



# **SFO GDP Parameters Selection Model (GPSM) Field Evaluation**

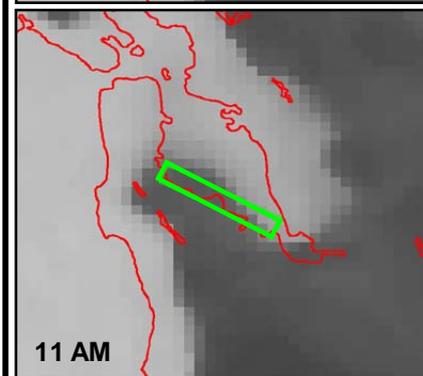
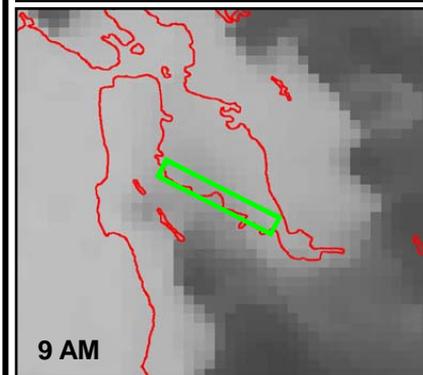
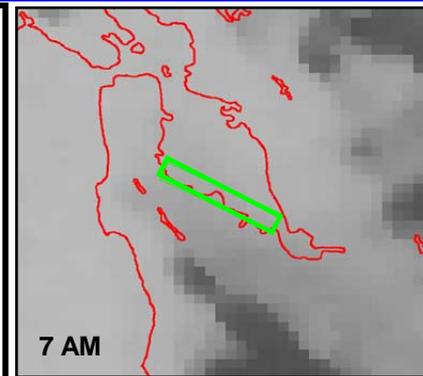
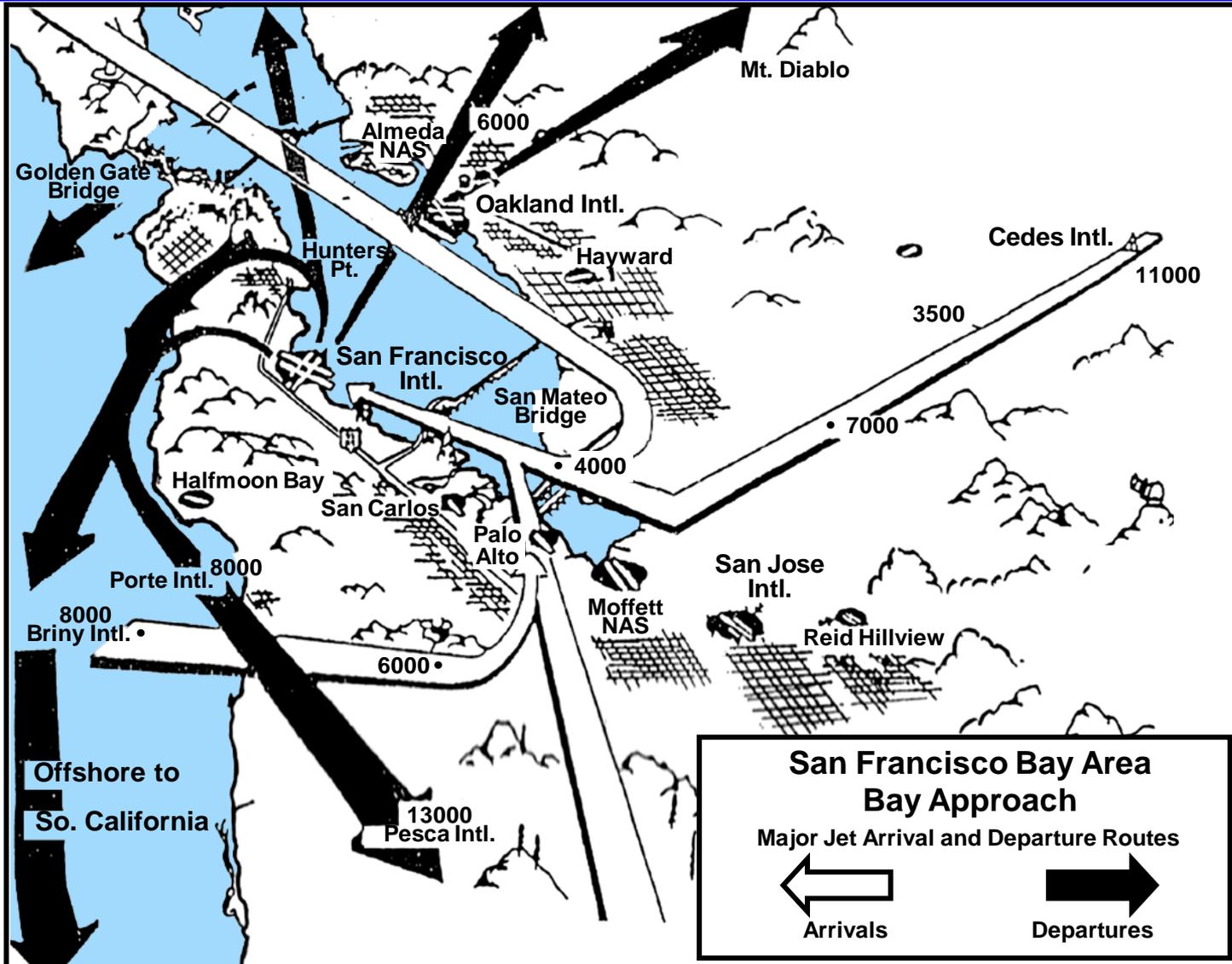
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**Dave Clark, MIT/LL  
Lara Cook, Mosaic ATM**

**Joint Interagency Weather Research Meeting  
24 March 2010**



# Summer Stratus Impact on SFO Approach



**San Francisco Bay Area Bay Approach**

Major Jet Arrival and Departure Routes

← Arrivals      → Departures



# Background



- **MIT/LL led development of SFO Marine Stratus Forecast System**
  - Provide forecast of stratus clearing to allow dual approaches
  - Intended as guidance for Ground Delay Programs (GDPs)
  - Forecasts updated throughout the morning hours
- **Prototype transferred to NWS Monterey in 2004**
- **Performance analysis conducted by NWS in 2008**
  - Forecasts performed as advertised
  - Minimal operational impact
- **Follow-up project initiated in 2009 to address operational issue**
  - GDP Parameter Selection Model (GPSM), [Mosaic ATM, Inc.]
  - Statistical model for recommending GDP parameters based on empirical forecast error distribution and known arrival traffic demand
- **Demonstration Summer 2010**



# SFO Stratus Forecast System

## MIT Lincoln Lab



### SFO Marine Stratus Forecast Guidance

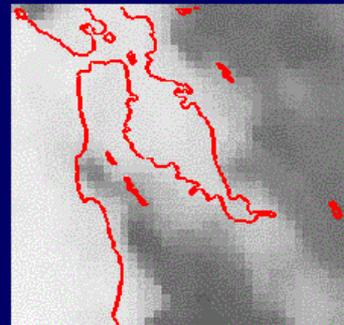
18:53:36 GMT

#### Surface Observations - 08/31/2003

[More Obs](#)

Time	Site	T	Td	Wind	Layer1	Layer2	Visib
1600	<a href="#">SFO</a>	59	55	1003	07 OVC		05
1601	<a href="#">SMB</a>	61	55	0703	07 OVC		09
1600	<a href="#">SQLL</a>	61	58	1104	N/A	N/A	N/A

#### Visible Satellite 16:00 GMT - 08



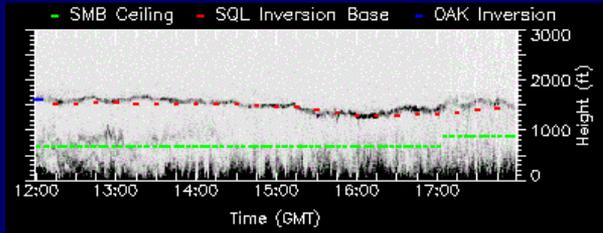
Animate:

- STOP
- PLAY
- STEP BWD
- STEP FWD
- SLOWER
- FASTER

#### SODAR Inversion Base

[Full Page Sodar...](#)

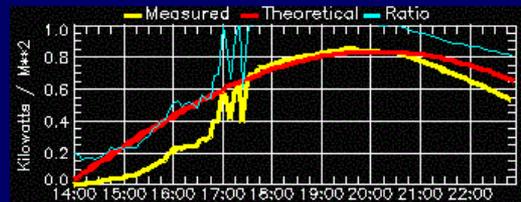
#### San Carlos - 08/31/2003



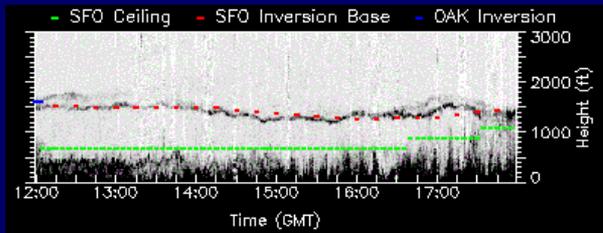
#### Solar Radiation

[Full Page Radiation...](#)

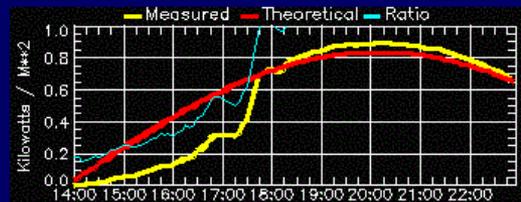
#### San Carlos - 08/31/2003



#### San Francisco - 08/31/2003



#### San Francisco - 08/31/2003



### CONSENSUS FORECAST

**16z** Approach Clear At **18:42** GMT  
 Model Run Confidence **Good**

#### Probability of Clearing By:

17Z	18Z	19Z	20Z
5%	30%	75%	<b>90%</b>

### COMPONENT FORECASTS

Run	Model	Fcst	Wgt
16:00	<a href="#">COBEL</a>	18:07	0.14
16:00	<a href="#">Local</a>	18:25	0.37
16:00	<a href="#">Regional</a>	18:01	0.13
16:00	<a href="#">Satellite</a>	19:28	0.36

#### Hourly Forecast Summary

#### More Forecast Info

[Model Forecast Details](#)

[Model Performance Summary](#)

[ETA Analysis Maps](#)

[On-Line Archive](#)

[View Prior Day\(s\)](#)

[2003 Rate-Change Times](#)

#### Help

[Training/ Explanations](#)

[Email Questions/ Comments](#)

[System Status](#)



# Consensus Forecast



**CONSENSUS FORECAST**

Run at: **16z**      Approach Clear At **17:39**      GMT  
**Model**      Confidence      **Good**  
**Run**

**Probability of Clearing By:**

17Z	18Z	19Z	20Z
30%	80%	<b>90%</b>	<b>95%</b>

**COMPONENT FORECASTS**

Run	Model	Fcst	Wgt
16:00	<u>COBEL</u>	17:53	0.21
16:00	<u>Local</u>	17:43	0.36
16:00	<u>Regional</u>	17:07	0.13
16:00	<u>Satellite</u>	17:37	0.31

Hourly Forecast Summary

Run at:  
9Z,  
11Z,  
13Z,  
15Z,  
16Z,  
17Z,  
18Z

Used mid-  
May to mid-  
October

Probabilistic  
elements of  
forecast

Physics-  
Based  
Model

Statistical  
Models

*Note: not all  
components  
are available  
for a given run*

Wgt based  
on type of  
day and  
hour of run



# Project Motivation



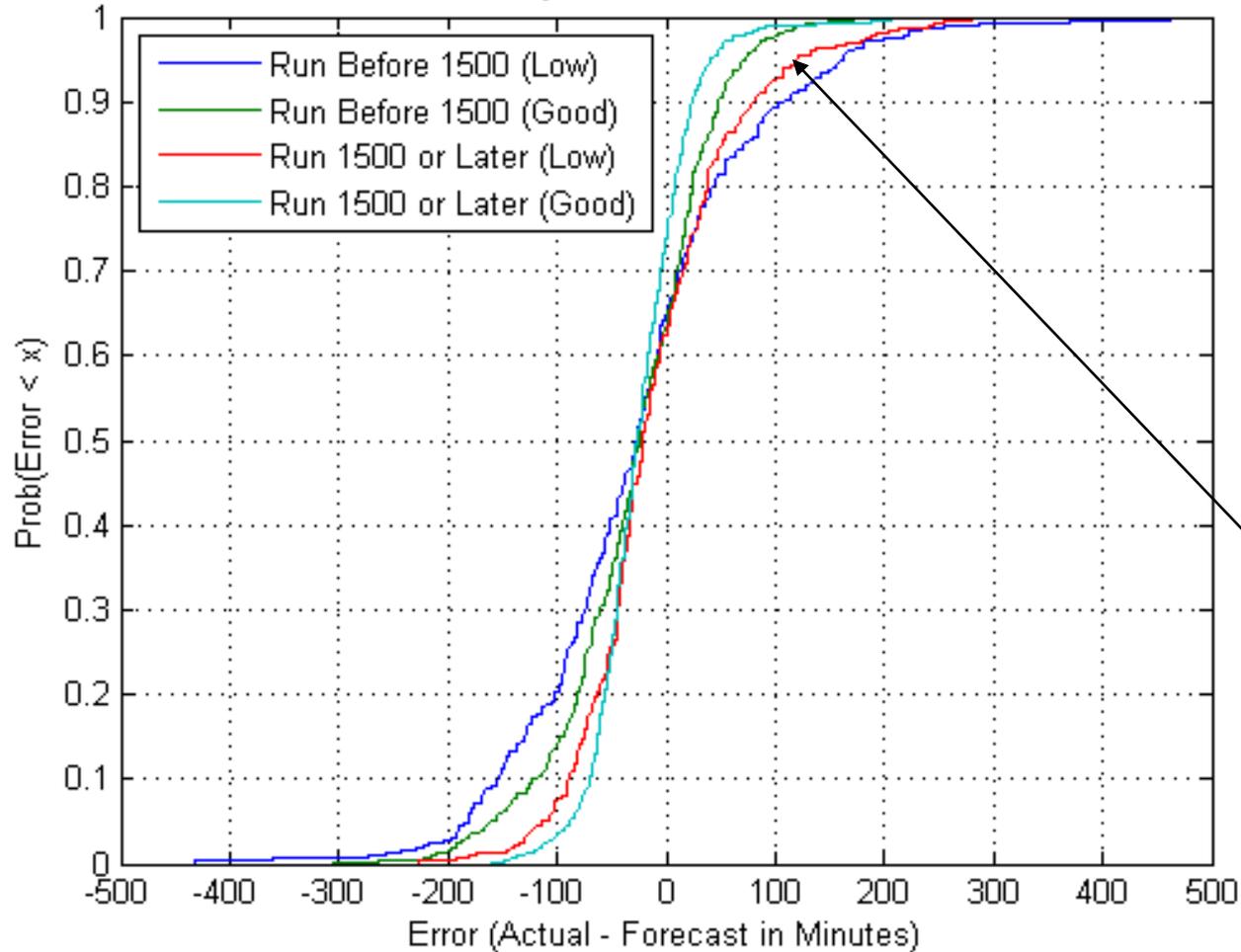
- **No significant change in GDP practices once the SFO Stratus Forecast System was deployed in 2004**
  - **No tangible reward to ATM for aggressive GDP**
- **The 4 probabilities of clearing by 17Z, 18Z, 19Z, and 20Z are difficult to interpret and use in GDP end time and scope decision making**
- **Realization that a model is required for translating probabilistic forecasts into TFM decisions**
  - **A human cannot evaluate all possible weather outcomes and their probabilities when selecting a GDP end time and scope**
  - **Key step towards NextGen vision of integration of weather and ATM decision making**
- **Field experiment in 2010 sponsored by FAA System Operations**



# Using Forecast Uncertainty



CDF of the Forecast Errors by Run Time Period and Confidence 2005-2008



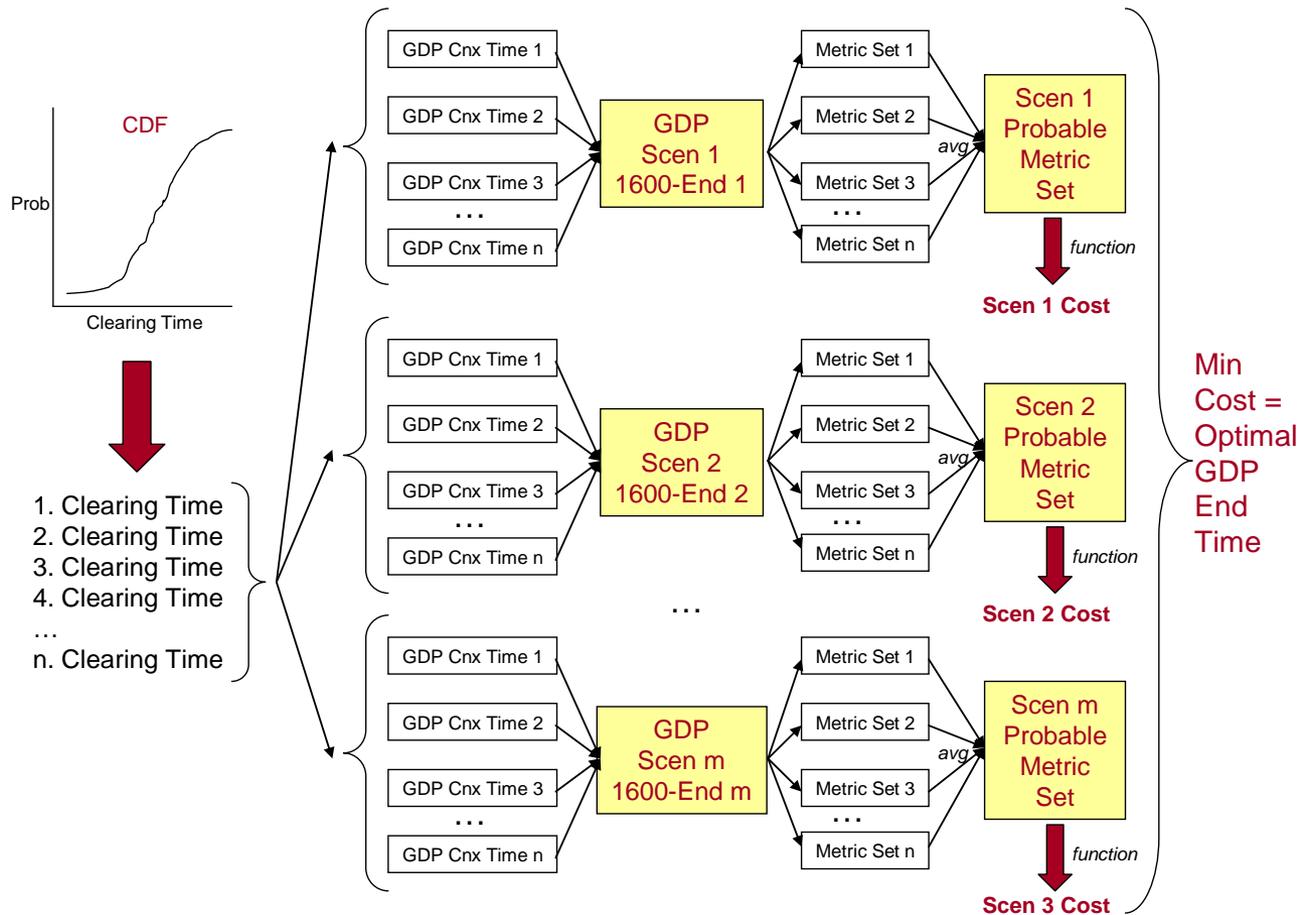
**Probability using  
2 hour guideline  
= 93% for low,  
99% for high**



# Selecting GDP End Time

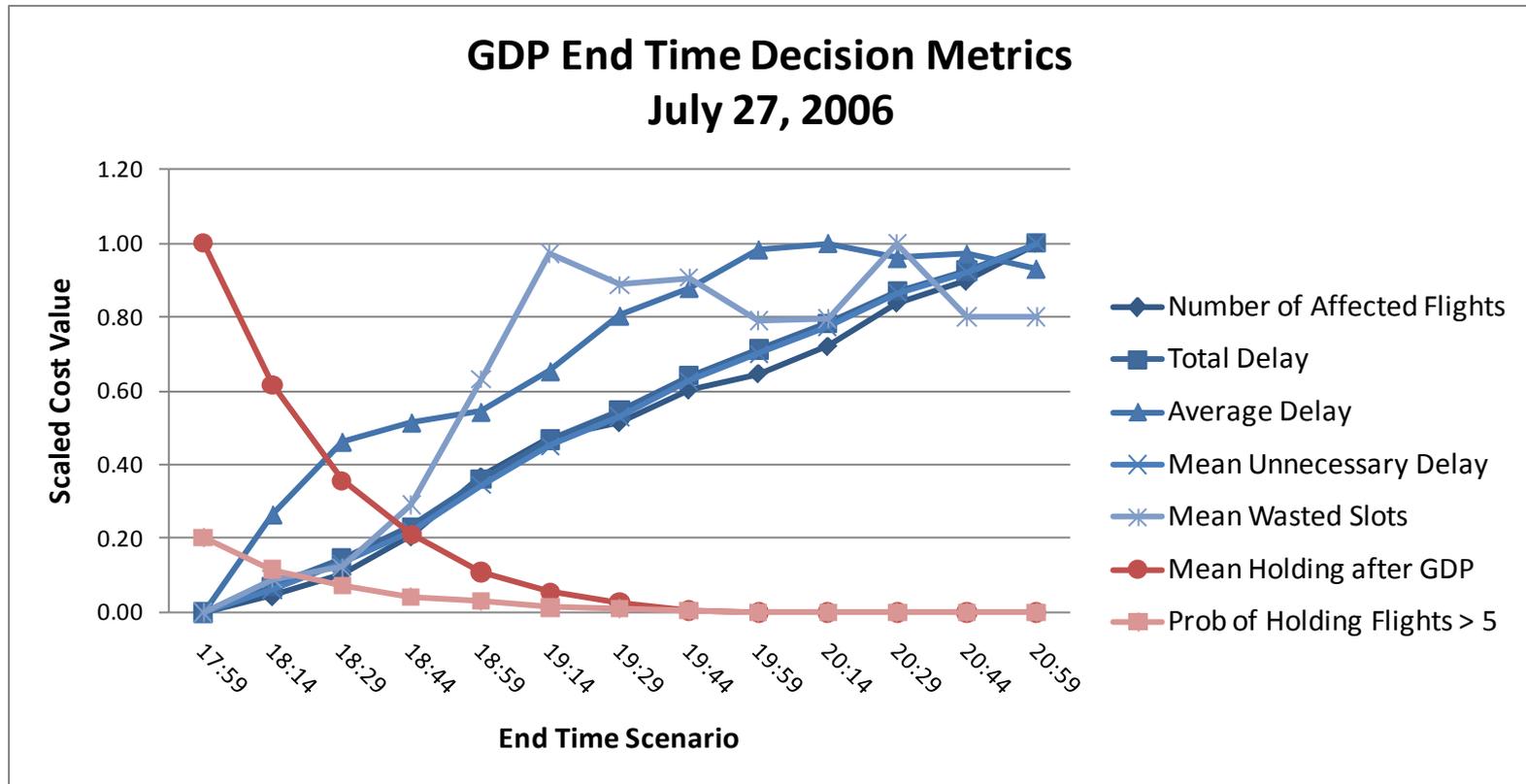


- Monte Carlo simulation approach
- Objective function captures the cost of each scenario





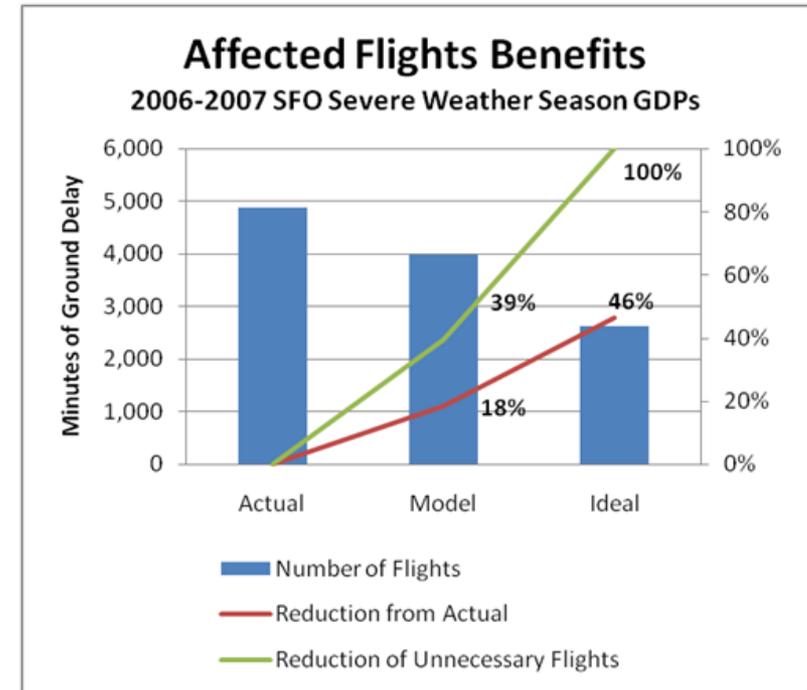
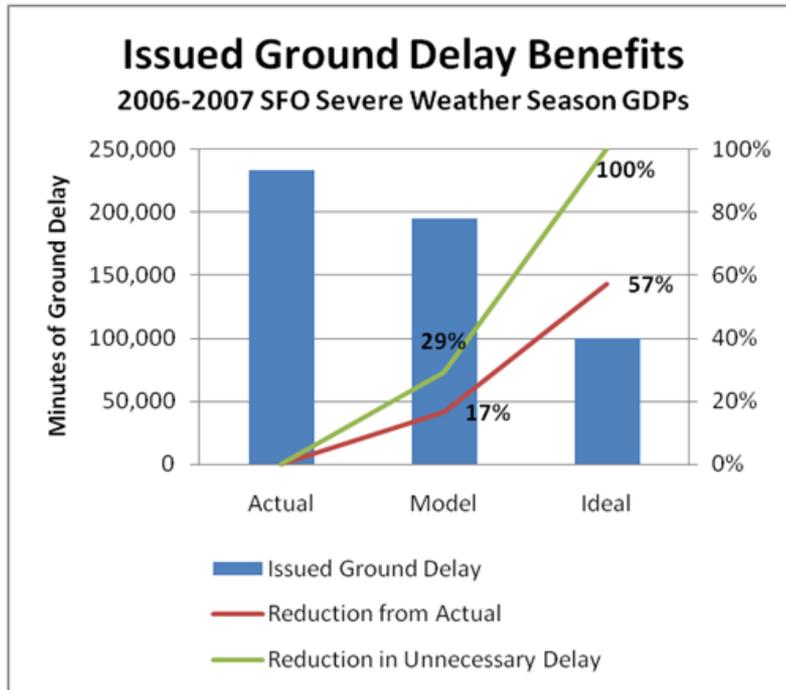
# Competing Goals



- Some metrics increase in cost with later end times, while others decrease
- Must balance the risks of users (excess delay) and ATC provider (excess demand)



# Model Benefits



**Annual Estimated Savings:**  
**\$2.83M per severe weather season**

*\* Assumes \$60.46 per minute delay, 77 GDPs per season*

- **61% (88 minutes) reduction in excess planned GDP minutes. From 143 minutes to 55 minutes.**
- **Model still selected an end time later than clearing time 86% of the time**
- **Model selected better end time 91% of the time.**



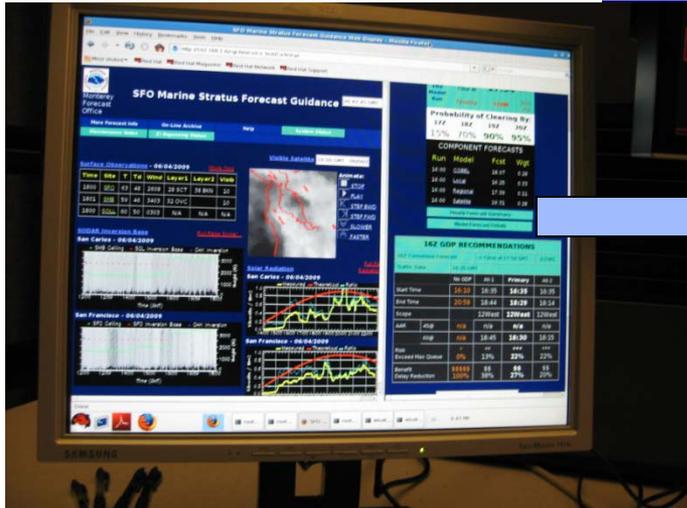
# Field Evaluation Planned for 2010



- **Mosaic ATM (working for NASA) and MIT Lincoln Lab have been funded by the FAA's System Operations Program Office to prepare for and conduct field trials during the 2010 stratus season of the model which utilizes the SSFS forecast to recommend GDP Parameters**
  - **MIT LL developing the necessary enhancements to the SFO Stratus Forecast System, including the display of the model's outputs and the interface with the GPSM**
  - **Mosaic ATM developing the model for selecting the GDP Parameters and the interfaces for collecting live ADL data and for communicating with the SSFS**



# Integration of GPSM into System



### CONSENSUS FORECAST

16z Approach Clear At **19:02** GMT  
 Model Run Quality Good

Probability of Clearing By:

17Z	18Z	19Z	20Z
5%	10%	50%	90%

### COMPONENT FORECASTS

Run	Model	Fcst	Wgt
16:00	COBEL	19:01	0.24
16:00	Local	17:17	0.28
16:00	Regional	18:43	0.14
16:00	Satellite	20:35	0.34

Hourly Forecast Summary  
 Model Forecast Details

*Field evaluation starts May 15*

**Successful SFO Stratus Forecast System / GPSM installation and integration testing completed in the operational environment at the ZOA CWSU.**

### 15Z GDP RECOMMENDATIONS

15Z Consensus Forecast -> Clear at 17.25 GMT [GOOD]

Traffic Data		15:18 GMT			
		Current	Alt-1	Primary	Alt-2
Start Time		15:30	15:30	15:30	15:30
End Time		18:59	18:14	18:29	18:44
Scope		12West	12West	12West	12West
AAR	45@	18:00	16:45	17:30	17:45
	60@	19:00	17:45	18:30	18:45
Risk Exceed Max Queue	*	1%	9%	6%	2%
Benefit Delay Reduction		\$\$ 24%	\$\$ 27%	\$\$ 20%	\$ 17%

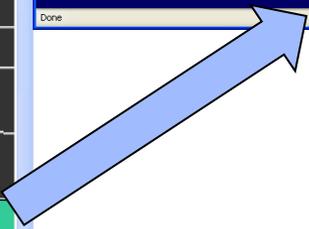
Expanded statistics

### GDP Parameter Statistics

#### 15Z GDP RECOMMENDATIONS

15Z Consensus Forecast -> Clear at 17.25 GMT [GOOD]

Traffic Data		15:18 GMT			
		Current	Alt-1	Primary	Alt-2
Start Time		15:30	15:30	15:30	15:30
End Time		18:59	18:14	18:29	18:44
Scope		12West	12West	12West	12West
AAR	45@	18:00	16:45	17:30	17:45
	60@	19:00	17:45	18:30	18:45
<b>Risk Assessment</b>					
Probability GDP End before clearing		8	15.3	13.1	10.1
Probability GDP End before clearing -30 min		4.6	10.1	7	6.1
Probability GDP End before clearing -60 min		3.4	6.1	4.6	3.7
CEDES - Probability Exceed Max Hold/Diversion		1/0	9/5	6/1	2/0
PYE - Probability Exceed Max Hold/Diversion		1/0	5/2	3/0	1/0
PIRAT - Probability Exceed Max Hold/Diversion		0/0	0/0	0/0	0/0
SKUNK - Probability Exceed Max Hold/Diversion		0/0	4/1	2/0	1/0
<b>Delay Impact</b>					
Number of affected flights		48	29	33	39
Max Ground Delay		83	103	90	97
Total Ground Delay		1729	1254	1399	1887
Average Ground Delay		36.0	43.2	42.4	48.4
Expected Airborne Holding		138	643	351	206





# Project Timeline

