



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)



An Analysis of Potential Capacity Enhancements Through Wind Dependent Wake Turbulence Procedures

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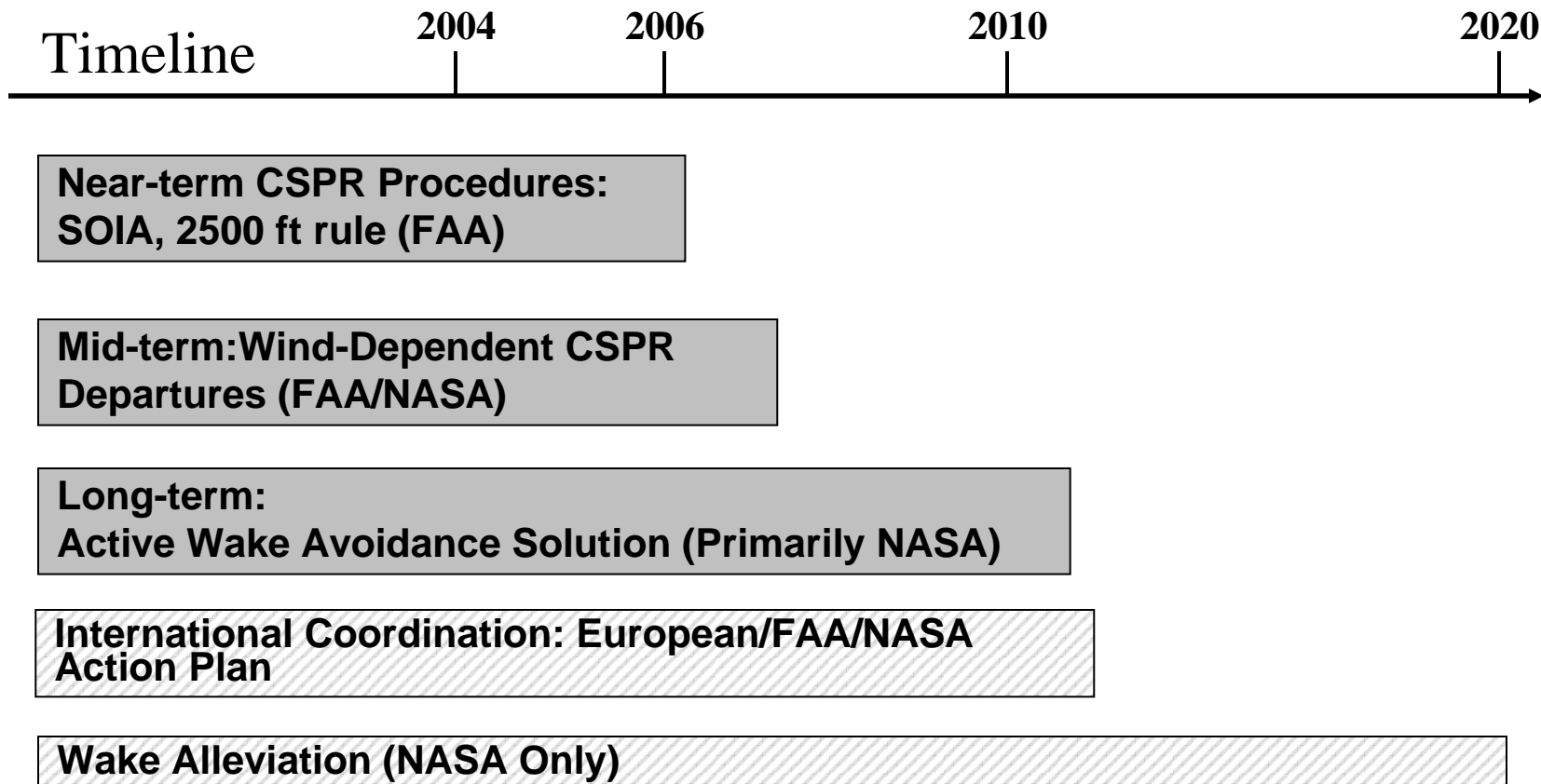
June 28, 2005



Mid-Term Solution as a Part of Overall FAA/NASA Wake Turbulence Research



Schedule for the FAA/NASA Wake Turbulence Research Program



**Near-term CSPR Procedures:
SOIA, 2500 ft rule (FAA)**

**Mid-term: Wind-Dependent CSPR
Departures (FAA/NASA)**

**Long-term:
Active Wake Avoidance Solution (Primarily NASA)**

**International Coordination: European/FAA/NASA
Action Plan**

Wake Alleviation (NASA Only)



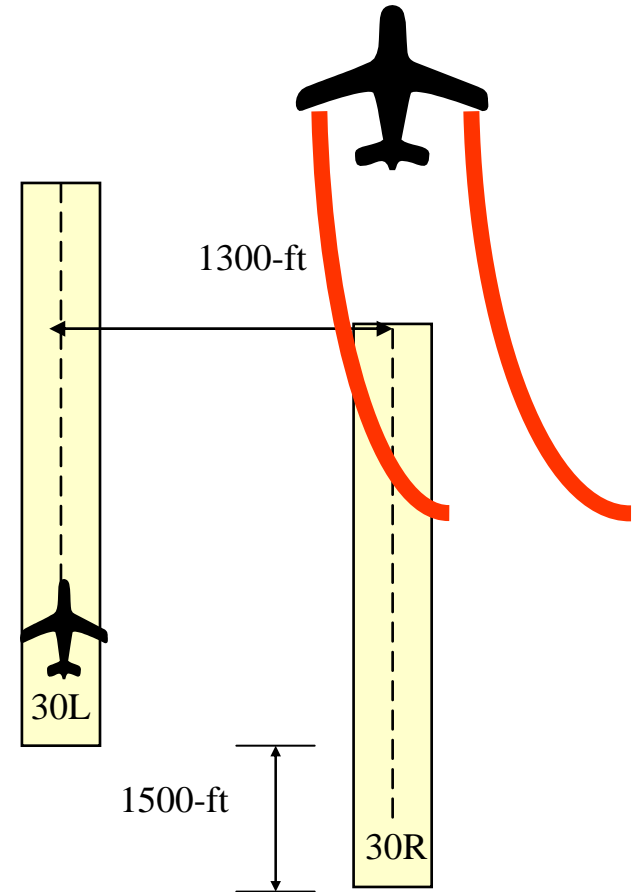
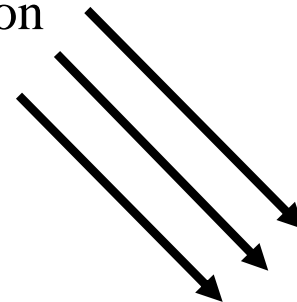


Problem Description

Example: STL Departures

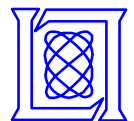


Wind Direction



Good VMC (3500ft and above)	Low VMC with Dual Arrivals (1200-3500 ft)	Low VMC with Single Arrivals (1000 - 1200 ft)	IMC (below 1000 ft)
66.88%	21.42%	2.50%	9.20%

90.8% of the time, just a
wake constraint

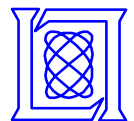




Guidelines for the Initial Concept of Use

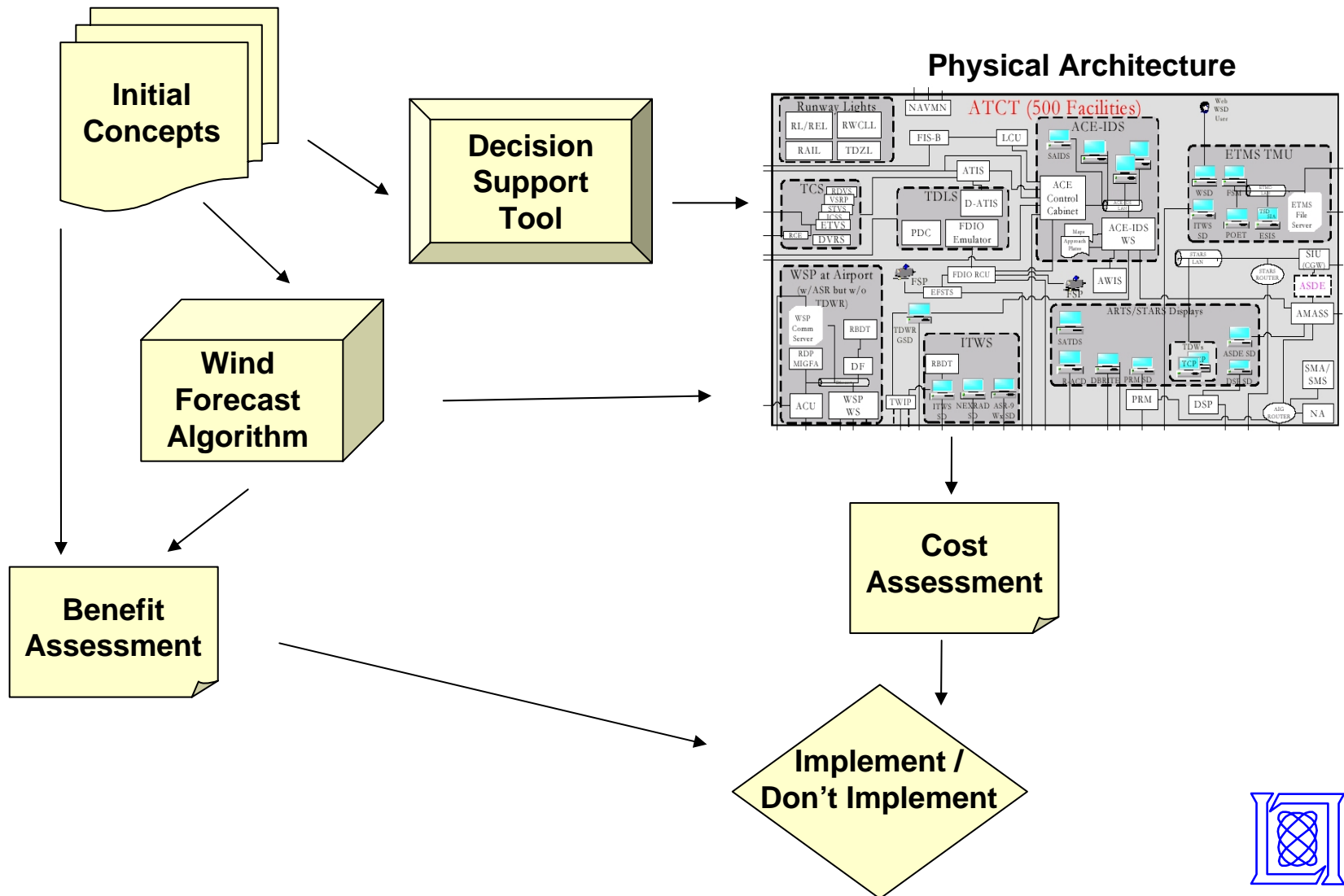


- **Provide a measurable benefit based on**
 - Hours of operation for various ceilings
 - Current separations for those ceilings
 - Current arrival/departure rates for those ceilings
- **Keep proposed operational changes small**
 - Same separation rule for all aircraft when reduced separation is possible
 - Simple indication (red/green) for the controller
 - No change in pilot procedures
- **Use existing NAS wind sensors**
- **Facilitate a stable ATC procedure**
 - Stable wind criteria
 - Extended periods of wind persistence
- **Host any DST on existing ATCT displays**





Integrated Design and Decision Making Process

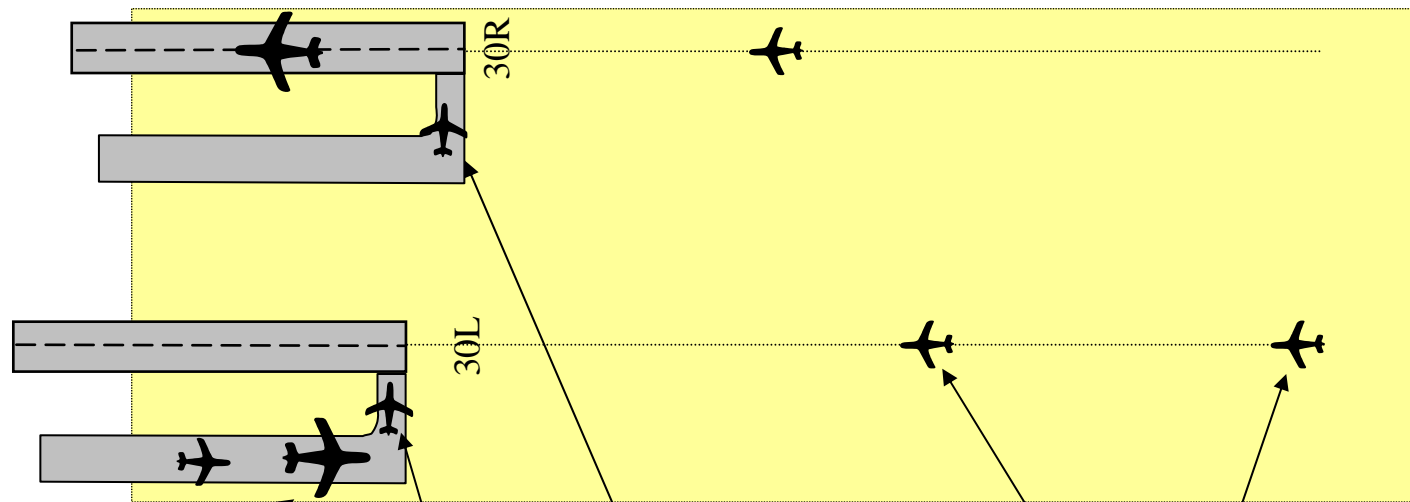




Concept Provides Initial Requirements for Wind Forecast Algorithm



Local controller planning horizon defines forecast requirement of about ten minutes

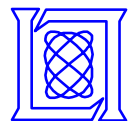


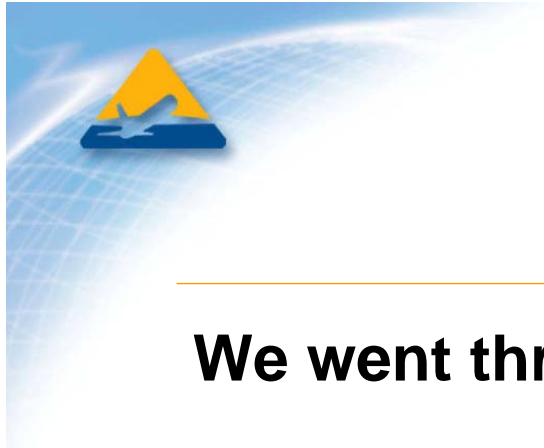
Local controller may develop plan for 2nd or 3rd aircraft in queue. Considerations include:

1) Type of aircraft in front

2) Type of aircraft just departing the parallel runway

3) Aircraft positions on final





Introduction

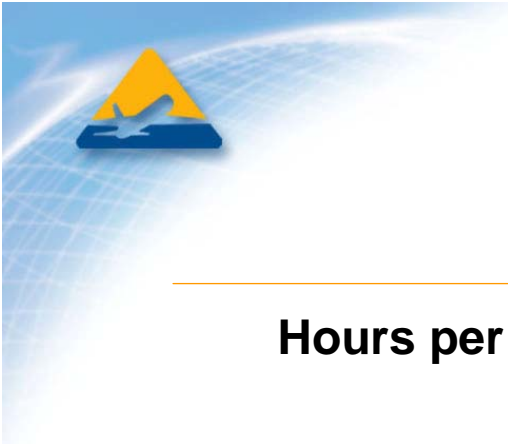


We went through a series of questions:

- **Question 1: Is the wind favorable often enough to get benefit?**
- **Question 2: Is the surface wind predictable?**
- **Question 3: Is the wind aloft predictable?**

The answers to these questions led to starting a prototype development effort

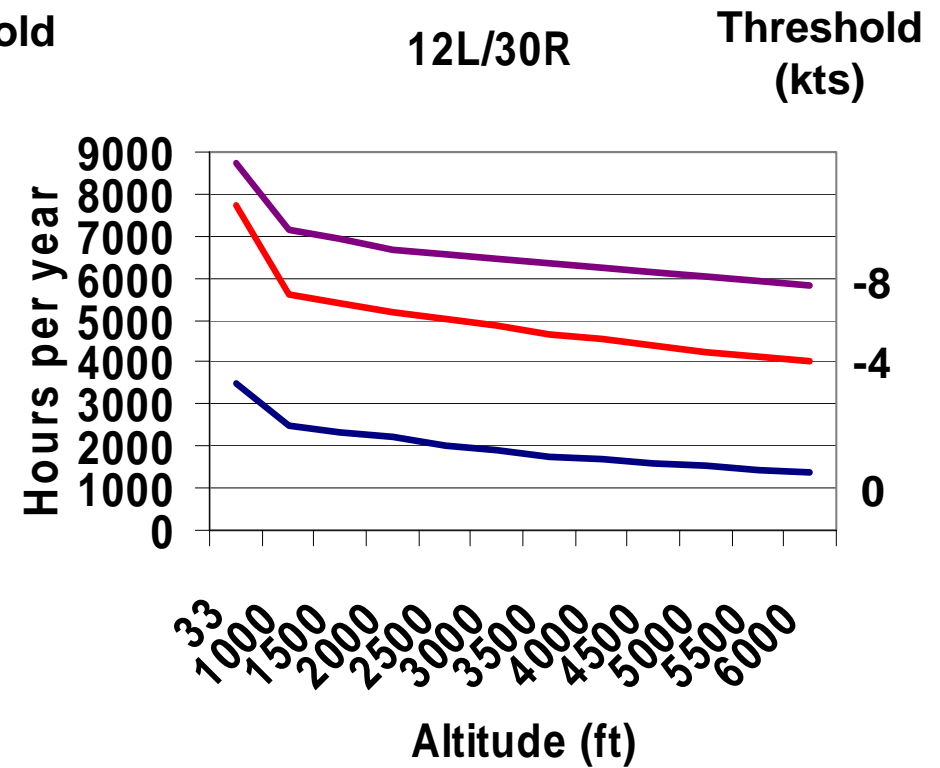
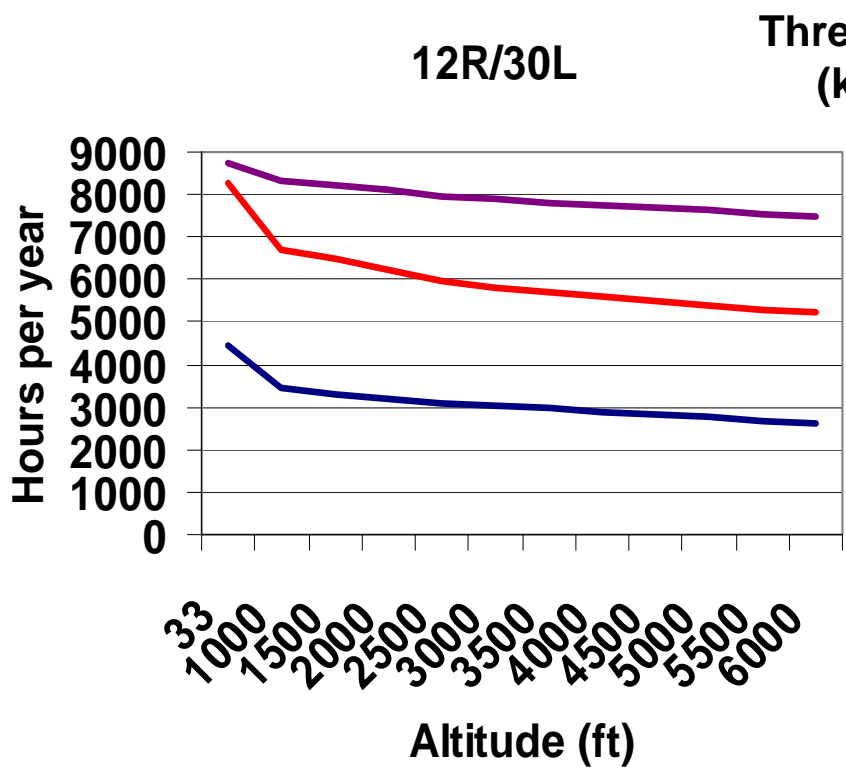




RUC/ASOS Climatology



Hours per year RUC/ASOS winds favorable by altitude

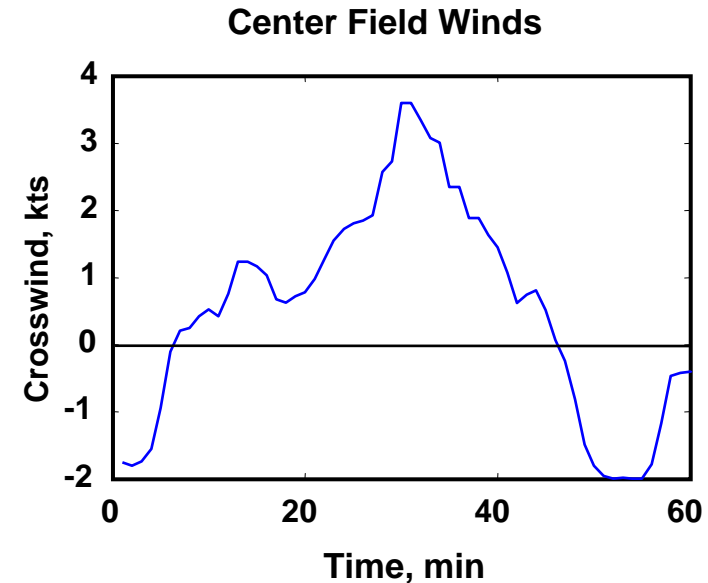




Prediction of Surface Crosswind



- **Need to predict when 2-minute mean crosswind will stay above threshold**
- **Time horizon much shorter for departures than arrivals**
 - 20 minutes for planning
 - 5 minutes for safety
- **Approach: Predict the range of future crosswinds. When the range of crosswinds are all above threshold, reduced spacing allowed.**

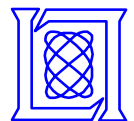
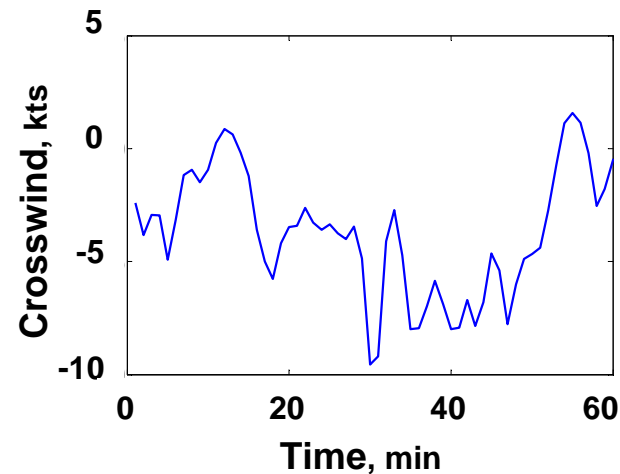
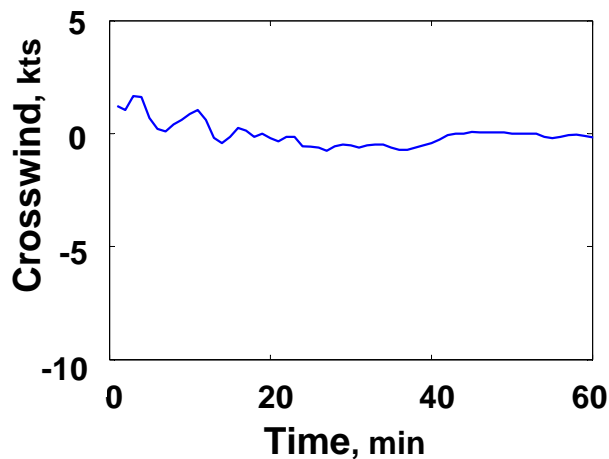
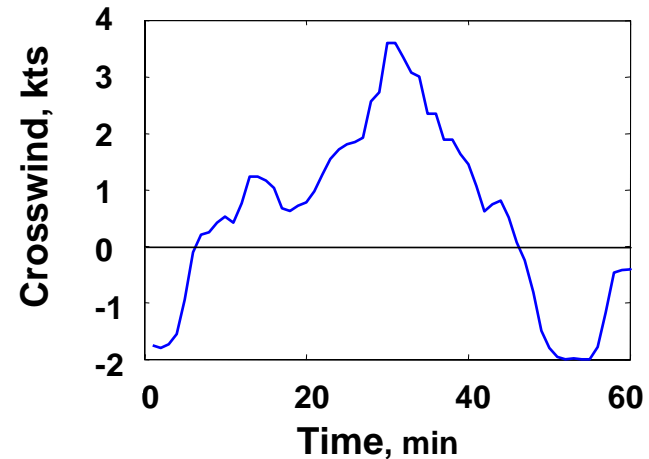




Prediction of Surface Crosswind

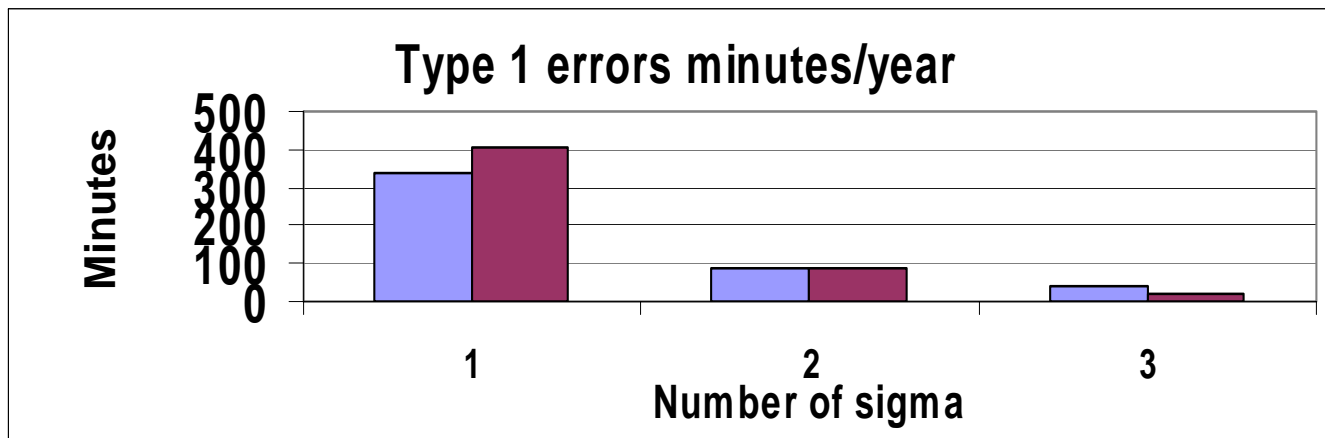
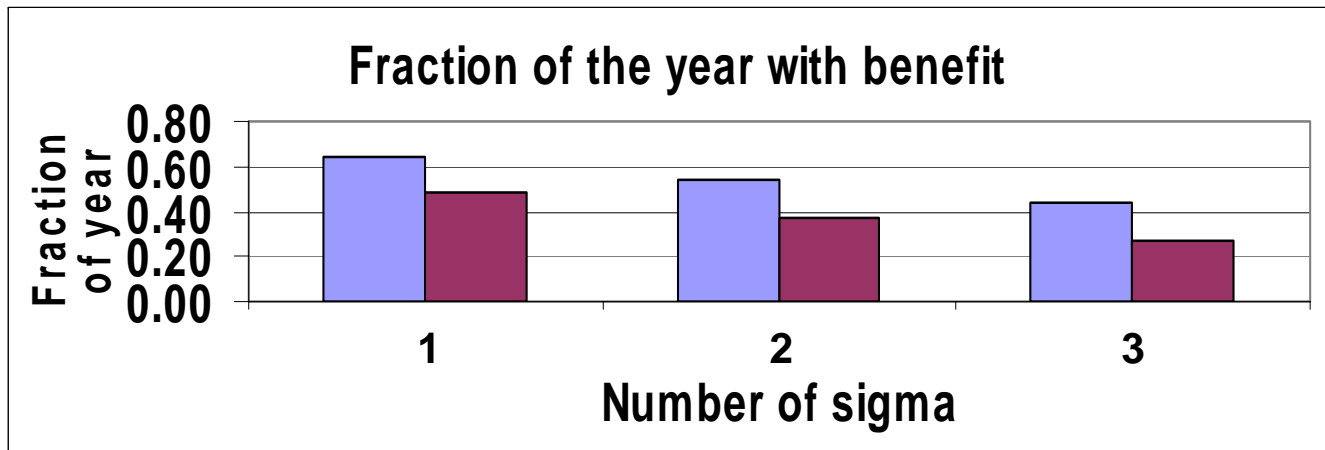


- Predict mean crosswind and variability (std dev) separately
- Predicted range of crosswind = **mean \pm n*standard deviations**
- Take advantage of trends
- Take advantage of current variability
- Use a mix of time scales
- Use linear regression to build models

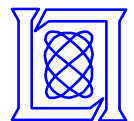


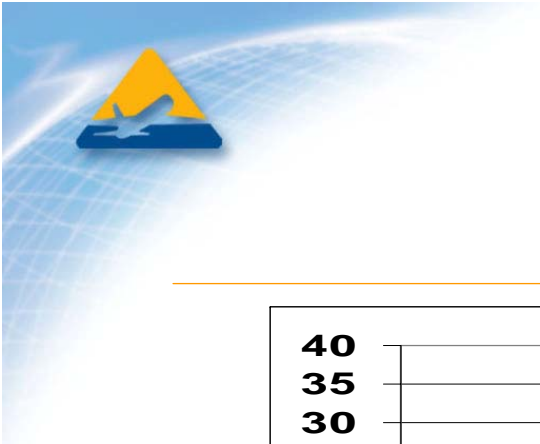


Surface Crosswind Prediction Performance



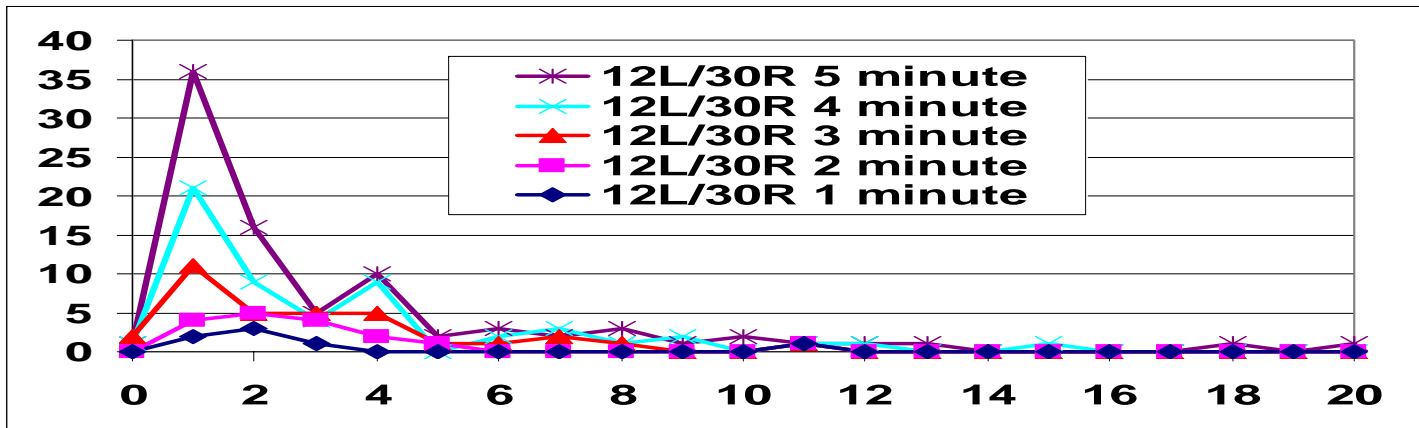
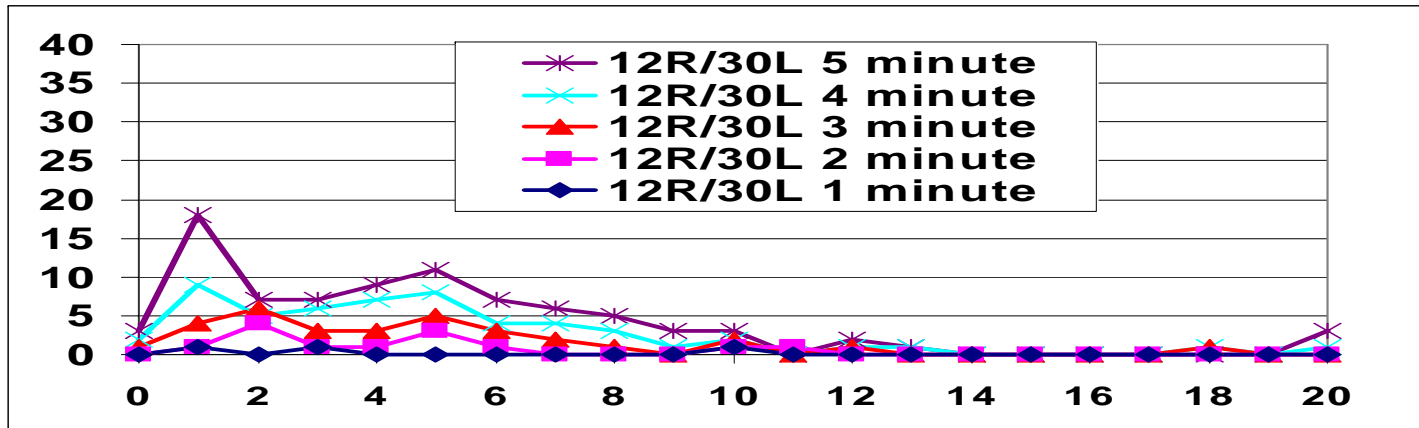
- **-4 kt crosswind threshold**





Type 1 Errors By Magnitude And Timing

Minutes of type 1 errors/yr



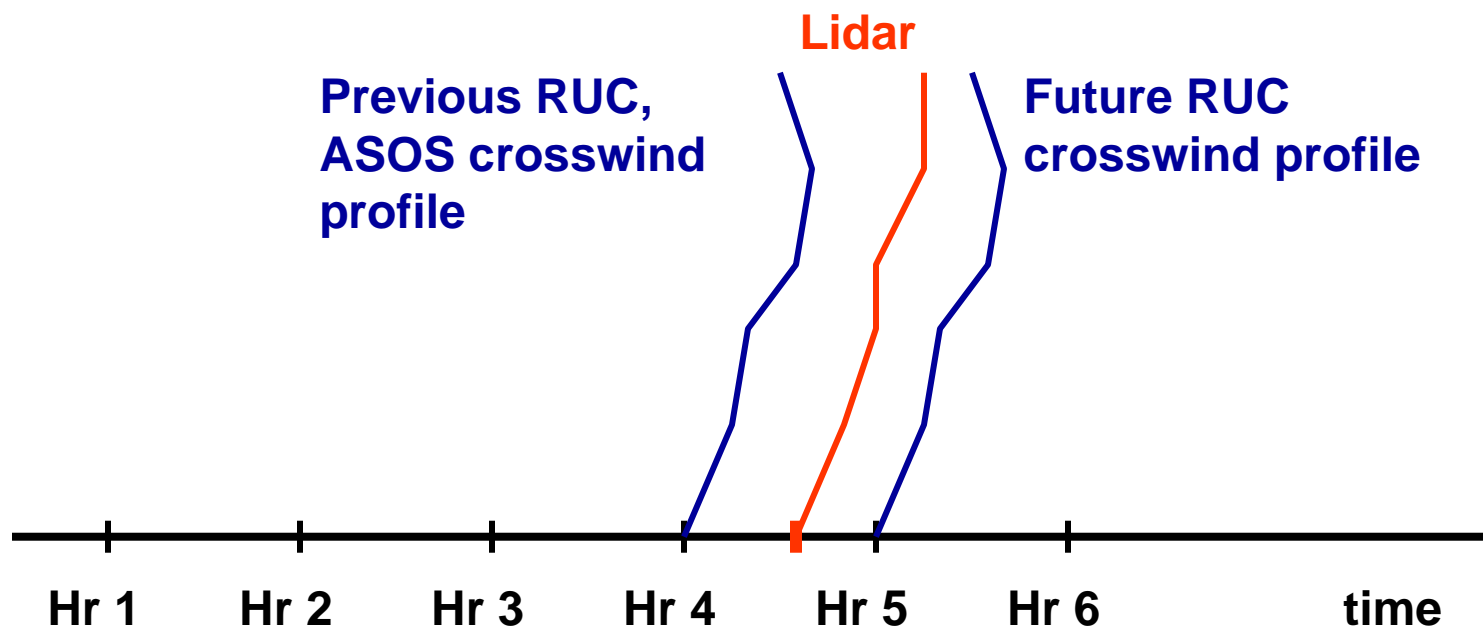
Magnitude of error (kts)

- -4 kt crosswind threshold



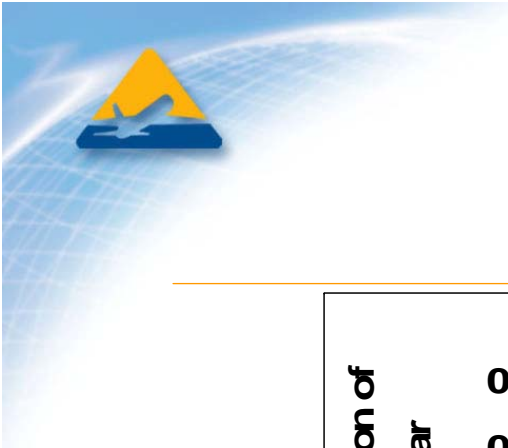


Prediction Of Winds Aloft

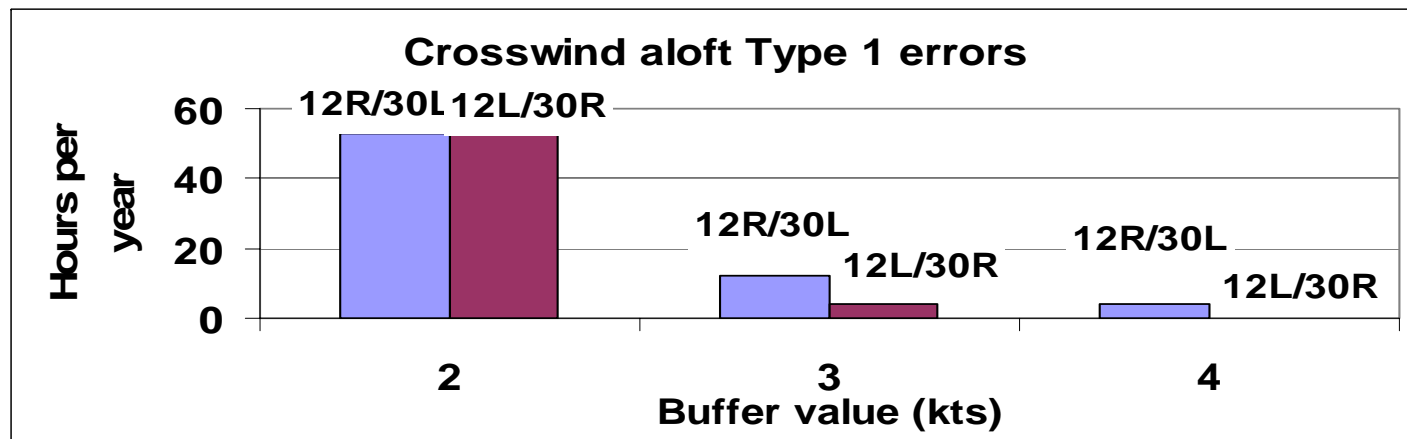
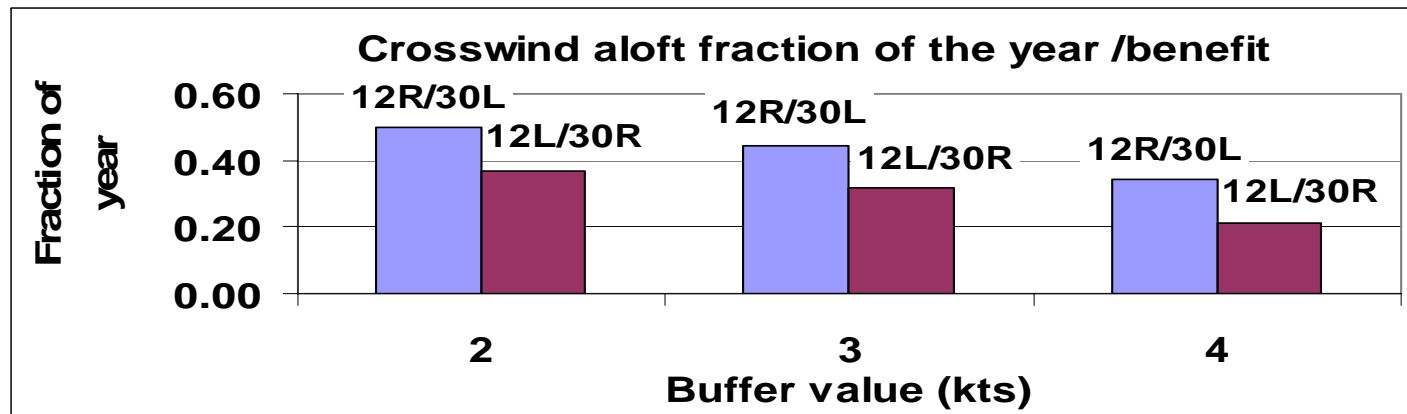


- If blue crosswind profiles have crosswinds greater than threshold + buffer: Predict wind aloft favorable
- Validate against Lidar profile (red profile)





Crosswinds Aloft Results

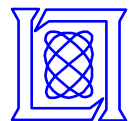
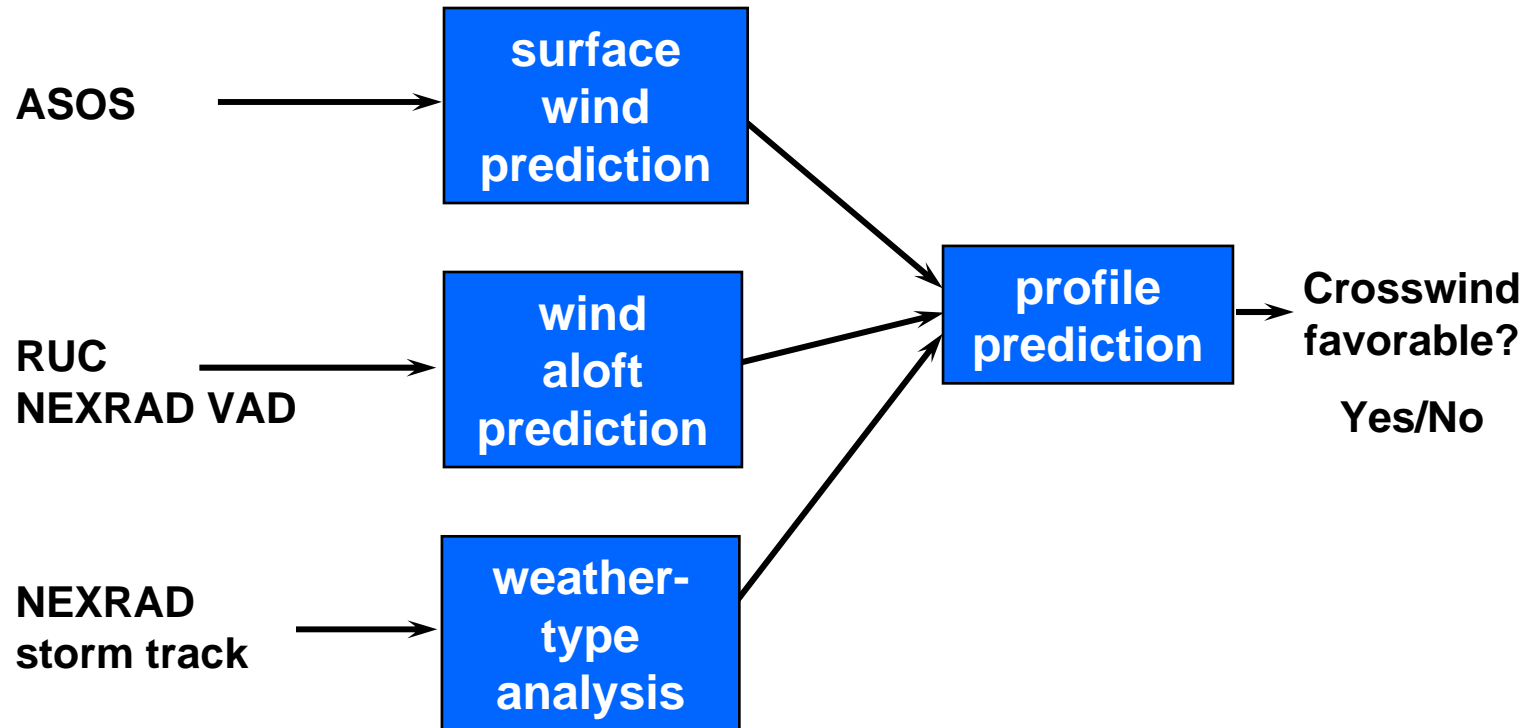


- Surface to 1000 ft
- 1437 samples, over 8 months
- 1 error scales to 4 hours per year





Prototype Wind Prediction System





Summary

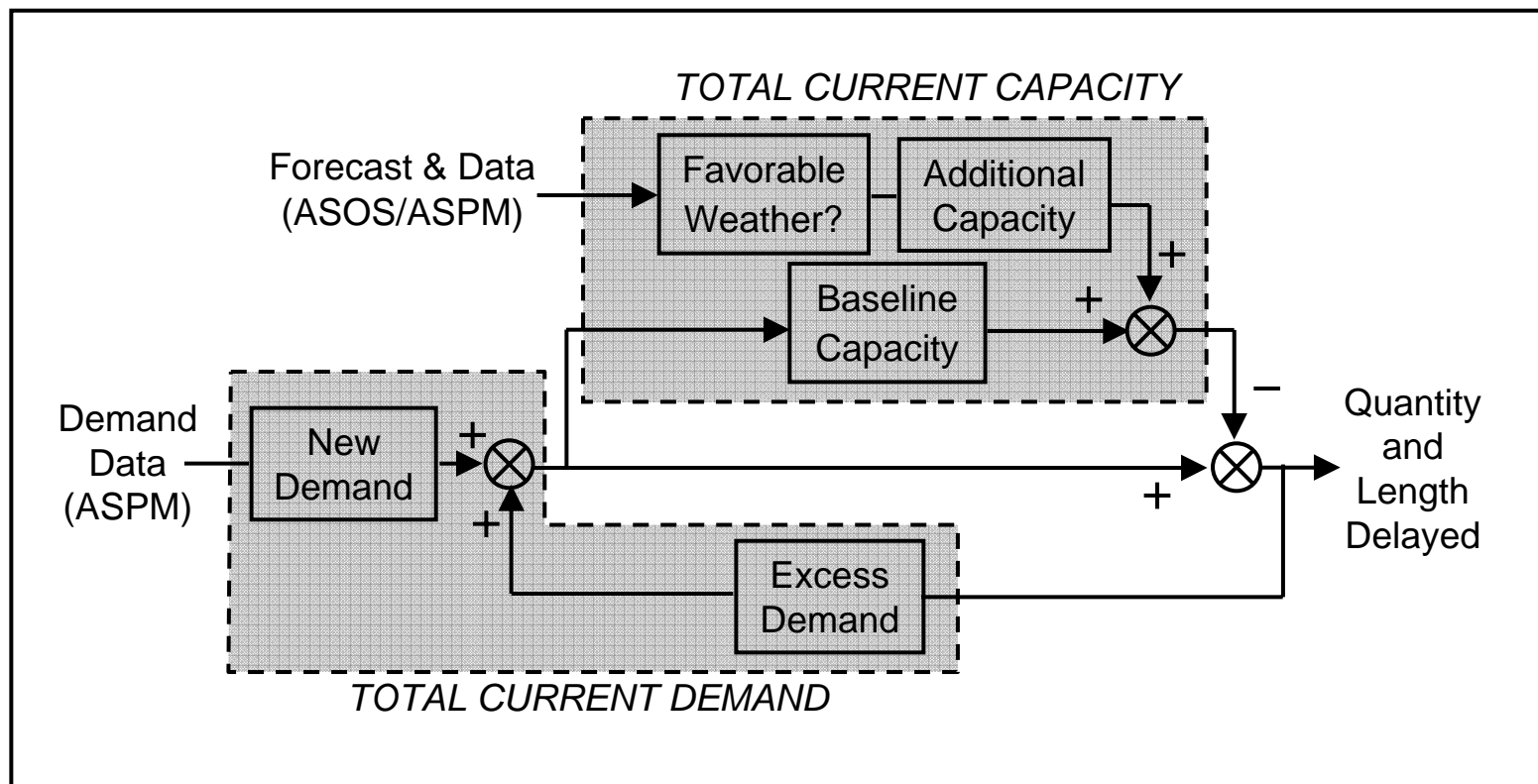


- **There are many time periods with favorable crosswinds aloft at St Louis**
- **The crosswind prediction results to date are very promising**
- **Prototype development is under way for St Louis**



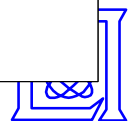
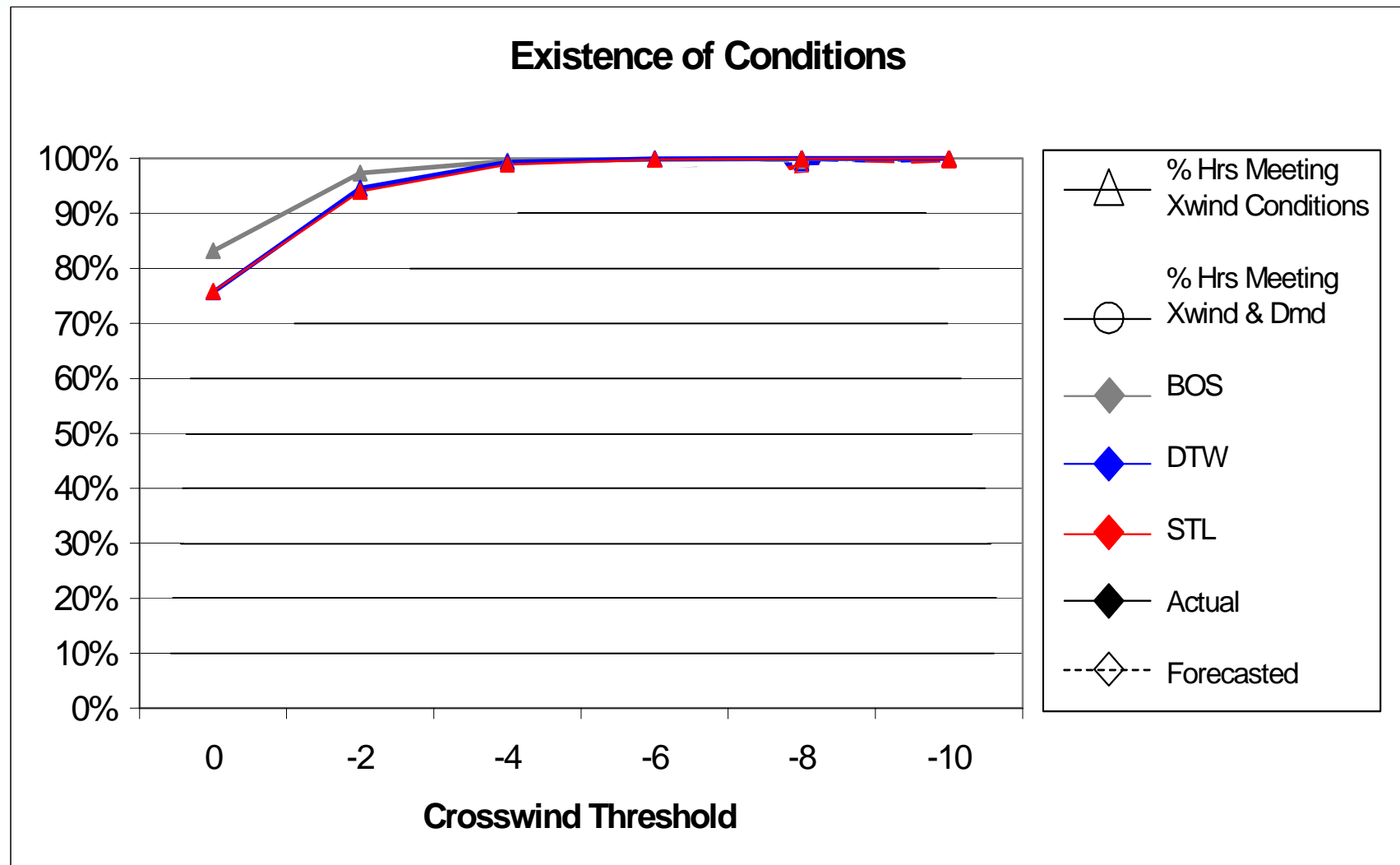


Capacity Benefit Analysis Process



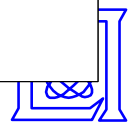
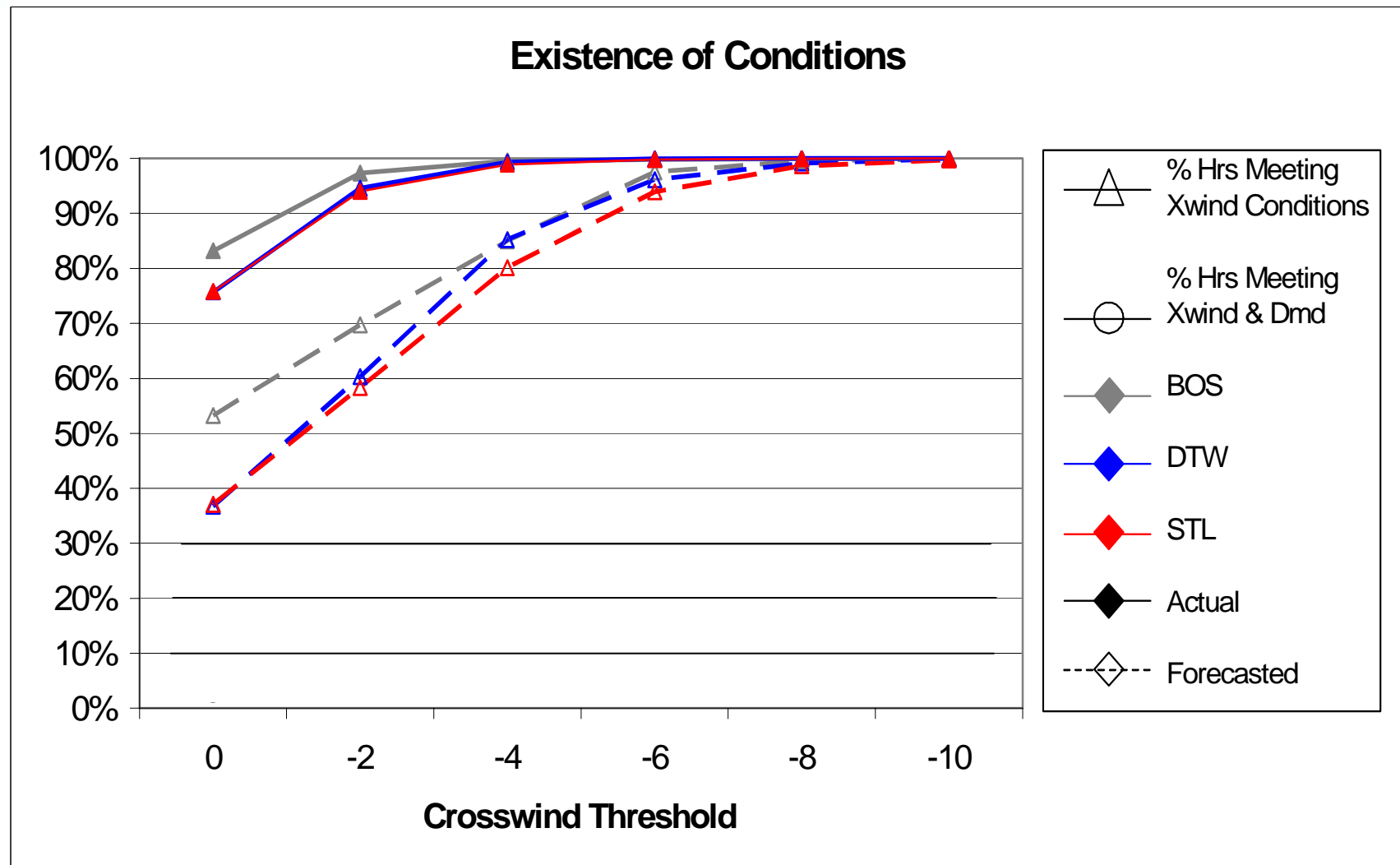


Impact of Excess Demand on Benefits



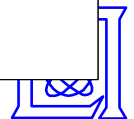
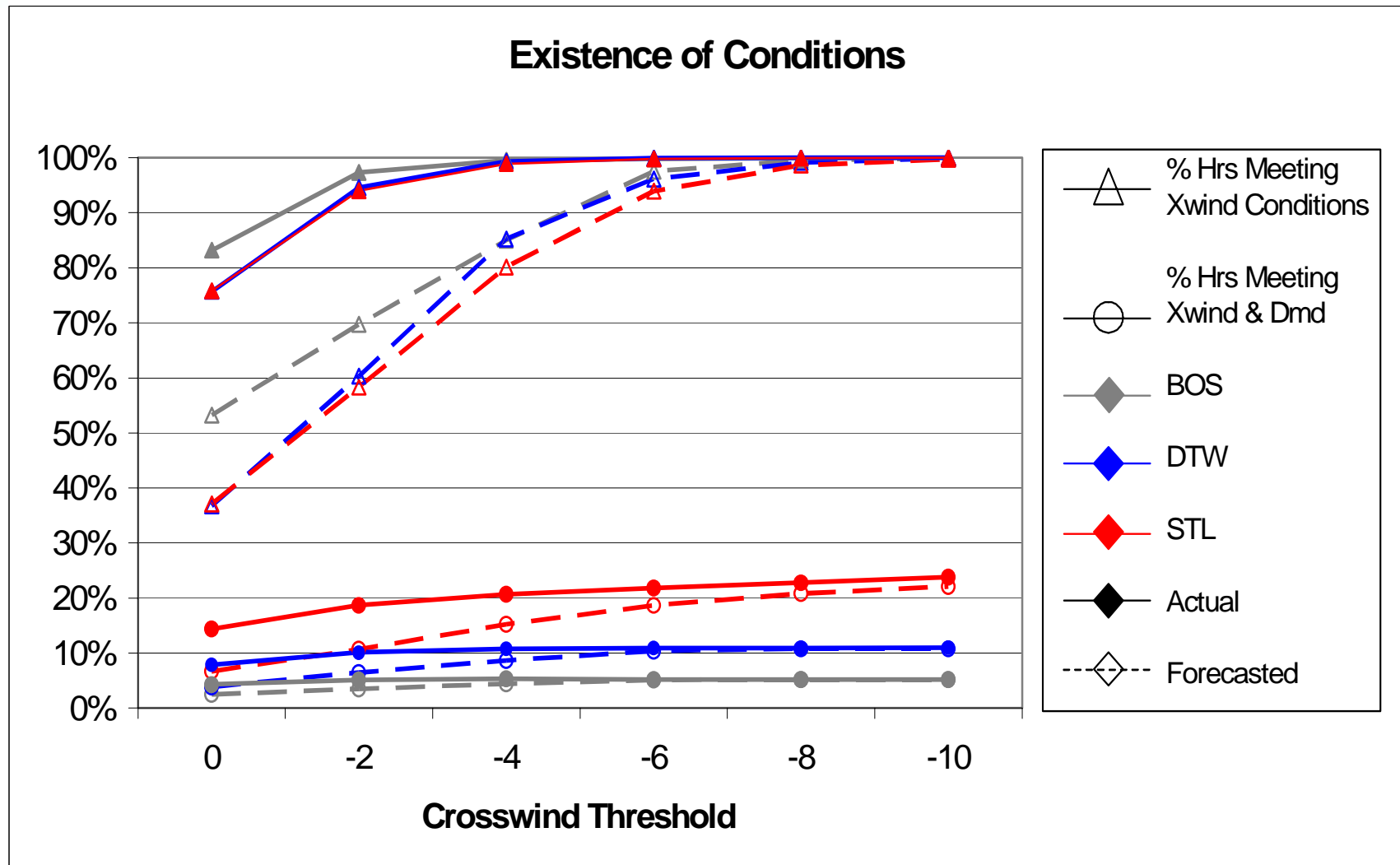


Impact of Excess Demand on Benefits





Impact of Excess Demand on Benefits

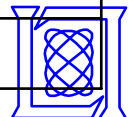




Capacity Enhancements



		Percentage Improvement Over Baseline Departure Capacity	
Airport/ Runway Pair	Percentage Heavies and B757s	Wind-Based Departure Procedure	Wind-Based Departure Procedure with Heavies/B757s Departing From Downwind Runway
CLE 5 W/R	1%	1%	3%
STL 12 L/R	7%	3%	14%
PHL 9 L/R	9%	5%	16%
SEA 16 L/R	12%	7%	11%
DTW 21 C/L	13%	19%	23%
DFW 35 C/L	14%	8%	12%
BOS 22 L/R	15%	8%	13%
EWR 22 L/R	18%	9%	14%
SFO 28 L/R	27%	14%	19%





Sample Local Control Position CHI on ACE-IDS



00080002 OKC Tower

WIND
030/15

ALTIMETER
29.88

TDWR
RVR

Sunrise/Sunset

Weight Class Groups
Landing Wake Turbulence
Departing Wake Turbulence
Departure Path Turbulence

PIREPS

NOTAMS
SUS 8L/26R RWNY LGTS OTS.
BLV LCY NDB OTS
CPS REMOTE FREQ. 122.1 OTS. USE 122.65

SUS
AWOS VFR
119.55
APCH IN USE
VA 8L/8R

CPS
Data Expired
Data Expired – Contact CPS Tower
APCH IN USE
VIS RWY12

BLV
Data Expired
Data Expired – Contact BLV Tower
APCH IN USE
WIND
ALTIMETER
VA 14L
070/12
29.89

STL
Record New ATIS Broadcast
METAR KSTL 231752Z 03015KT 10SM SCT250 38/18 A2989
APCH IN USE
WIND
ALTIMETER
VA 12L/12R
090/10
29.88

SIA MAIN APPROACH CHARTS AIRPORT INFO **Wake Change** CHECKLIST EMERGENCY CHECKLIST OMC ALT 29.88

Cannot use color as sole indicator.

Need alarm if wake-free indication changes while controller is viewing another page





Simulation Facility

