to highest feasible value

Red color indicates that this slider was automatically set

Candidate approval - Administrator



Submitted By:
American

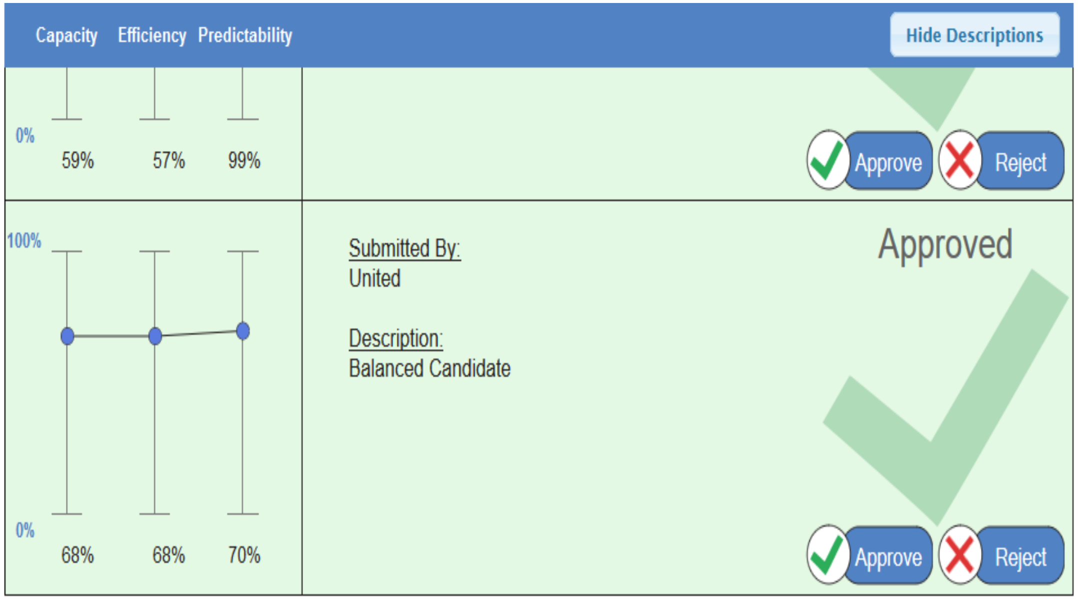
Pending

Submitted By:
American

Pending

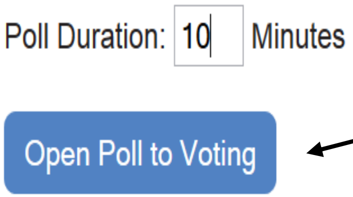
Administrator may approve or reject any submitted candidate

Candidate approval - Administrator



Submitted By:
United

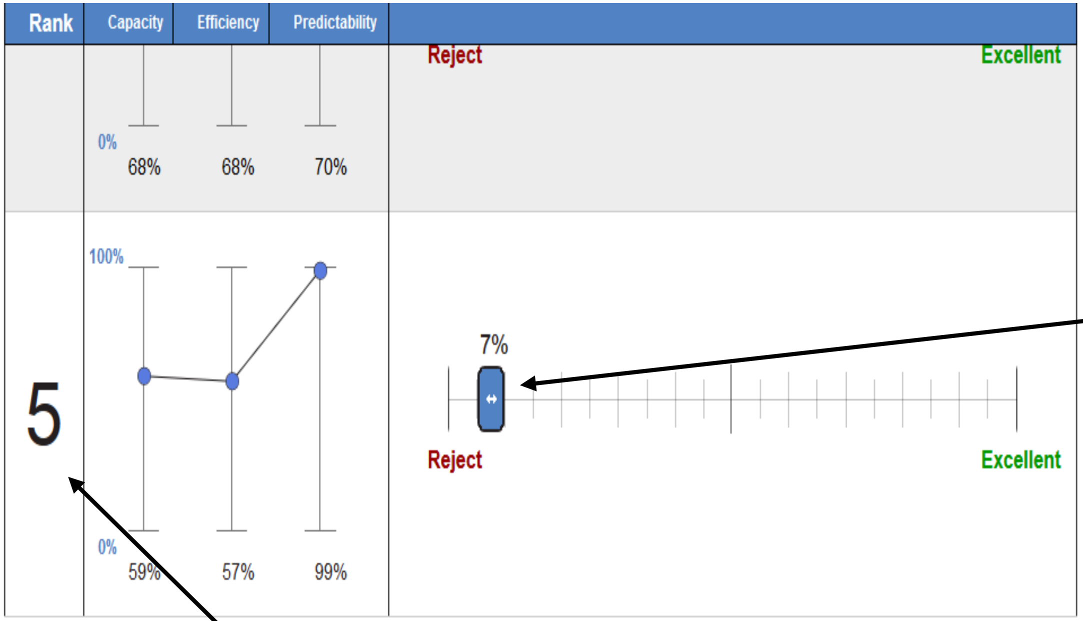
Description:
Balanced Candidate



Poll Duration: 10 Minutes

Once the administrator has finished approving candidates, then the poll is opened to voting

Grading Candidates - Participants



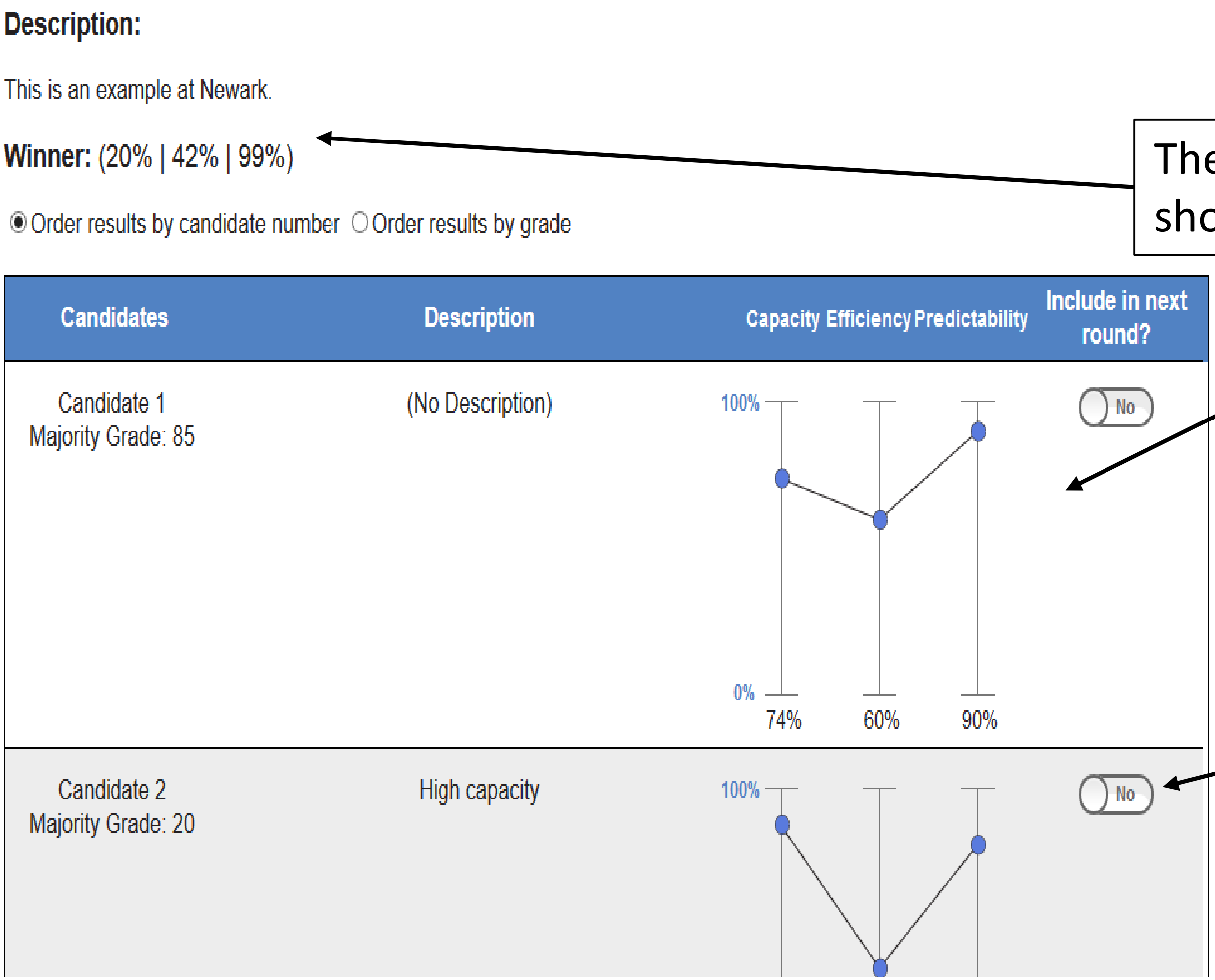
Participants assign each candidate a grade using a slider

Submit

The rank that the user has given each candidate is shown

Time Remaining
05:10

Viewing Results - Administrator



Description:

This is an example at Newark.

Winner: (20% | 42% | 99%)

● Order results by candidate number ○ Order results by grade

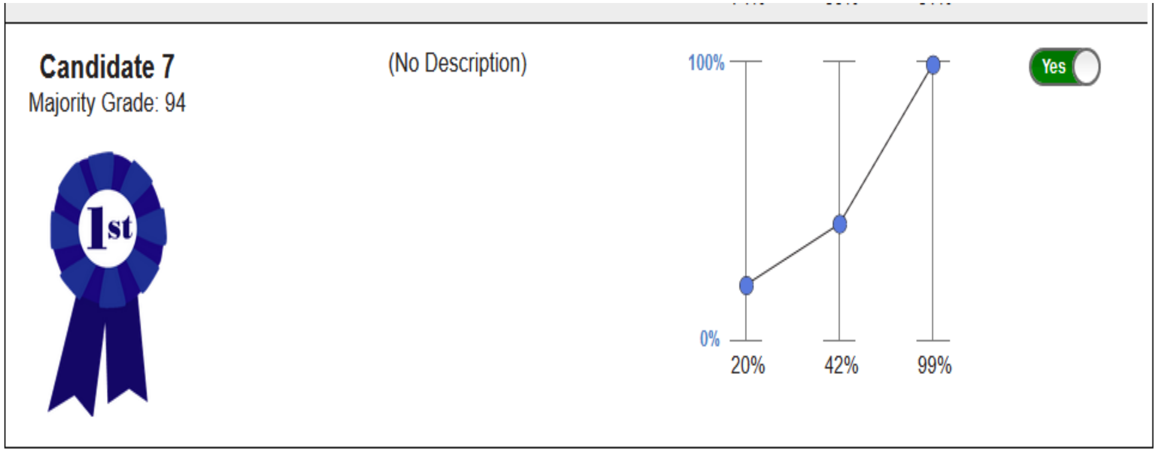
Candidates	Description	Capacity Efficiency Predictability	Include in next round?
Candidate 1 Majority Grade: 85	(No Description)	74% 60% 90%	No
Candidate 2 Majority Grade: 20	High capacity		No

The winning candidate is shown

All candidates and their majority grades are shown

The administrator may select candidates for inclusion in another poll

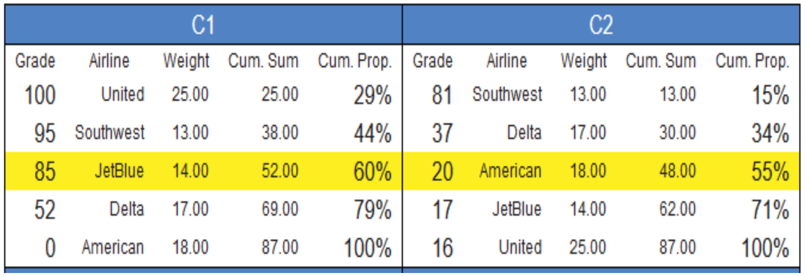
Viewing Results - Administrator



Candidate 7
Majority Grade: 94

(No Description)

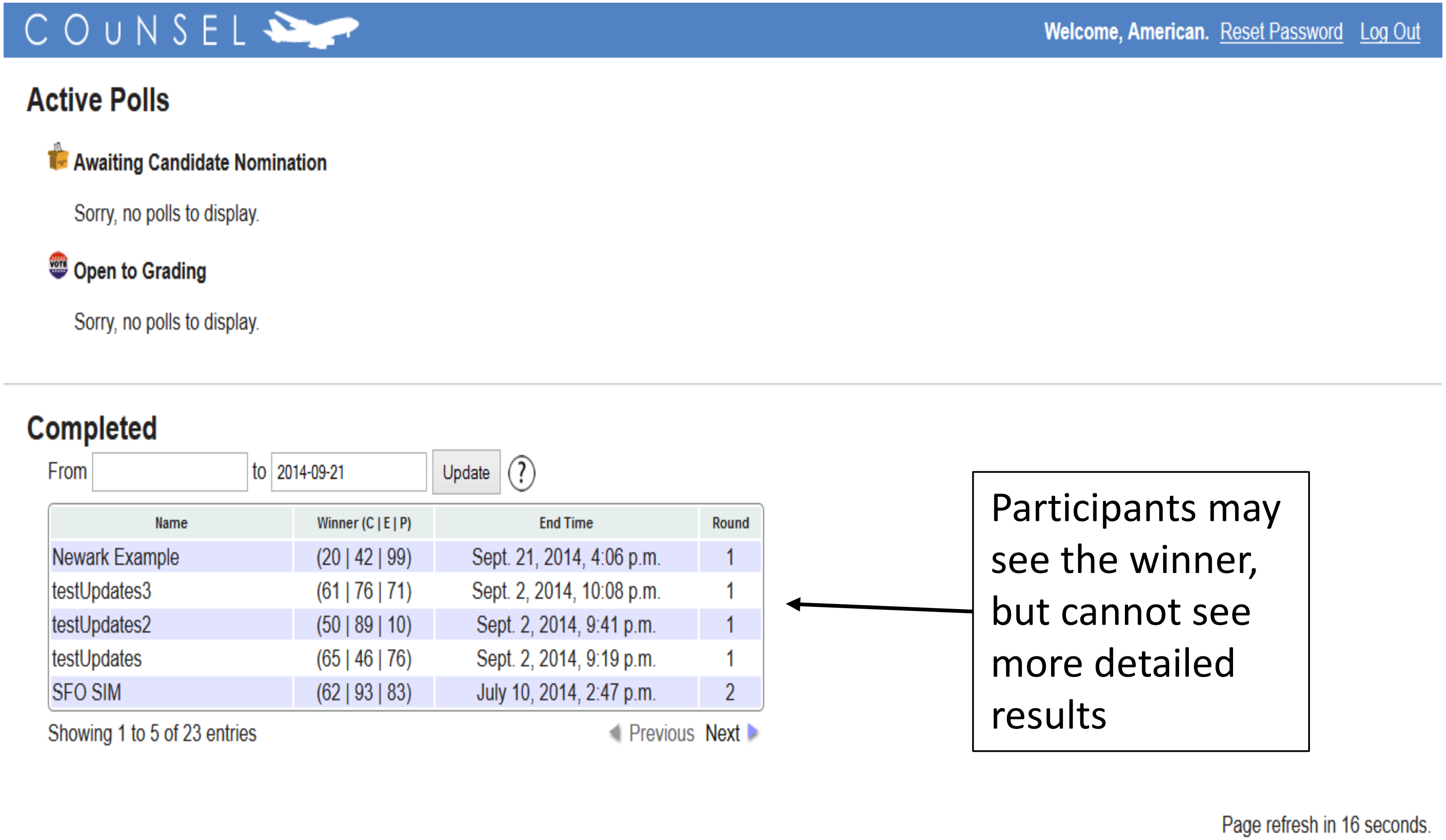
The administrator may create another poll based on the results of this poll



C1					C2				
Grade	Airline	Weight	Cum. Sum	Cum. Prop.	Grade	Airline	Weight	Cum. Sum	Cum. Prop.
100	United	25.00	25.00	29%	81	Southwest	13.00	13.00	15%
95	Southwest	13.00	38.00	44%	37	Delta	17.00	30.00	34%
85	JetBlue	14.00	52.00	60%	20	American	18.00	48.00	55%
52	Delta	17.00	69.00	79%	17	JetBlue	14.00	62.00	71%
0	American	18.00	87.00	100%	16	United	25.00	87.00	100%

The administrator may also view each user's grade of each candidate

Viewing Results - Participant



Active Polls

Awaiting Candidate Nomination

Sorry, no polls to display.

Open to Grading

Sorry, no polls to display.

Completed

From ☐ to 2014-09-21 Update ?

Name	Winner (C | E | P)	End Time	Round
Newark Example	(20 | 42 | 99)	Sept. 21, 2014, 4:06 p.m.	1
testUpdates3	(61 | 76 | 71)	Sept. 2, 2014, 10:08 p.m.	1
testUpdates2	(50 | 89 | 10)	Sept. 2, 2014, 9:41 p.m.	1
testUpdates	(65 | 46 | 76)	Sept. 2, 2014, 9:19 p.m.	1
SFO SIM	(62 | 93 | 83)	July 10, 2014, 2:47 p.m.	2

Showing 1 to 5 of 23 entries

Page refresh in 16 seconds.

Participants may see the winner, but cannot see more detailed results