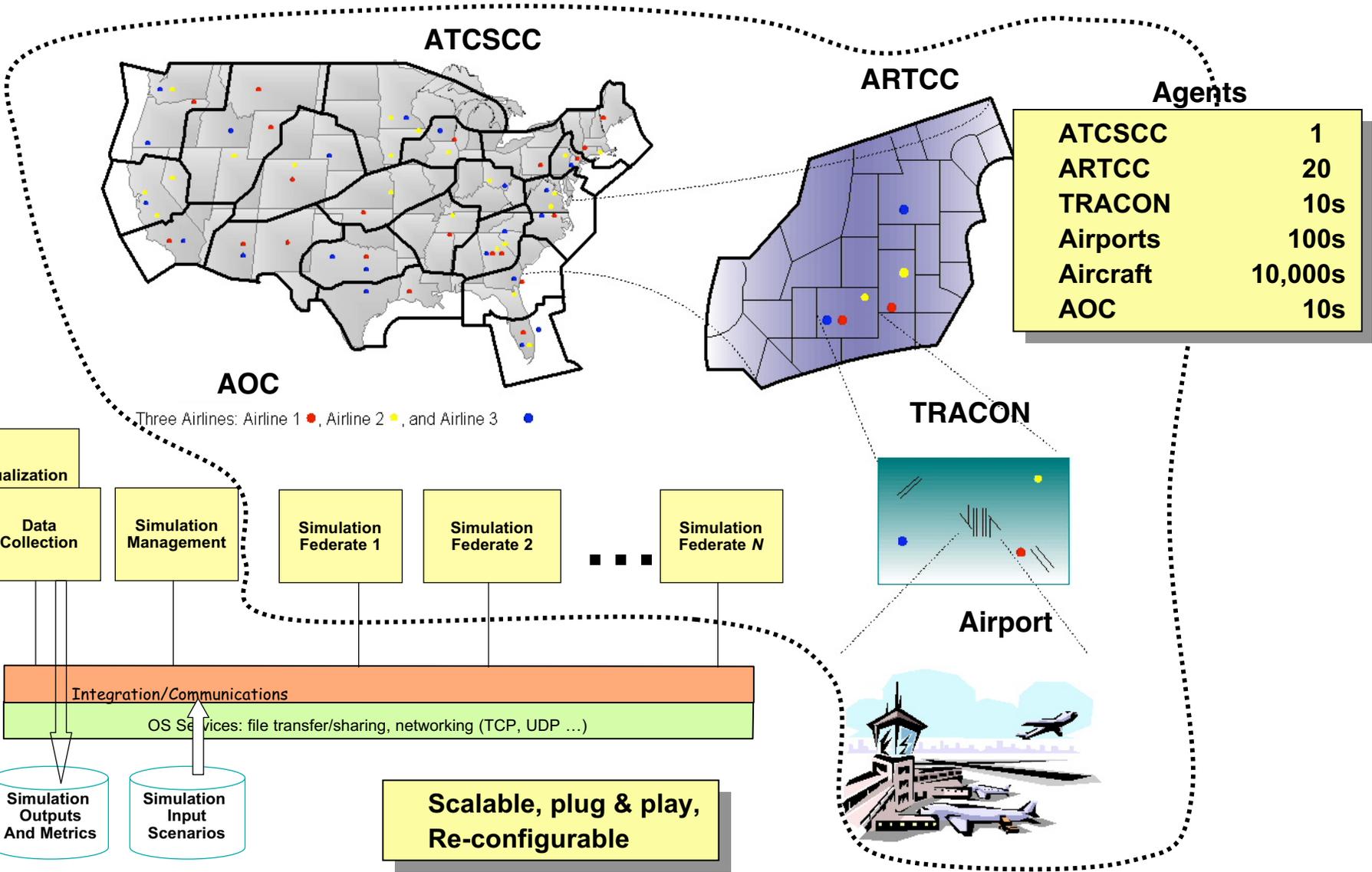


Project Description

- Assess Airspace Concept Evaluation System (ACES) Build 1.2
- Characterize National Airspace System (NAS) delay by varying:
 - Demand
 - Capacity
- 4 month project
 - 1 month – preprocessing
 - 1 month – running test cases
 - 2 months – post processing and analysis



- Constraints
 - No Sector Capacity Limits
 - No AOC functionality
 - No Canceled Flights
 - No Conflict Detection and Resolution
 - Low Fidelity Terminal/Surface
 - No Arrival Queue

- Available Options
 - Delay Maneuvers
 - TRACON Departure Fix Separation

ACES Inputs Demand

- Airport Capacity
- Airport Taxi Times
- Aircraft TRACON Transition Times
- Center/Sector Boundaries
- Flight Data Set
- IFR/VFR Conditions

ACES Inputs Capacity

- Airport Capacity
- Airport Taxi Times
- Aircraft TRACON Transition Times
- Center/Sector Boundaries
- Flight Data Set
- IFR/VFR Conditions

ACES Output Delay

- Data Collection Tool
 - Metrics per flight
 - Takeoff Airport
 - Landing Airport
 - Actual times
 - Scheduled times



Demand

D=Demand

Total number of loaded flights after configuration

10:00 AM GMT, 0 Aircraft, Scale 4207NM, System Configured

Select the grid resolution: High resolution (0.05 degree)

Scenario selection for 7 Generic Masters

Select Generic Master Assignments: CurrentDemand_7_gm.csv

Select flight data set: fds_CD_05_17_2002.csv USE BINARY DATA ----

Select Scenario Data File: none Set STD: none

Set Severity Level: SL_FATAL

LOGGING LEVEL

- initialization
- runtime
- testing

Overwrite sector capacity with specified value 200

Overwrite airport IFR/VFR acceptance rates with specified value

- Perform Delay Maneuvers
- Perform CD&R
- Apply Tracon departure fix separation
- Invoke AOC operation

Data Collection Parameters

Enter scenario number:

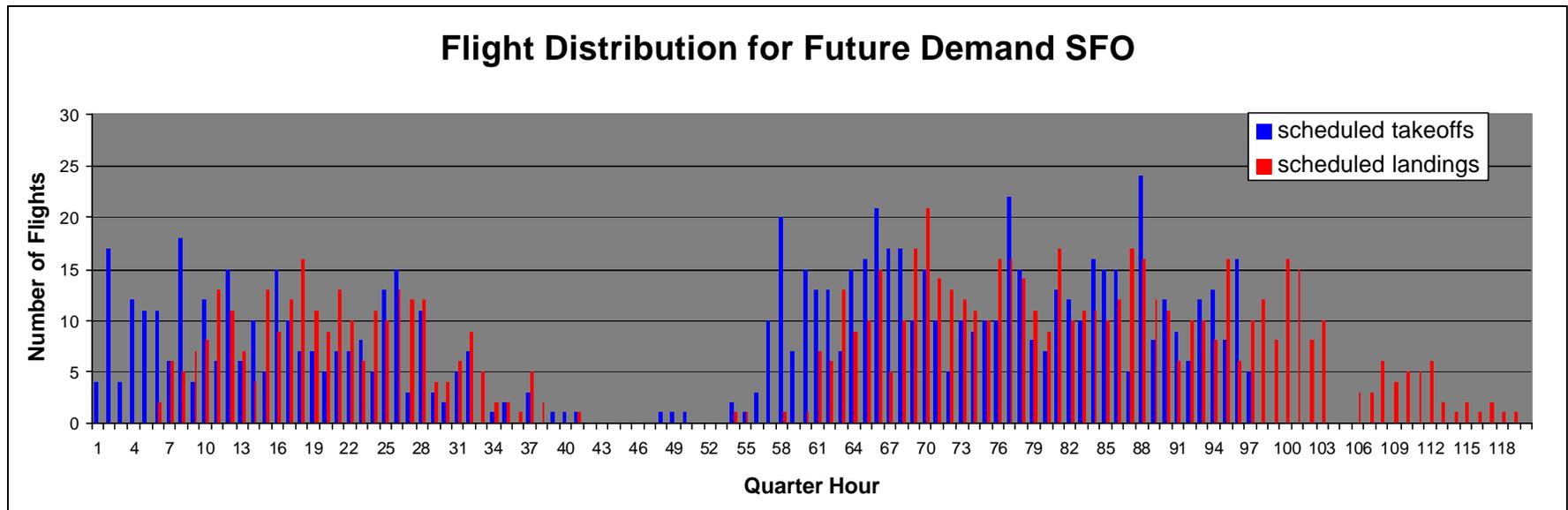
CONFIRM

Loaded 16468 flights. Rejected 1407 from 17875 flights in the flight data set

- Given Flight Data Sets
 - Data Set Scope
 - 98 Airports
 - Domestic
 - Commercial passenger
 - Current Demand 5/17/2002
 - 16468 loaded out of 17875
 - Future Demand 2022
 - 33186 loaded out of 36252
 - Developed additional intermediate demand data sets

- Filter Future Demand Data Set Maintaining Distribution Profiles
- Distribution Profile based on flight schedule
 - Compute the number of flights scheduled to takeoff and land at each airport every quarter hour.

Takeoff matrix = $T(A, Q)$, Landing matrix = $L(A, Q)$



α =desired reduction ratio

$$T_r(A, Q) = \alpha T(A, Q), L_r(A, Q) = \alpha L(A, Q)$$

T_r and L_r become matrices of the number of flights we want to remove from the Future Demand data set

For each flight:

A_t =takeoff airport

A_l =landing airport

Q_t =qtr hour scheduled to takeoff from A_t

Q_l =qtr hour scheduled to land at A_l

Flight Filtering Algorithm

For each Flight in the FD data set:

if flight was rejected during FD configuration
remove flight

if $T_r(A_t, Q_t) > 0.5$ and $L_r(A_l, Q_l) > 0.5$
remove flight

$$T_r(A_t, Q_t) = T_r(A_t, Q_t) - 1$$

$$L_r(A_l, Q_l) = L_r(A_l, Q_l) - 1$$

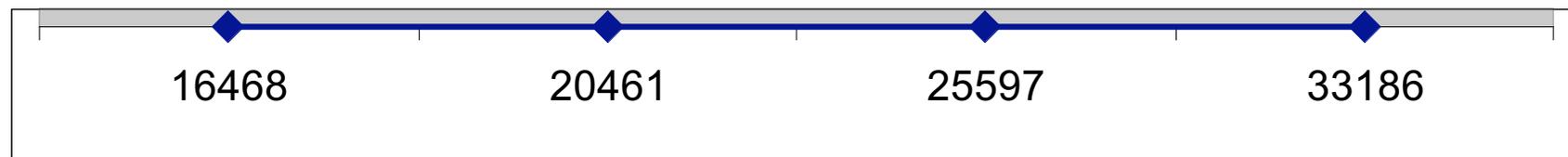
else

add flight to new data set

Flight Filtering Results

- $\alpha = 1/6$
 - 25597 flights
- $\alpha = 1/3$
 - 20461 flights

4 fairly equally distributed demand points



- Airport Capacity = aircraft per quarter hour
- VFR/IFR conditions per quarter hour

$C_a(A, Q)$ =Arrival Capacity Matrix

$C_d(A, Q)$ =Departure capacity Matrix

$C_t(A, Q)$ =Total capacity Matrix

NAS Capacity Measurements

$$C_{NASa} = \frac{1}{D} \sum L(A, Q) \cdot C_a(A, Q)^T$$

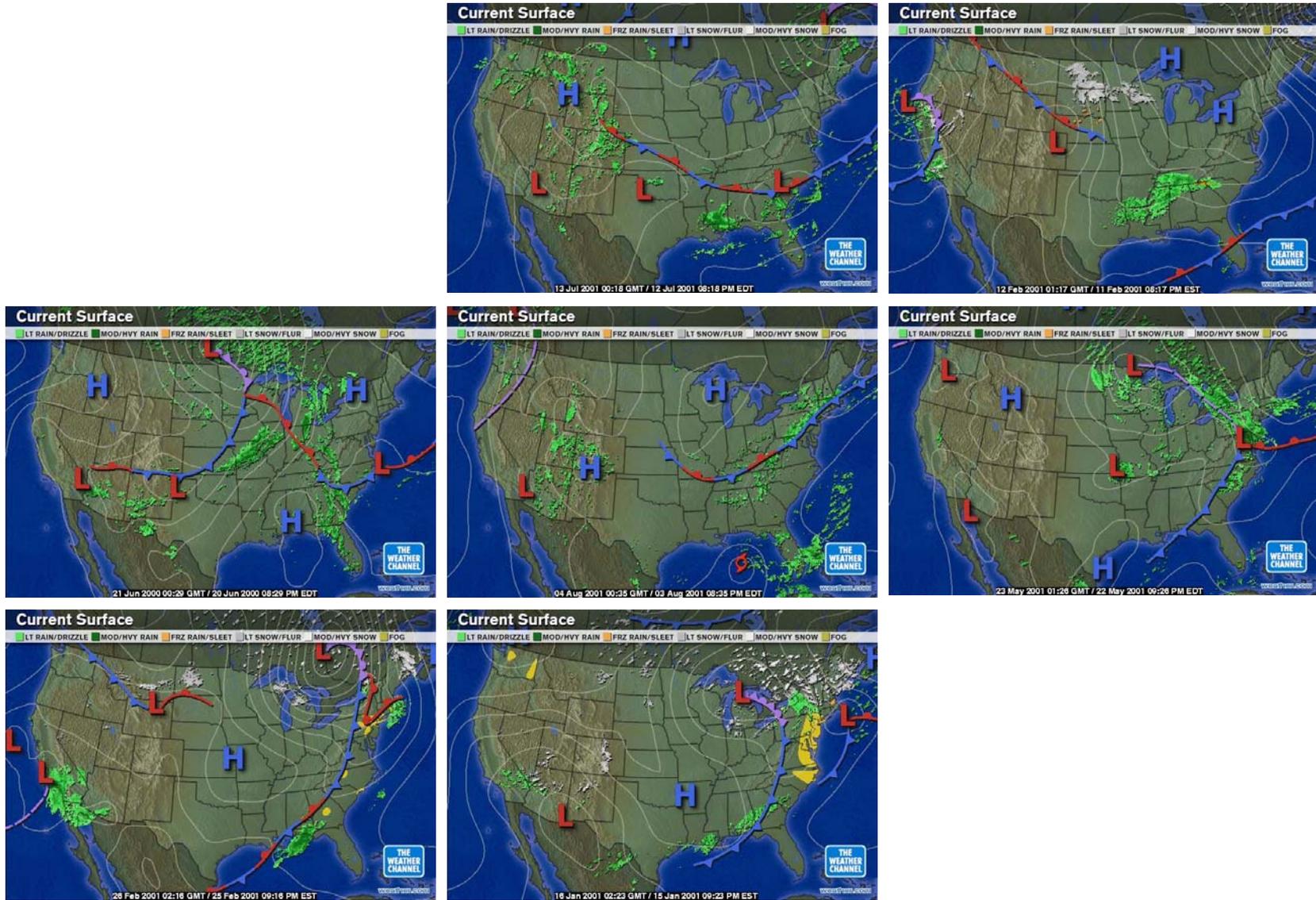
$$C_{NASd} = \frac{1}{D} \sum T(A, Q) \cdot C_d(A, Q)^T$$

$$C_{NAS t} = \frac{1}{2D} \sum (L(A, Q) + T(A, Q)) \cdot C_t(A, Q)^T$$

- VFR/IFR conditions represent different weather days
 - Perfect Day – all airports VFR all day
 - Bad Day – top 30 airports IFR all day
 - Intermediate Days
 - 7 Days from “Selection of Datasets For NAS-Wide Simulation Validations” by Metron Aviation.
 - IFR/VFR conditions from Aircraft System Performance Metrics (ASPM) data for the top 49 airports.
 - 50% = no weather
 - 50% = weather affected delay

Intermediate Capacity Days

Virtual Airspace Modeling & Simulation - TIM 4, Feb. 10-11, 2004



9 VFR/IFR Condition Days

Virtual Airspace Modeling & Simulation - TIM 4, Feb. 10-11, 2004

all VFR (capacity 142.0-142.6) qtr=1



7/12/2001 (capacity 139.9-140.1)



6/20/2000 (capacity 139.0-139.7)



2/11/2001 (capacity 138.6-140.2)



8/3/2001 (capacity 137.0-137.7)



5/22/2001 (capacity 135.6-136.3)



2/25/2001 (capacity 134.4-135.0)



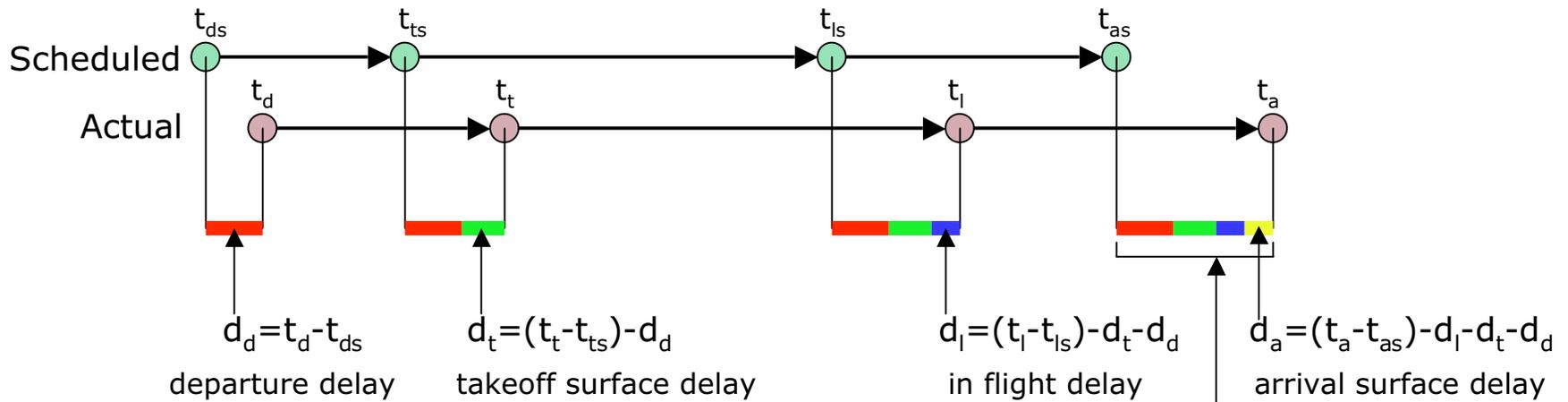
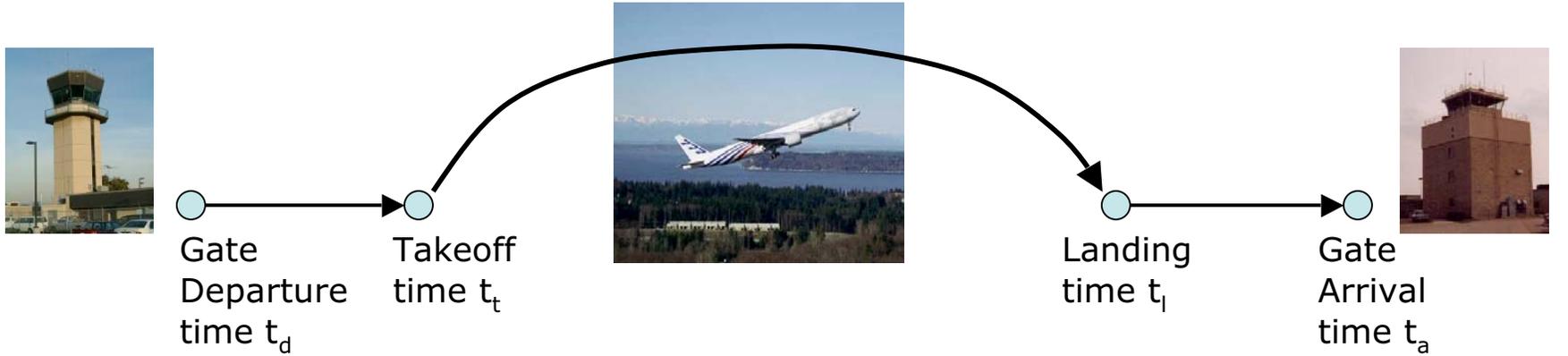
1/15/2001 (capacity 131.0-132.1)



top 30 IFR (capacity 125.3-126.4)

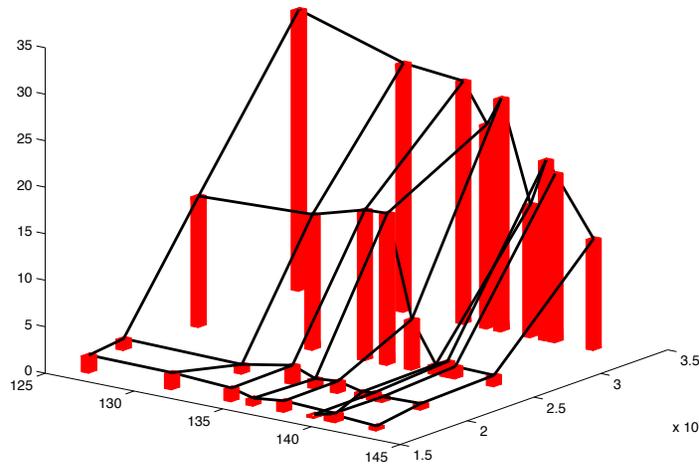


Delay

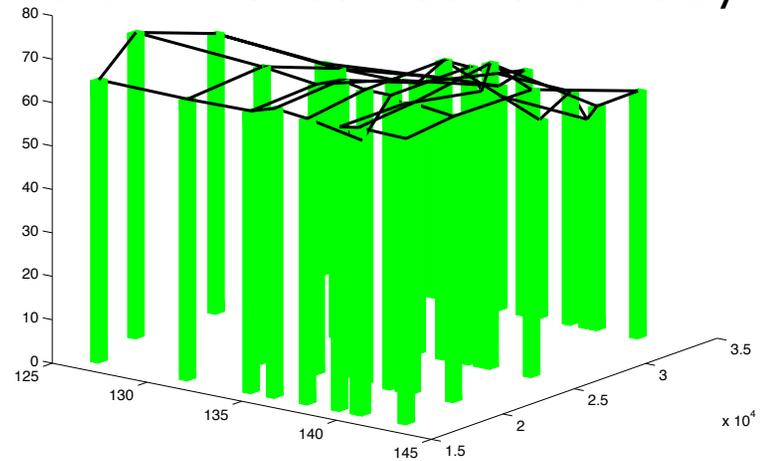


$$\text{Total delay} = t_a - t_{as} = d_d + d_t + d_l + d_a$$

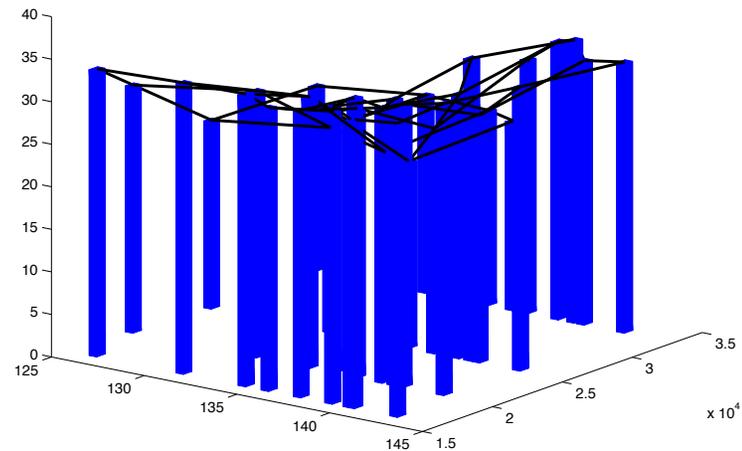
Percent Departure Delay



Percent Takeoff Surface Delay



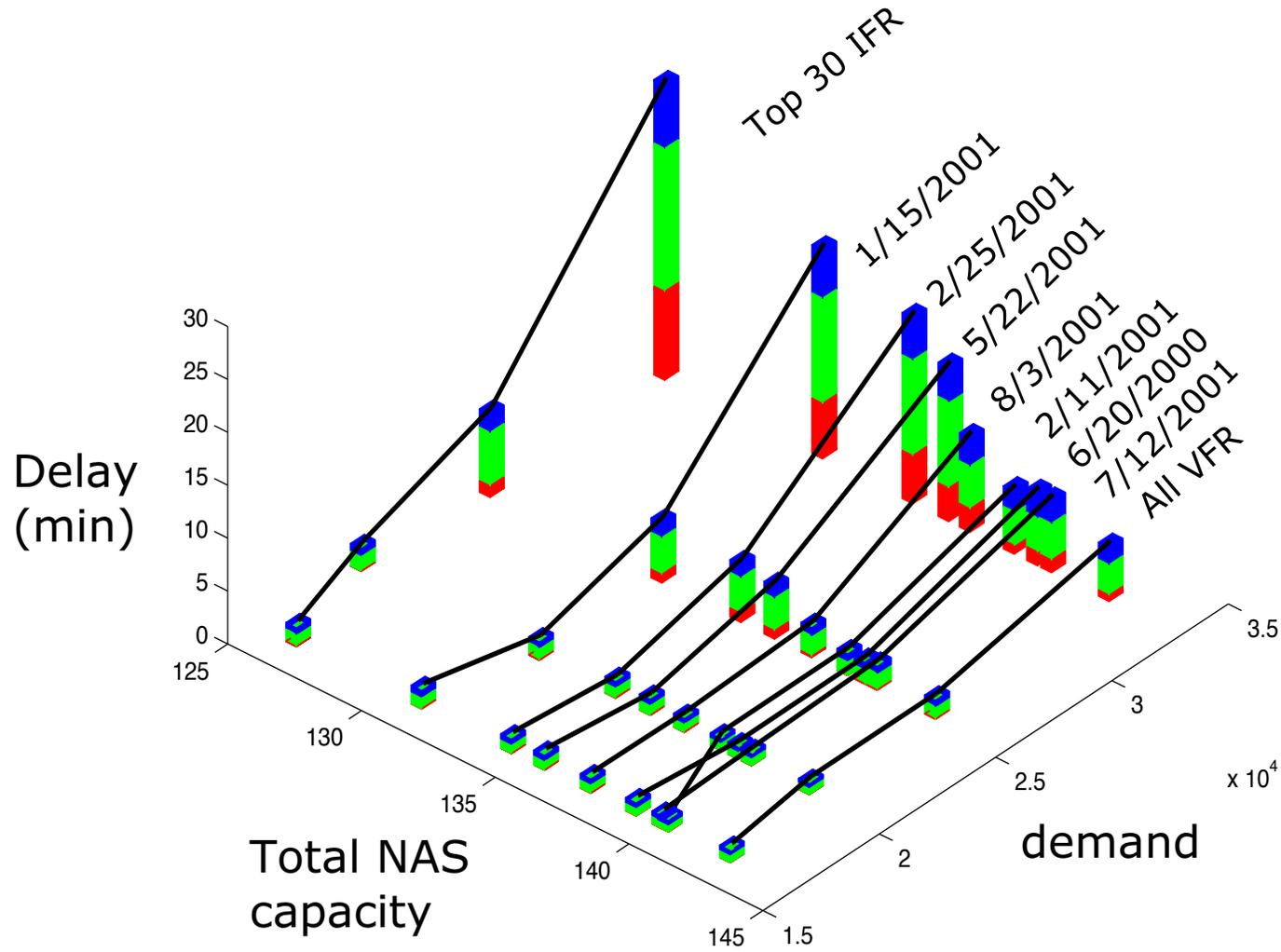
Percent In Flight Delay



- Departure delay percentage increases as demand increases and capacity decreases.
- Takeoff Surface delay claims the greatest percentage.

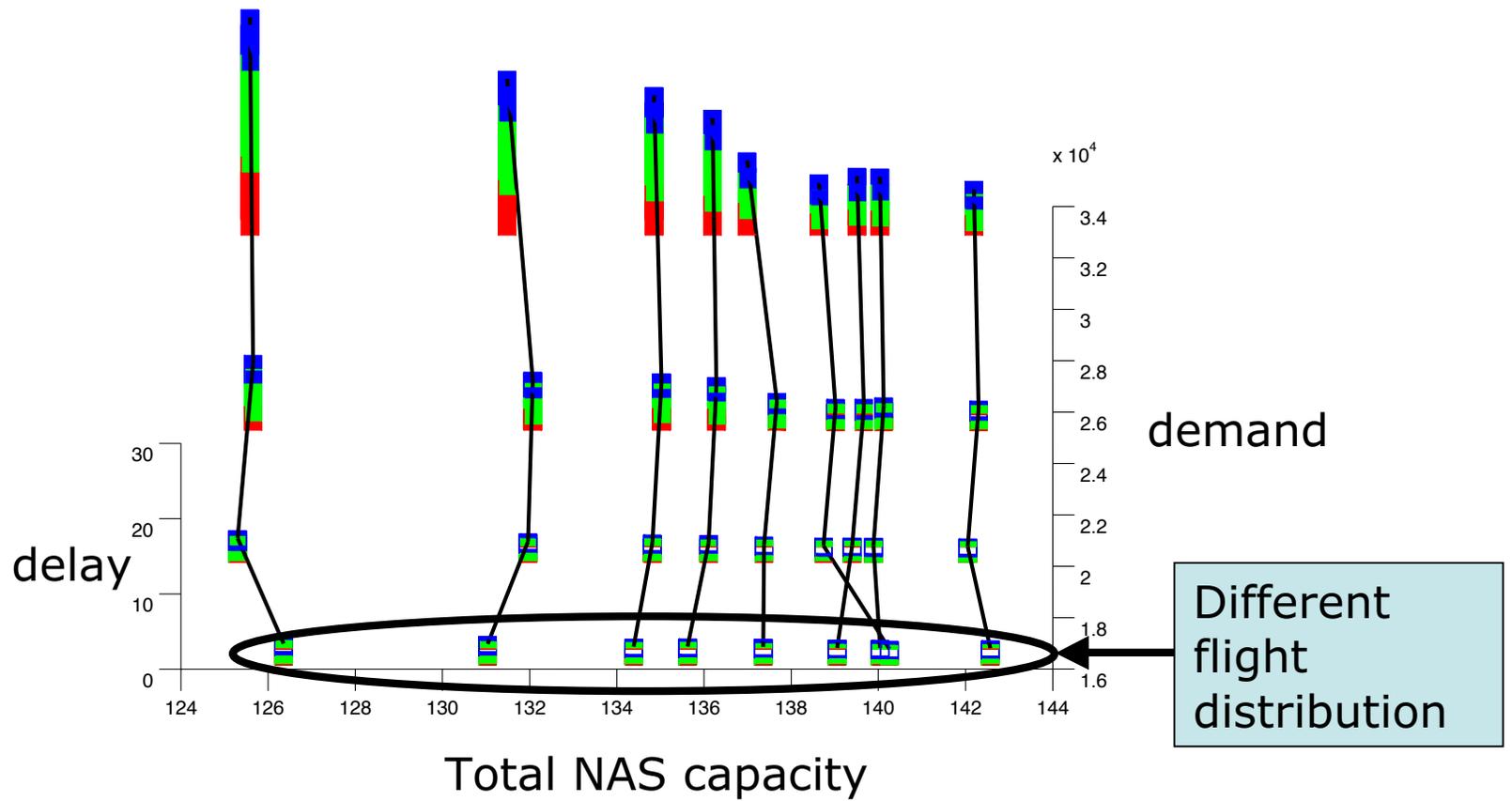
Corresponding Weather Days

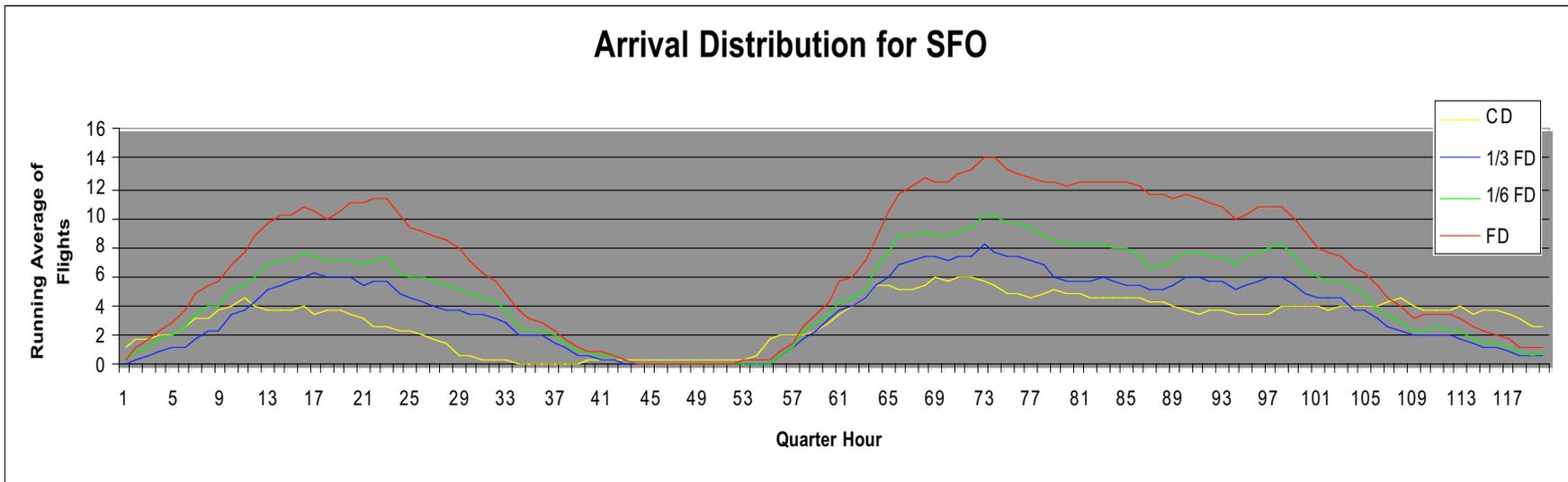
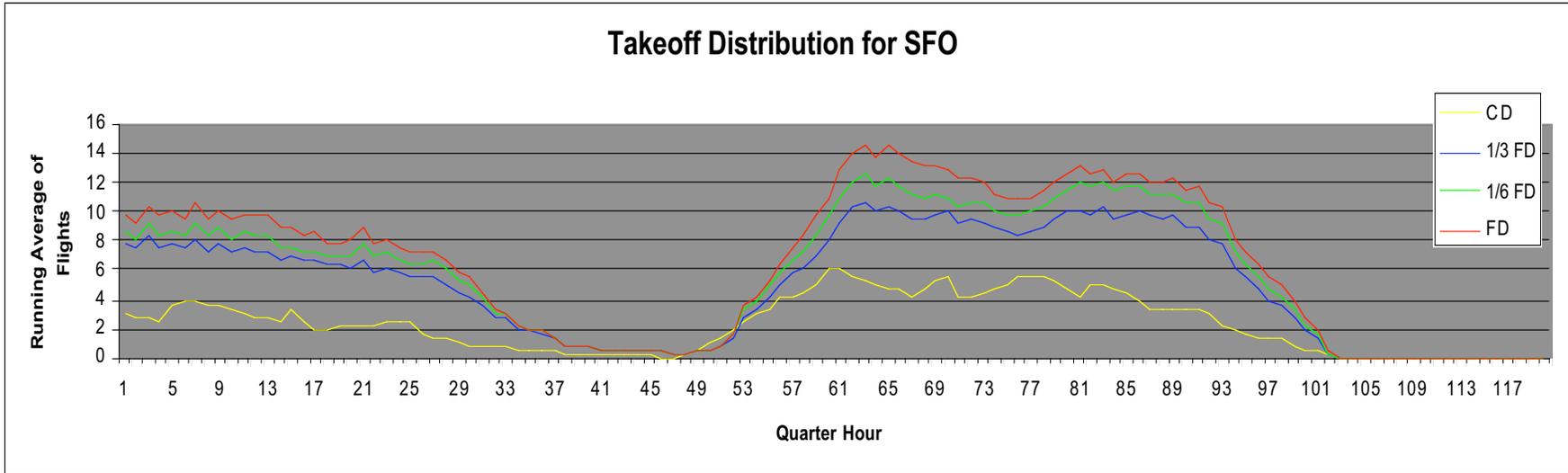
Virtual Airspace Modeling & Simulation - TIM 4, Feb. 10-11, 2004



Corresponding Weather Days

Virtual Airspace Modeling & Simulation - TIM 4, Feb. 10-11, 2004



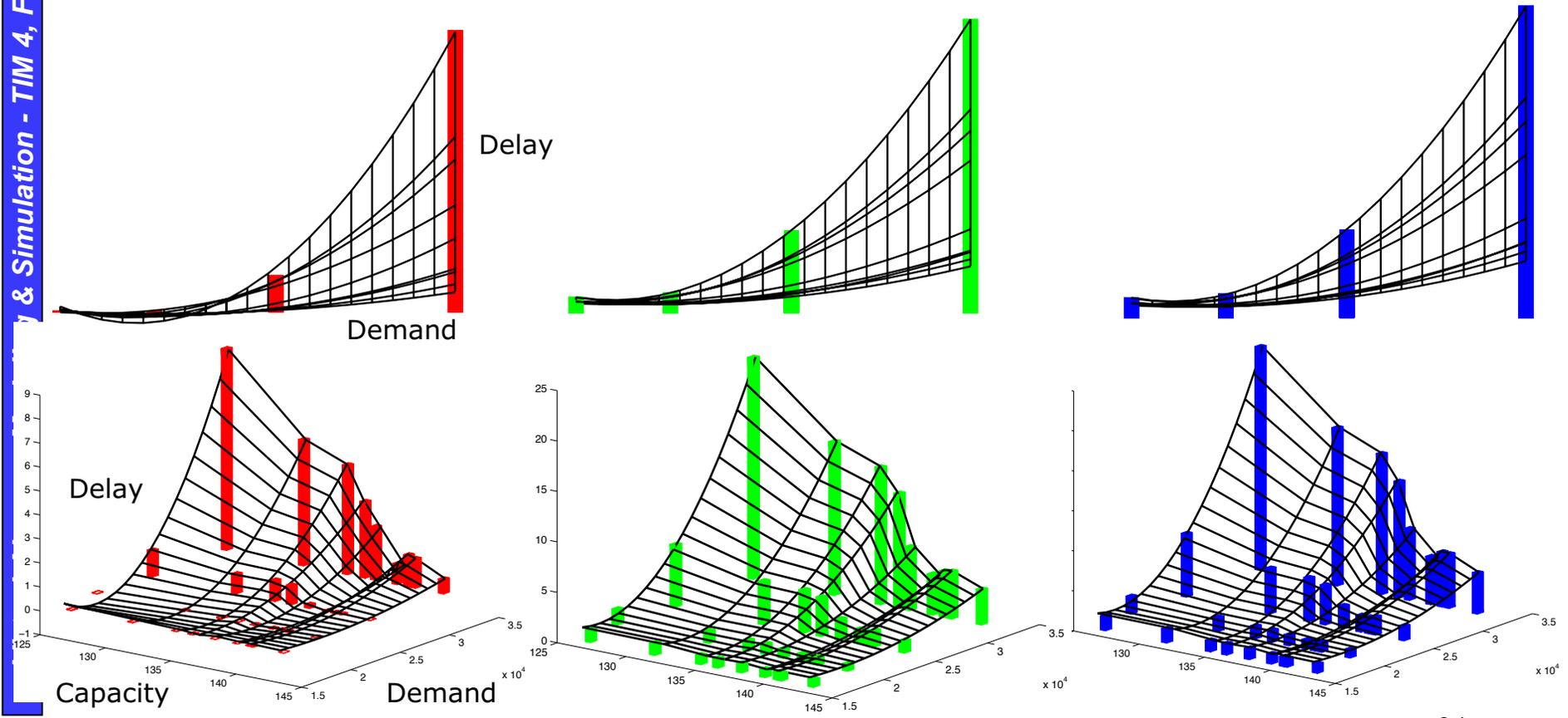


Quadratic curves produced the smallest and most random looking residuals.

Departure Delay

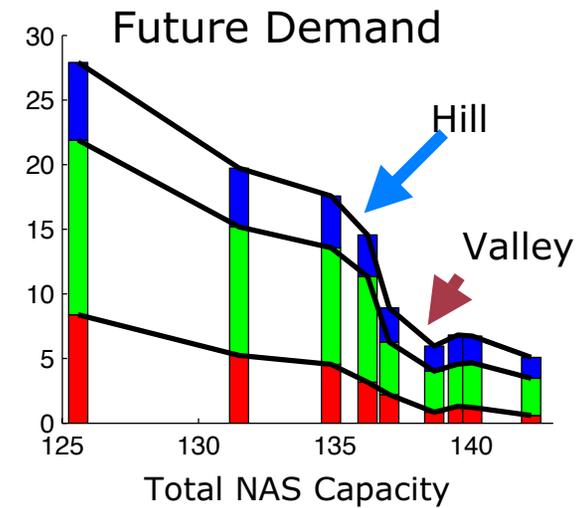
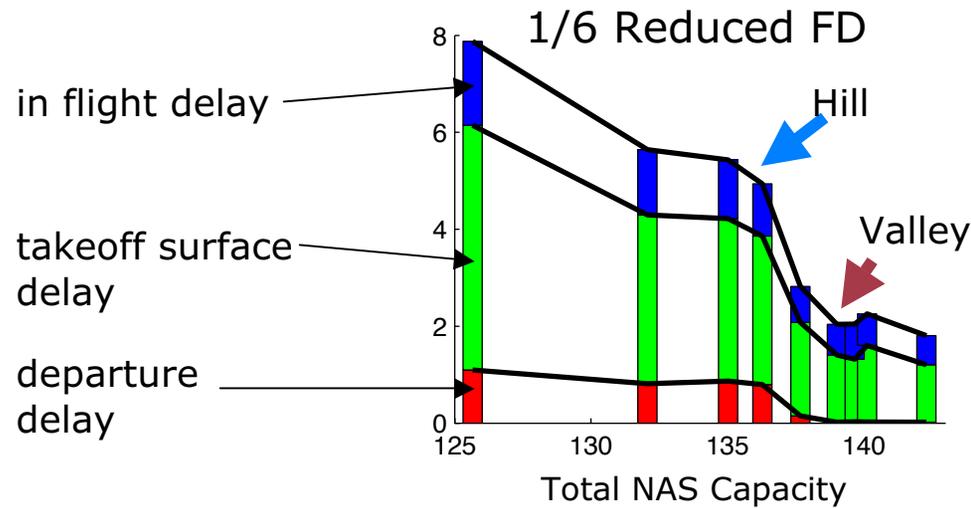
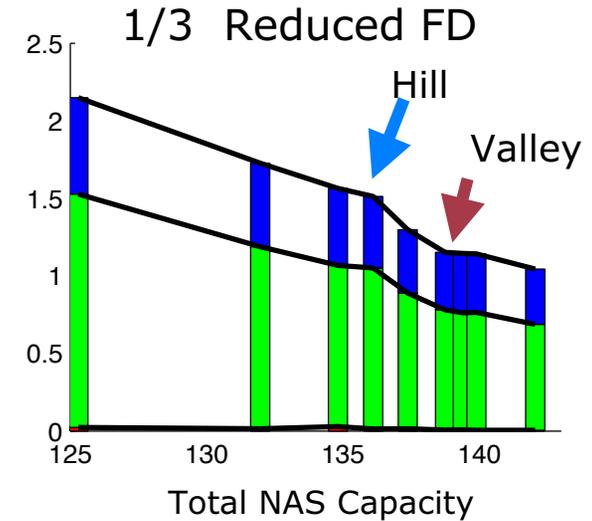
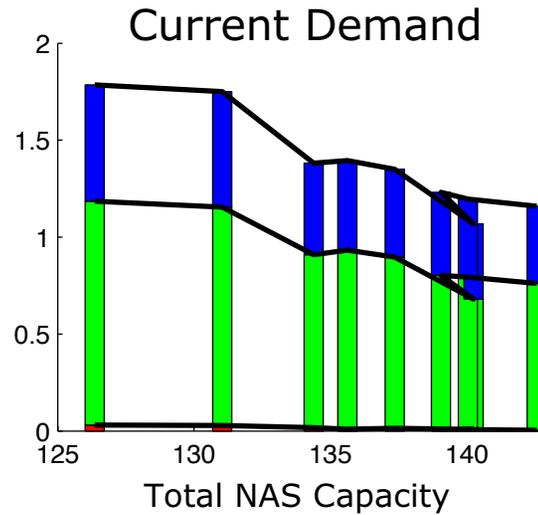
Takeoff Delay

In Flight Delay



Capacity vs. Delay

Virtual Airspace Modeling & Simulation - TIM 4, Feb. 10-11, 2004



9 VFR/IFR Condition Days

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2/25/2001 (capacity 134.4-135.0)



1/15/2001 (capacity 131.0-132.1)



top 30 IFR (capacity 125.3-126.4)



- Assess ACES Build 1.2
 - Characterized NAS with limited build 1.2 functionality.
 - Improved understanding of current ACES capabilities will help define future requirements.
 - Verified the need for sophisticated pre/post processing tools.
- Characterize NAS-wide delay
 - Quantified the delay increase trend with increased demand and lowered capacity.
 - Quadratic Demand vs. Delay Curves
 - Linear trends in Capacity vs. Delay
 - Regional concentrations of airports in IFR state requires more investigation.

