AIRPORT OPERATIONS ANALYSIS & IMPROVEMENT

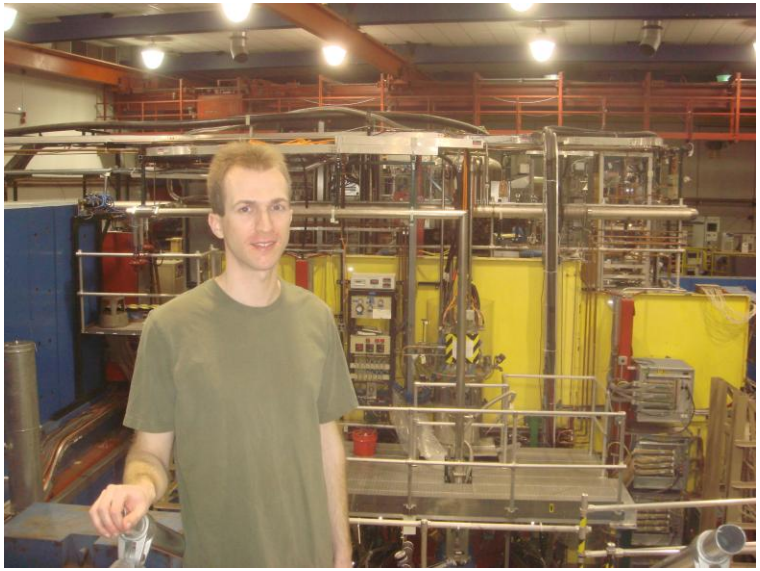
Steve Stroiney
2013-04-26
Saab Sensis Corporation

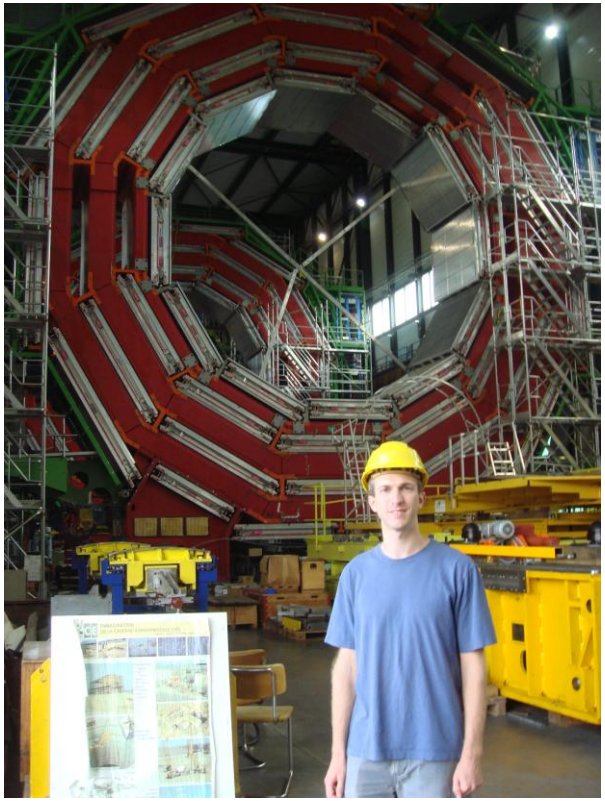
OUTLINE

- Myself – my background
- The Collaboration – Saab Sensis
- Background & Motivation – how airports work
- The Hardware – sensors & data sources
- Monte Carlo – simulation of runway safety systems
- Results – departure management at JFK airport
- Final Thoughts – comparison to particle physics

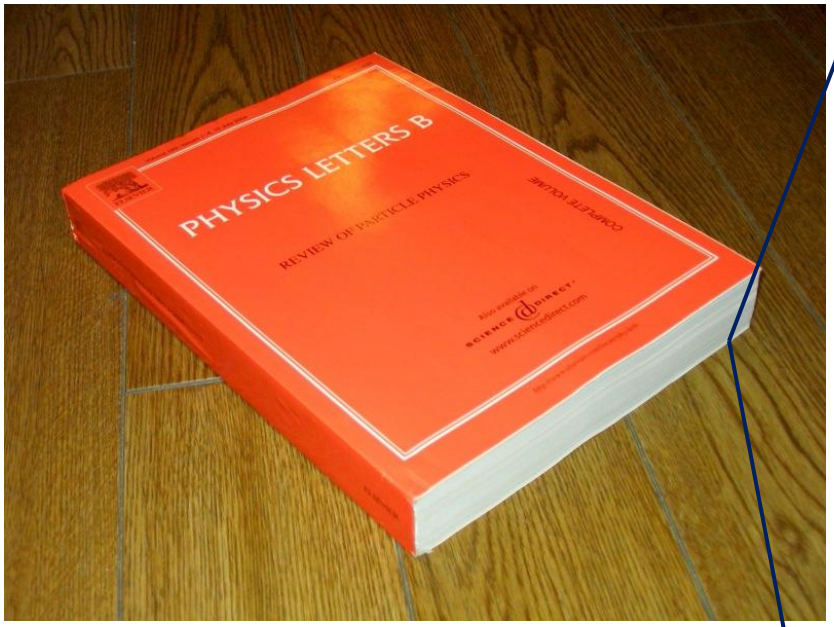
MY BACKGROUND

- Physics grad student at Cornell
- Started fall 2003, completed Ph.D. in Dec. 2008
- Advisor: Anders Ryd
- Worked on the CLEO-c and CMS experiments





MY BACKGROUND



CHARMED MESONS
($C = \pm 1$)

$D^+ = c\overline{d}$, $D^0 = c\overline{u}$, $\overline{D}^0 = \overline{c}u$, $D^- = \overline{c}d$, similarly for D^*'s

$I(J^P) = \frac{1}{2}(0^-)$

$D^{\pm}$

$D^{\pm}$ MASS

The fit includes $D^{\pm}$, D^0, $D_s^{\pm}$, $D^{*\pm}$, D^{*0}, $D_s^{*\pm}$, $D_1(2420)^0$, $D_2^*(2460)^0$, and $D_{s1}(2536)^{\pm}$ mass and mass difference measurements.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
1869.62 ± 0.15 OUR FIT	Error includes scale factor of 1.1.				
1869.5 ± 0.4 OUR AVERAGE					
1869.53 ± 0.49 ± 0.20	110	± 15	ANJOS/N	10A	KEDR e^+e^- at $\psi(3770)$
1870.0 ± 0.5 ± 1.0	317		BARLAG	90C	ACCM π^-Cu 230 GeV
1869.4 ± 0.6			[1] TRILLING	81	RVUE e^+e^- 3.77 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

1875 ± 10	9		AGAMOVICH	87	EMUL Photoproduction
1860 ± 16	6		AGAMOVICH	84	EMUL Photoproduction
1863 ± 4			DERRICK	84	HRS e^+e^- 29 GeV
1868.4 ± 0.5			[1] SCHINDLER	81	MRK2 e^+e^- 3.77 GeV
1874 ± 5			GOLDHABER	77	MRK1 D^0, D^+ recoil spectra
1868.3 ± 0.9			[1] PERUZZI	77	LGW e^+e^- 3.77 GeV
1874 ± 11			PICCOLO	77	MRK1 e^+e^- 4.03, 4.41 GeV
1876 ± 15	50		PERUZZI	76	MRK1 $K^{\mp}\pi^{\pm}\pi^{\pm}$

[1] PERUZZI 77 and SCHINDLER 81 errors do not include the 0.13% uncertainty in the absolute SPEAR energy calibration. TRILLING 81 uses the high precision $\Delta(\psi(3.1S))$ and $\psi(2.1S)$ measurements of ZHOLENTZ 80 to determine this uncertainty and combines the PERUZZI 77 and SCHINDLER 81 results to obtain the value quoted.

$D^{\pm}$ MEAN LIFE

Measurements with an error > 100×10^{-15} s have been omitted from the Listings.

VALUE (10^{-12} s)	EVTS	DOCUMENT ID		TECN	COMMENT
1.040 ± 0.007 OUR AVERAGE					
1039.4 ± 4.3 ± 7.0	110k		LINK	02I	FOCS γ nucleus, $\approx$ 180 GeV
$1033.6 \pm 22.2 \,^{+9.9}_{-12.7}$	3777		BONVICINI	99	CLEO e^+e^- near $\Upsilon(4S)$
1040 ± 15 ± 11	9k		FRABETTI	94D	E687 $D^+ \to K^-\pi^+\pi^+$

• • • We do not use the following data for averages, fits, limits, etc. • • •

1075 ± 40 ± 18	2455		FRABETTI	91	E687 γ Be, $D^+ \to K^-\pi^+\pi^+$
1030 ± 80 ± 60	200		AVERY	85	NA14 γ $D^+ \to K^-\pi^+\pi^+$
$1050 \,^{+77}_{-72}$	363		BARLAG	90C	ACCM π^-Cu 230 GeV
1040 ± 70 ± 70	363		ALBRECHT	88I	ARG e^+e^- 10 GeV
1030 ± 50 ± 25	2992		RAAS	88	ES91 Photoproduction

[2] BARLAG 90C estimates the systematic error to be negligible.

$D^{\pm}$ DECAY MODES

Most decay modes (other than the semileptonic modes) that involve a neutral K meson are now given as K^0_S modes, not as K^0 modes. Nearly always it is a K^0_S that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that $\Gamma(K^0_S) = \Gamma(\overline{K}^0)$.

Scale factor/

Leptonic and semileptonic modes

Γ_{12}	$D^+ \to e^+\nu_e$	< 8.8	$\times 10^{-6}$	CL=90%
Γ_{13}	$D^+ \to \mu^+\nu_\mu$	(3.82 ±0.33) $\times 10^{-4}$		
Γ_{14}	$D^+ \to \tau^+\nu_\tau$	< 1.2	$\times 10^{-3}$	CL=90%
Γ_{15}	$D^+ \to \overline{K}^0 e^+\nu_e$	(8.83 ±0.22) %		
Γ_{16}	$D^+ \to \overline{K}^0 \mu^+\nu_\mu$	(9.2 ±0.6) %		
Γ_{17}	$D^+ \to K^-\pi^+ e^+\nu_e$	(4.00 ±0.10) %		
Γ_{18}	$D^+ \to \overline{K}^*(892)^0 e^+\nu_e$, $\overline{K}^*(892)^0 \to K^-\pi^+$	(3.60 ±0.10) %		
Γ_{19}	$D^+ \to (K^-\pi^+)_{S\text{-wave}} e^+\nu_e$	(2.32 ±0.10) $\times 10^{-3}$		
Γ_{20}	$D^+ \to \overline{K}^*(1410)^0 e^+\nu_e$, $\overline{K}^*(1410)^0 \to K^-\pi^+$	< 6	$\times 10^{-3}$	CL=90%
Γ_{21}	$D^+ \to \overline{K}_0^*(1430)^0 e^+\nu_e$, $\overline{K}_0^*(1430)^0 \to K^-\pi^+$	< 5	$\times 10^{-4}$	CL=90%
Γ_{22}	$D^+ \to K^-\pi^+ e^+\nu_e$ nonresonant	< 7	$\times 10^{-3}$	CL=90%
Γ_{23}	$D^+ \to K^-\pi^+\mu^+\nu_\mu$	(3.8 ±0.4) %		
Γ_{24}	$D^+ \to \overline{K}^*(892)^0 \mu^+\nu_\mu$, $\overline{K}^*(892)^0 \to K^-\pi^+$	(3.52 ±0.10) %		
Γ_{25}	$D^+ \to K^-\pi^+\mu^+\nu_\mu$ nonresonant	(2.0 ±0.5) $\times 10^{-3}$		
Γ_{26}	$D^+ \to K^-\pi^+\pi^0\mu^+\nu_\mu$	< 1.6	$\times 10^{-3}$	CL=90%
Γ_{27}	$D^+ \to \pi^0 e^+\nu_e$	(4.05 ±0.18) $\times 10^{-3}$		
Γ_{28}	$D^+ \to \eta e^+\nu_e$	(1.14 ±0.10) $\times 10^{-3}$		
Γ_{29}	$D^+ \to \rho^0 e^+\nu_e$	(2.2 ±0.4) $\times 10^{-3}$		
Γ_{30}	$D^+ \to \rho^0\mu^+\nu_\mu$	(2.8 ±0.4) $\times 10^{-3}$		
Γ_{31}	$D^+ \to \omega e^+\nu_e$	(1.6 $^{+0.2}_{-0.3}$) $\times 10^{-3}$		
Γ_{32}	$D^+ \to \eta'(958) e^+\nu_e$	(2.2 ±0.5) $\times 10^{-4}$		
Γ_{33}	$D^+ \to \phi e^+\nu_e$	< 9	$\times 10^{-4}$	CL=90%

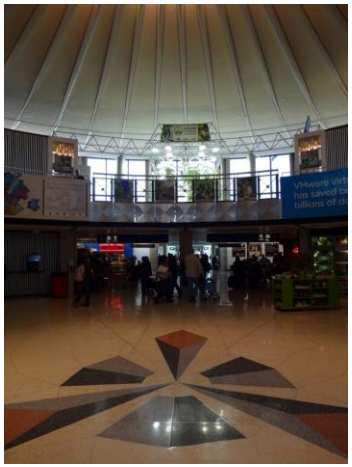
Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

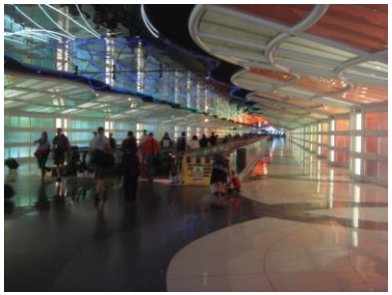
Γ_{34}	$D^+ \to \overline{K}^*(892)^0 e^+\nu_e$	(5.52 ±0.15) %		
Γ_{35}	$D^+ \to \overline{K}^*(892)^0 \mu^+\nu_\mu$	(5.28 ±0.15) %		
Γ_{36}	$D^+ \to \overline{K}_0^*(1430)^0 \mu^+\nu_\mu$	< 2.6	$\times 10^{-4}$	
Γ_{37}	$D^+ \to \overline{K}_1(1680)^0 \mu^+\nu_\mu$	< 1.5	$\times 10^{-4}$	

Hadronic modes with a K^- or $\overline{K}^0 K^+$

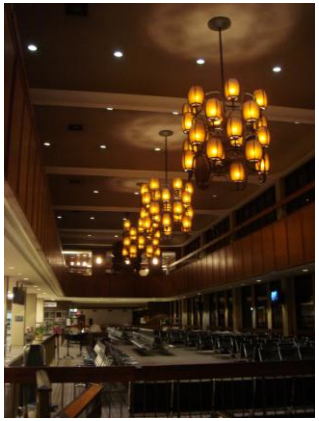
Γ_{38}	$D^+ \to K^0_S\pi^+$	(1.47 ±0.07) %		S=2.0
Γ_{39}	$D^+ \to K^0_L\pi^+$	(1.46 ±0.05) %		
Γ_{40}	$D^+ \to K^-2\pi^+$	[a] (9.13 ±0.19) %		S=1.1
Γ_{41}	$D^+ \to (K^-\pi^+)_{S\text{-wave}}\pi^+$	(7.32 ±0.19) %		
Γ_{42}	$D^+ \to \overline{K}_0^*(800)^0\pi^+$, $\overline{K}_0^*(800) \to K^-\pi^+$			
Γ_{43}	$D^+ \to \overline{K}_0^*(1430)^0\pi^+$, $\overline{K}_0^*(1430)^0 \to K^-\pi^+$	[a] (1.21 ±0.26) %		
Γ_{44}	$D^+ \to \overline{K}^*(892)^0\pi^+$, $\overline{K}^*(892)^0 \to K^-\pi^+$	(1.21 ±0.11) %		
Γ_{45}	$D^+ \to \overline{K}^*(1410)^0\pi^+$, $\overline{K}^{*0} \to K^-\pi^+$	not seen		
Γ_{46}	$D^+ \to \overline{K}_0^*(1430)^0\pi^+$, $\overline{K}_0^*(1430)^0 \to K^-\pi^+$	[a] (2.2 ±0.7) $\times 10^{-4}$		
Γ_{47}	$D^+ \to \overline{K}_1(1680)^0\pi^+$, $\overline{K}_1(1680)^0 \to K^-\pi^+$	[a] (2.1 ±1.1) $\times 10^{-4}$		
Γ_{48}	$D^+ \to K^-(2\pi^+)_{P\text{-}2}$	(1.61 ±0.26) %		
Γ_{49}	$D^+ \to K^-2\pi^+$ nonresonant			
Γ_{50}	$D^+ \to K^0_S\pi^+\pi^0$	[a] (7.09 ±0.21) %		
Γ_{51}	$D^+ \to \overline{K}^*(892)^0\pi^+$, $\overline{K}^*(892)^0 \to K^0_S\pi^0$	(5.45 ±0.17) %		
Γ_{52}	$D^+ \to \overline{K}^*(892)^0\pi^+$, $\overline{K}^*(892)^0 \to K^-\pi^+$	(1.64 ±0.08) %		
Γ_{53}	$D^+ \to \overline{K}_0^*(1430)^0\pi^+$, $\overline{K}_0^*(1430)^0 \to K^0_S\pi^0$	(1.9 ±0.4) $\times 10^{-3}$		
Γ_{54}	$D^+ \to \overline{K}_0^*(1430)^0\pi^+$, $\overline{K}_0^*(1430)^0 \to K^-\pi^+$	(1.9 ±0.4) $\times 10^{-3}$		
Γ_{55}	$D^+ \to \overline{K}_2^*(1430)^0\pi^+$, $\overline{K}_2^*(1430)^0 \to K^0_S\pi^0$	(1.2 ±0.4) $\times 10^{-3}$		
Γ_{56}	$D^+ \to \overline{K}_2^*(1430)^0\pi^+$, $\overline{K}_2^*(1430)^0 \to K^-\pi^+$	(1.2 ±0.4) $\times 10^{-3}$		
Γ_{57}	$D^+ \to \overline{K}_1(1680)^0\pi^+$, $\overline{K}_1(1680)^0 \to K^0_S\pi^0$	(1.1 ±0.5) $\times 10^{-3}$		
Γ_{58}	$D^+ \to \overline{K}_1(1680)^0\pi^+$, $\overline{K}_1(1680)^0 \to K^-\pi^+$	(1.1 ±0.5) $\times 10^{-3}$		
Γ_{59}	$D^+ \to \overline{K}^*(892)^0 a_1(1260)^+$	[a] (9.0 ±1.3) $\times 10^{-3}$		
Γ_{60}	$D^+ \to \overline{K}^*(892)^0 2\pi^+\pi^-$ no-ρ, $\overline{K}^*(892)^0 \to K^-\pi^+$			

EXPLORING AIRPORTS



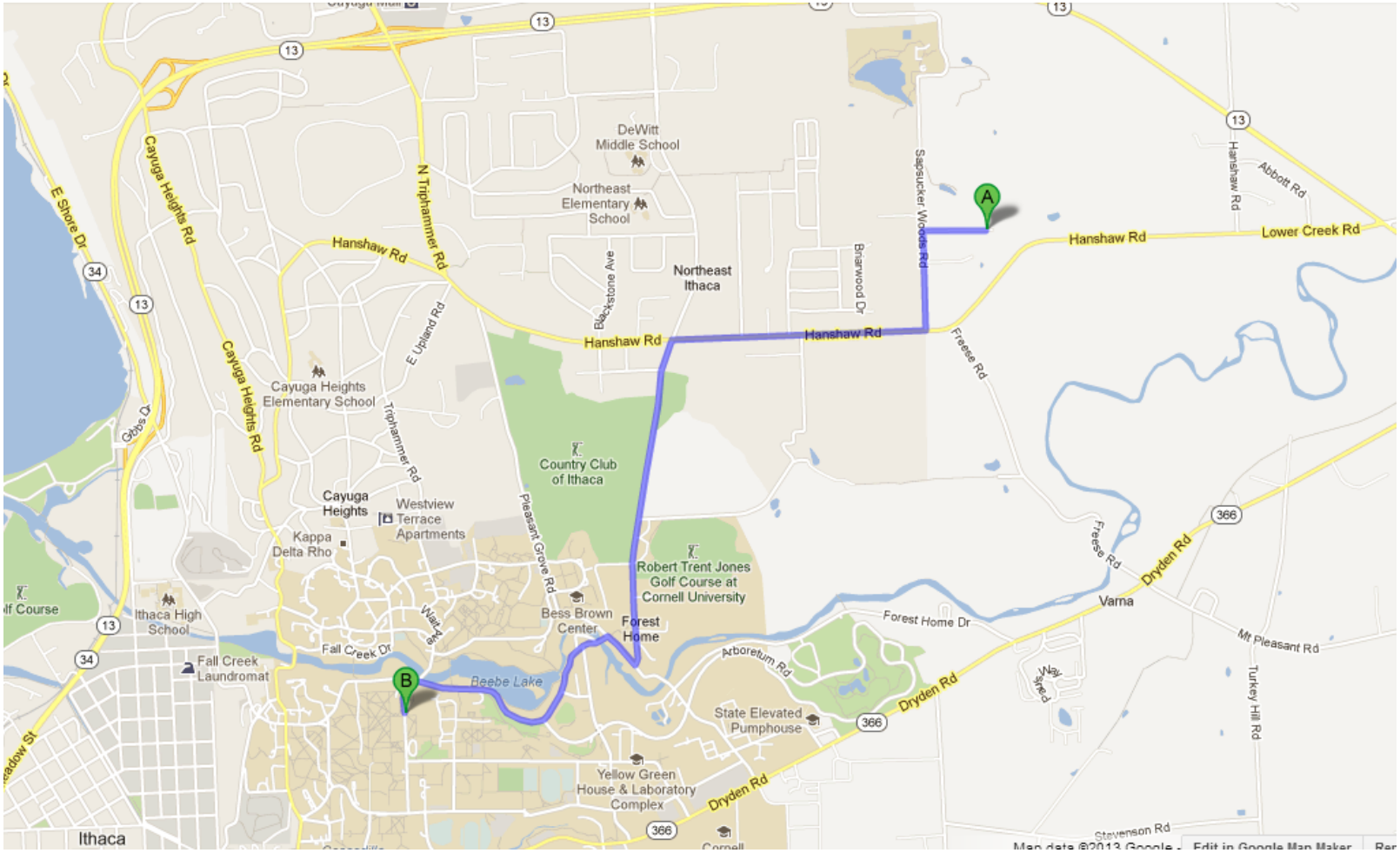







I'VE COME A LONG WAY TO BE HERE TODAY...



OUTLINE

- Myself – my background
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- Background & Motivation – how airports work
- The Hardware – sensors & data sources
- Monte Carlo – simulation of runway safety systems
- Results – departure management at JFK airport
- Final Thoughts – comparison to particle physics

SAAB SENSIS at a glance

- A global aerospace and defense company founded in 1985. Specializing in advanced air traffic management and defense radar and security systems.
- A U.S. company of approximately 500 employees, headquartered in Syracuse.
- A wholly-owned subsidiary of Saab AB since 2011.
- With Saab, Saab Sensis has a strong and broad product portfolio, a global presence and the ability to serve customers in the U.S. and world-wide.

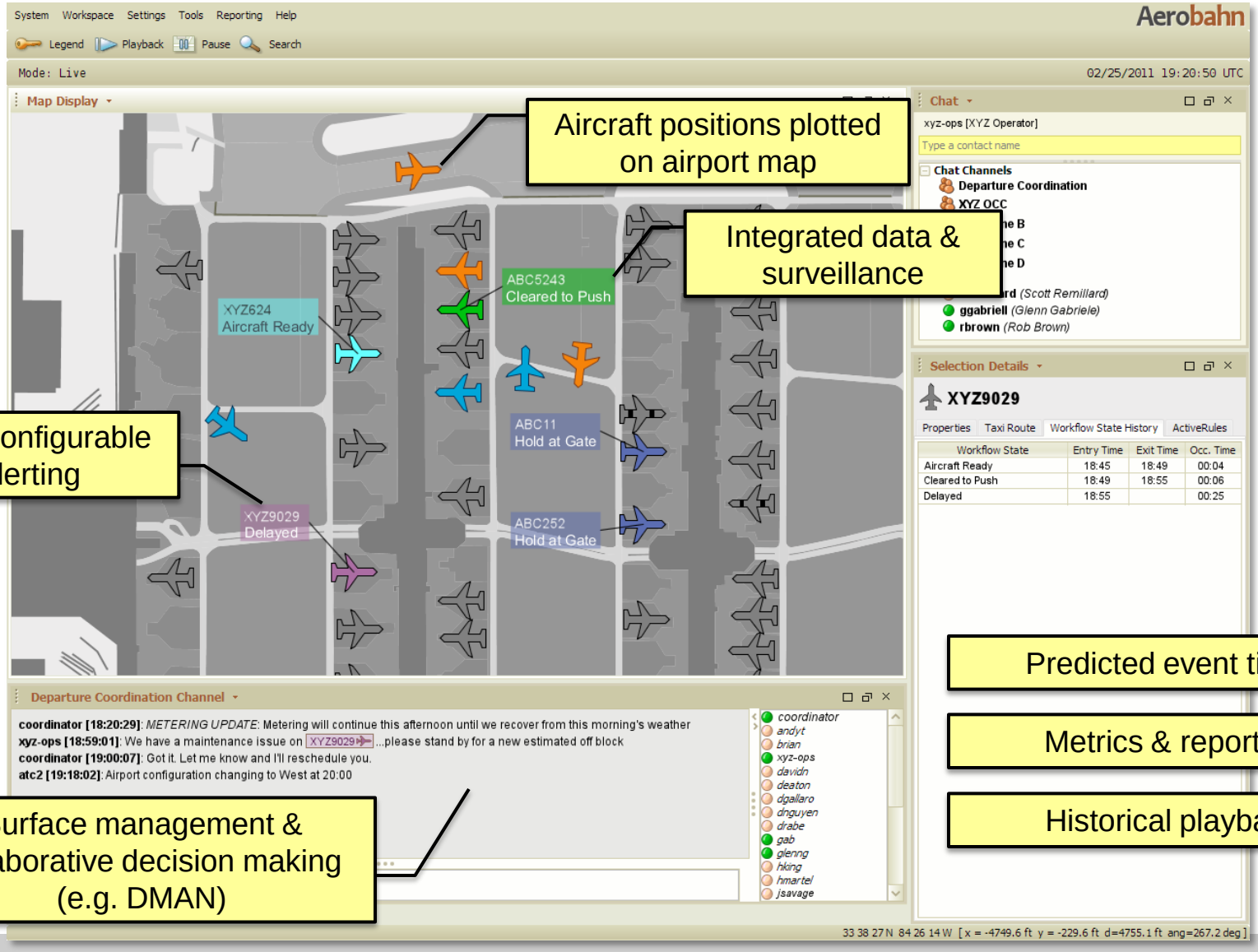
OUR CUSTOMERS

- U.S. Federal Aviation Administration & international counterparts
  - Radar systems
  - Runway safety systems – ASDE-X & Runway Status Lights
  - Data analysis contracts
- Airports & airlines
  - Surface traffic display & optimization tools – Aerobahn
- NASA
  - Studies of future air traffic management concepts
- Department of Defense
  - Military radar systems

OUR CUSTOMERS' GOALS

- Safety
  - Aviation is already very safe, but we can always do better.
  - Will proposed changes reduce safety?
- Efficiency
  - Reduced taxi times, flight times, & delay
  - Improved on-time performance
  - Greater flexibility for airlines
- Interaction of Safety & Efficiency
  - Can we reduce margins to improve efficiency without reducing safety?
- "NextGen"
  - FAA "branding" for all the improvements they'd like to make

SAAB SENSIS AEROBAHN



Aircraft positions plotted on airport map

Integrated data & surveillance

User-configurable alerting

Surface management & collaborative decision making (e.g. DMAN)

Predicted event times

Metrics & reporting

Historical playback

10

WHAT'S MY JOB?

- Title: "Research Engineer" or "Analyst"
- "Advanced Development" division
  - Prototype development, data analysis, benefits studies
  - Wide variety of backgrounds (engineering, math, geology)
- Tools to improve efficiency
  - Led Departure Manager and Managed Gate Operations projects
  - Participated in system design and algorithm development for Aerobahn Departure Metering at JFK airport
- Simulations of future safety systems
  - Developed concepts and algorithms for surface safety systems under NASA projects
- Algorithm development
  - Aircraft movement planning
- Airport data analysis
  - Benefits estimates

WHY THIS JOB?

- It’s near Ithaca
- I’ve always loved airports and airplanes
  - (Site visits! ☺)
- I like to optimize things
- It’s been very interesting and intellectually enriching
  - Artificial intelligence, planning, & optimization algorithms
  - Software development

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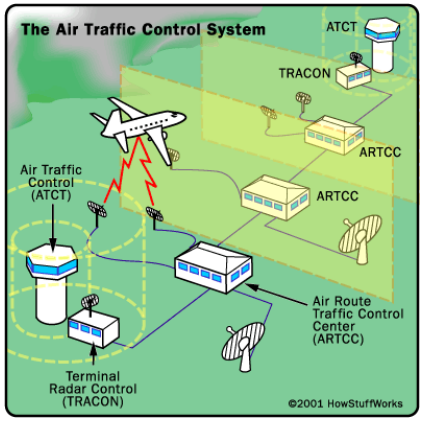

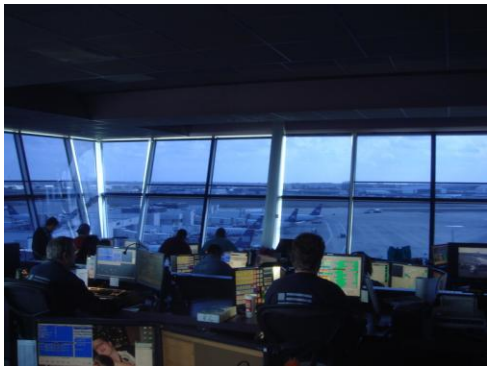

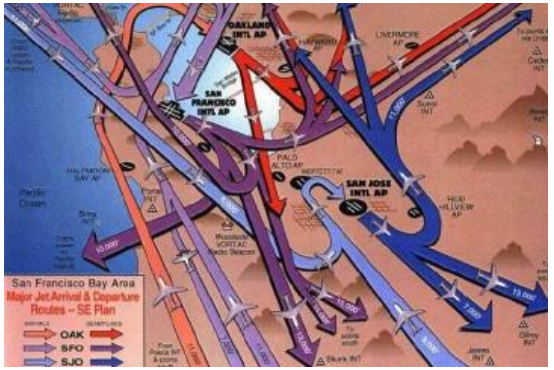

BEHIND THE SCENES...

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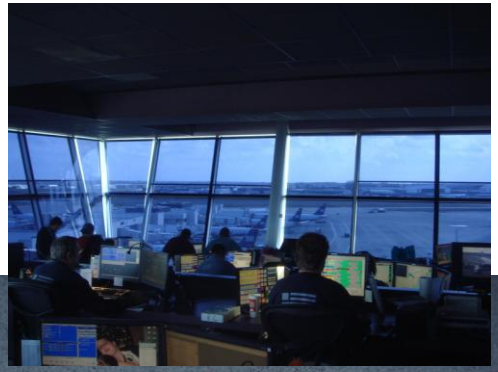
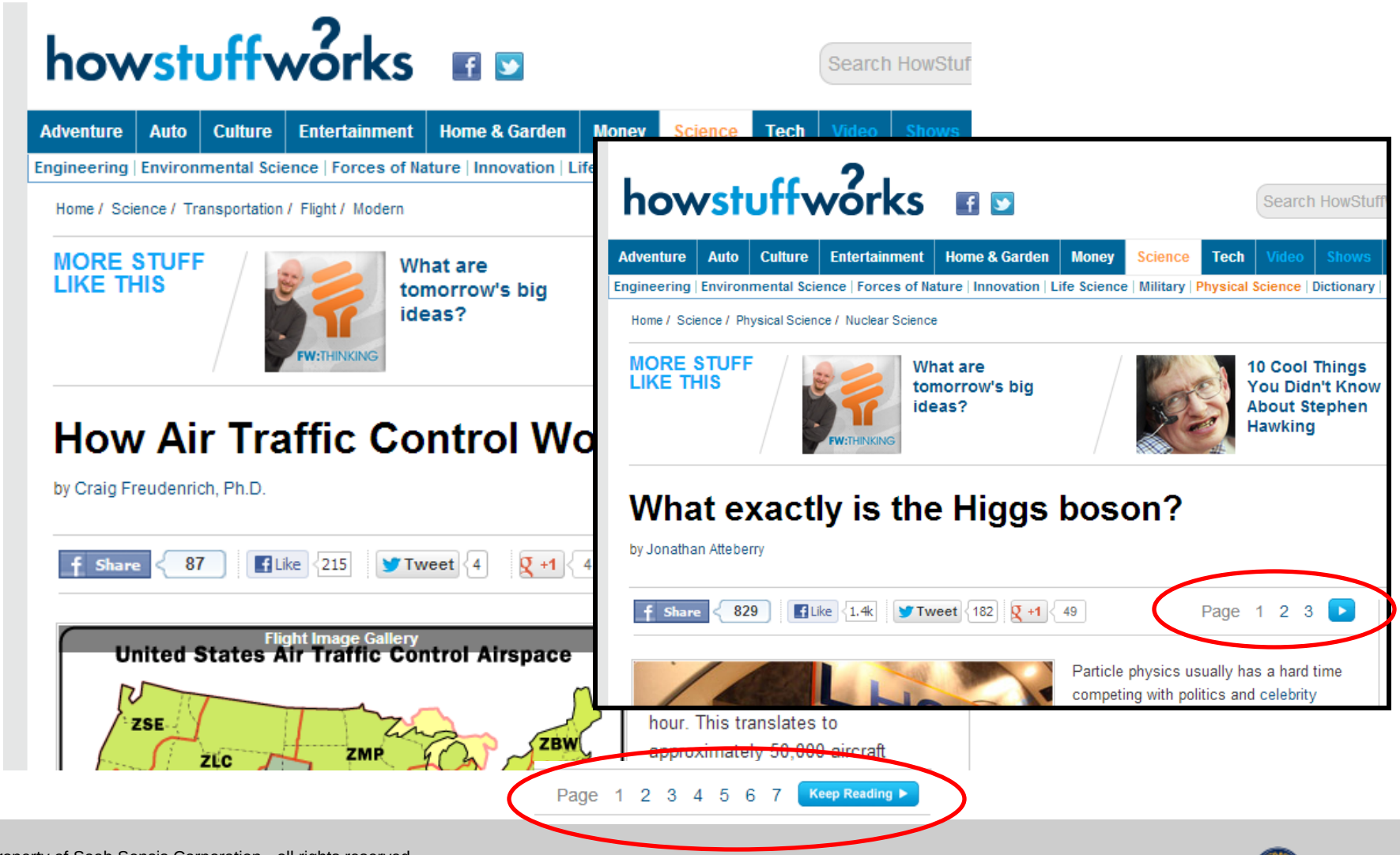


HOW AIR TRAFFIC CONTROL WORKS



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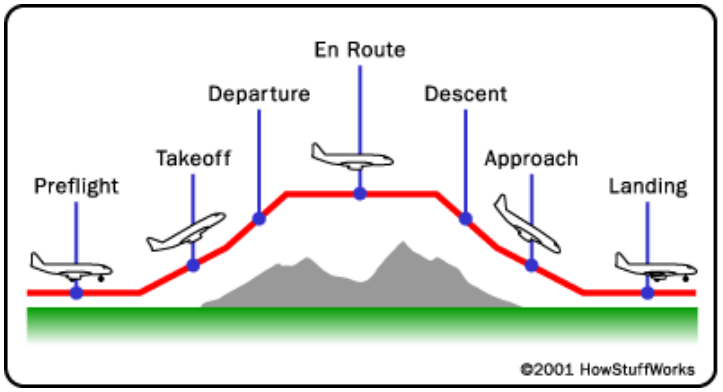
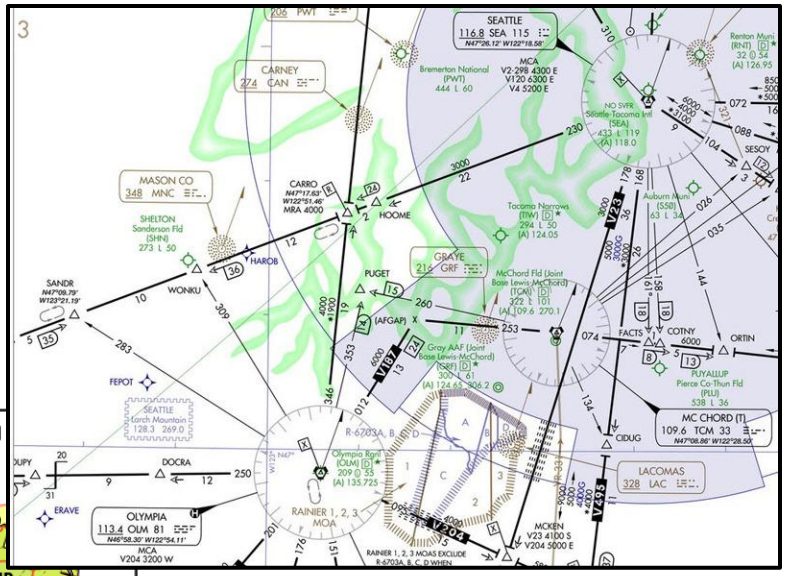
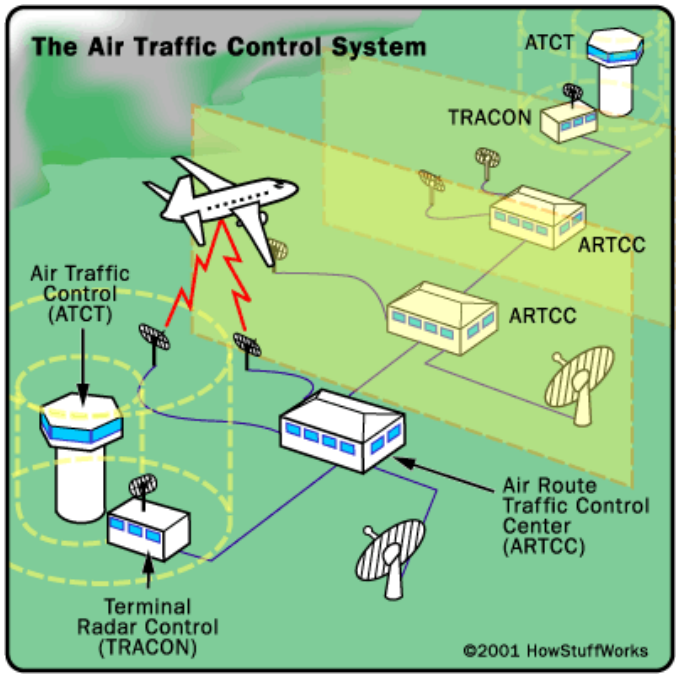
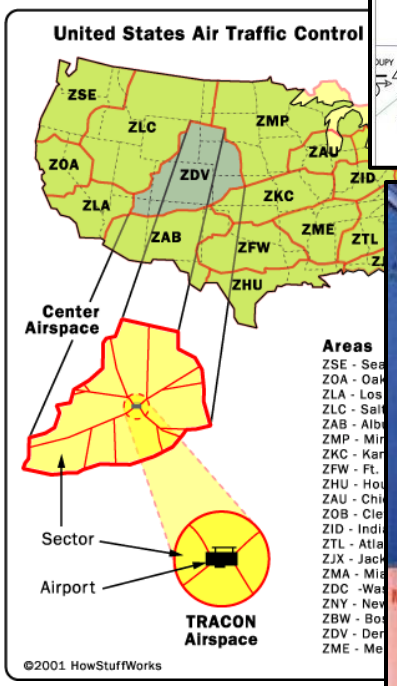
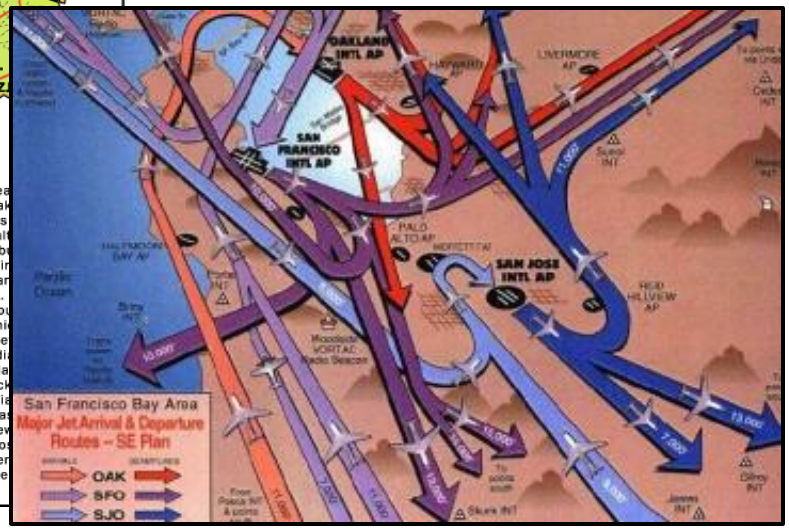




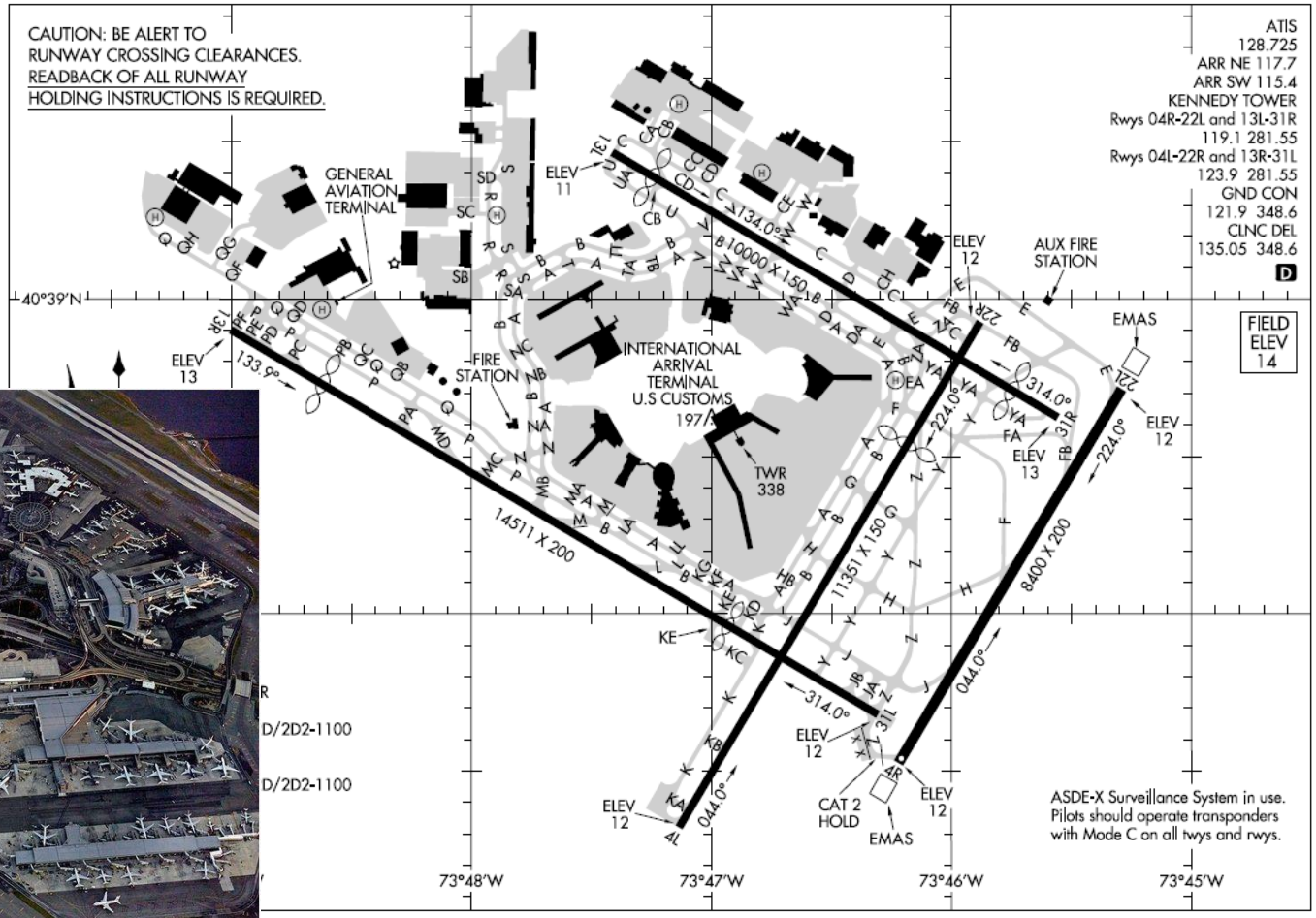






HOW AIRPORTS WORK

New York JFK



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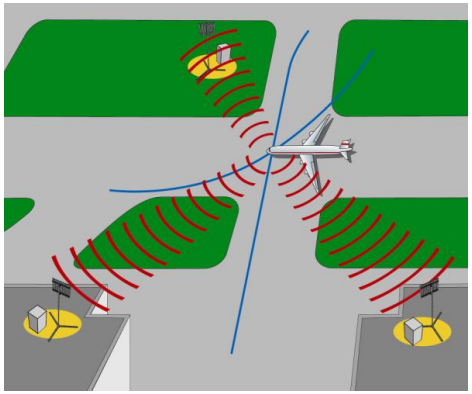
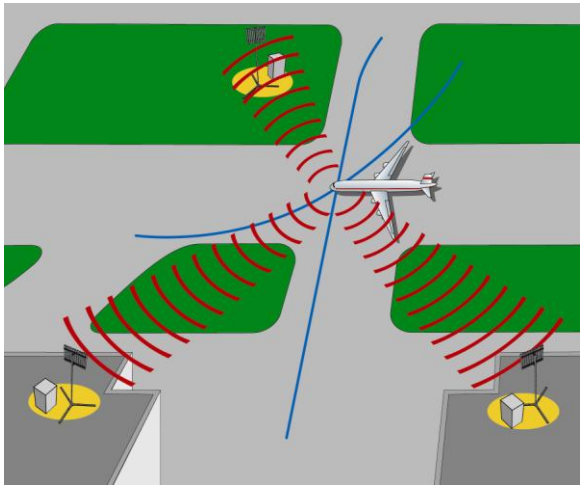


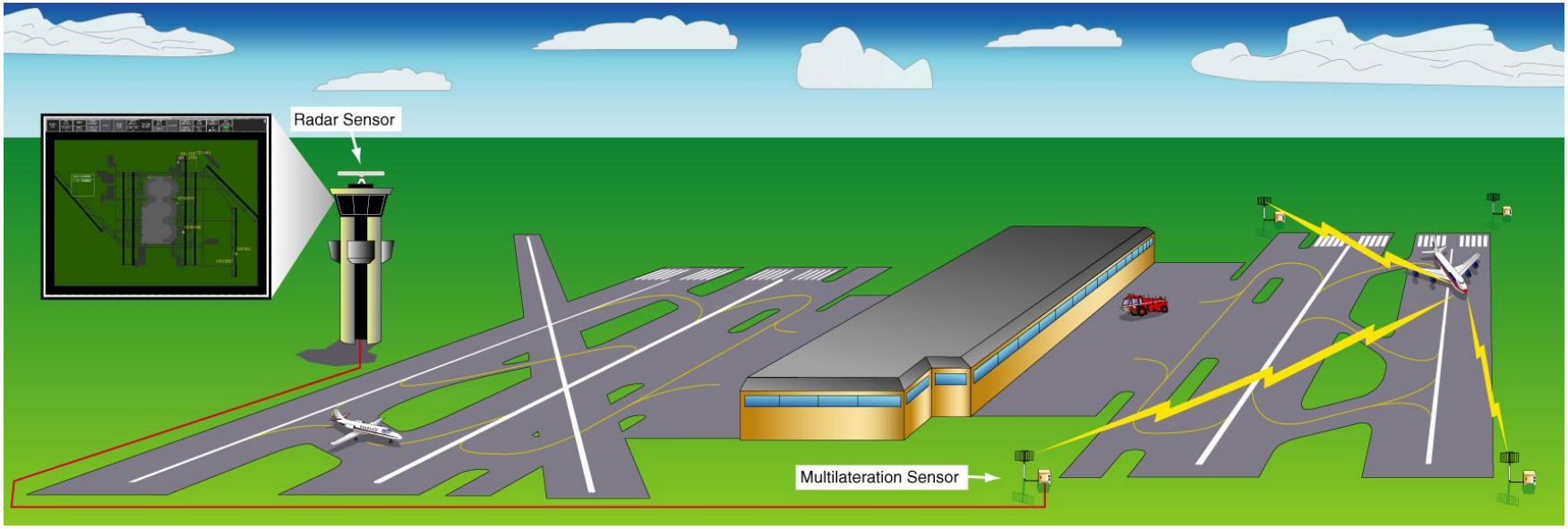
DATA SOURCES

- Airport Surface Surveillance (ASDE-X)
  - Aircraft positions as a function of time
- FAA Aviation System Performance Metrics (ASPM)
  - Airport capacity, throughput, & runways in use every 15 minutes
- Bureau of Transportation Statistics On-Time Performance Data
  - Scheduled and actual out, off, on, & in (OOOI) times for U.S. domestic flights
- FAA Aircraft Situation Display to Industry
  - Aircraft positions throughout the country, updated every minute
- Weather, other scattered items

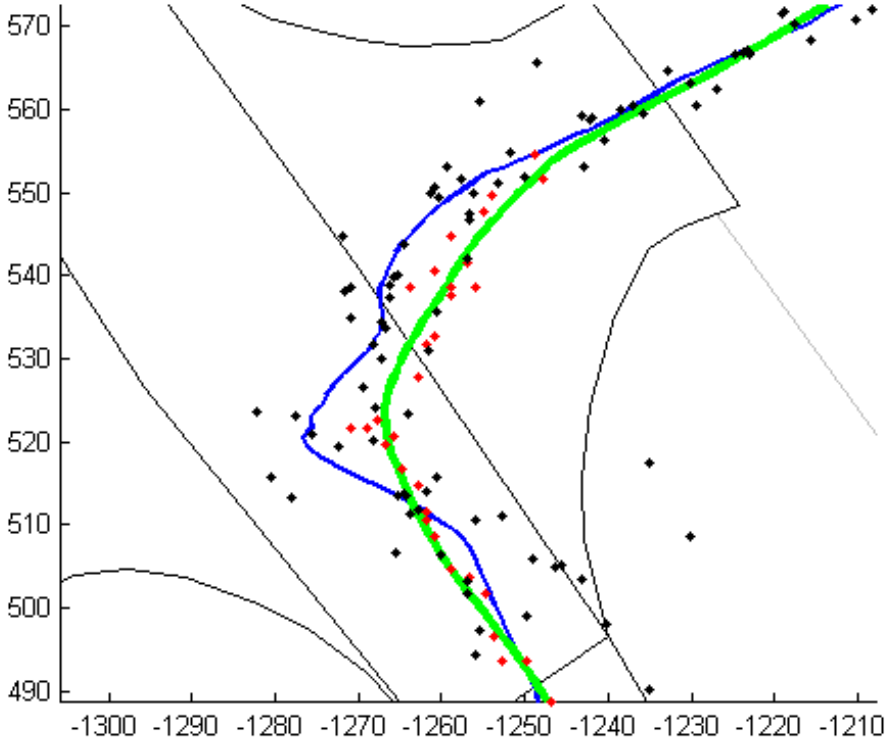
SURFACE SURVEILLANCE VIA MULTI-LATERATION

- Estimated aircraft position once per second
- Displayed live on airport map
- Used to drive safety alerts
- Stored for analysis



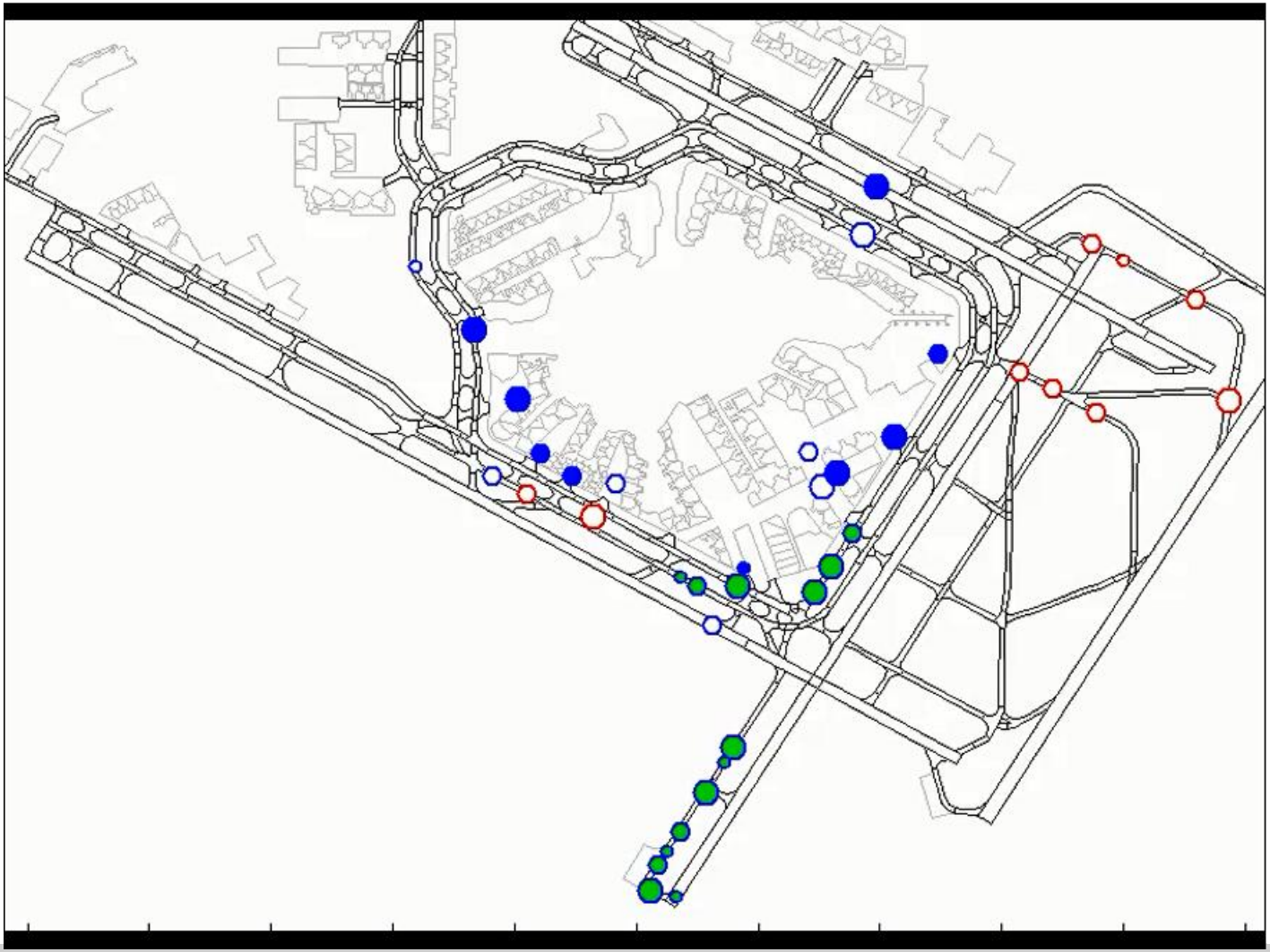


ANALYZING SURFACE SURVEILLANCE DATA



BLACK: MLAT Position Data
RED: SMR Position Data
BLUE: Track Reconstruction (Ver. 3)
GREEN: Track Reconstruction (Ver. 4)

ANALYZING SURFACE SURVEILLANCE DATA



MANAGING THE DATA

- 1 day of JFK surface traffic data:
  - ~ 1200 flights
  - ~ 200 MB – 1 GB on disk
- Analysis environment: usually Matlab ☹
- Issues:
  - Scattered storage
  - Can be memory- and CPU-intensive
  - Versioning of data
  - Versioning of analysis algorithms
  - Distinguishing different sources of the “same” piece of information (e.g. surveillance-derived vs. carrier-reported gate departure)
  - Duplication of effort

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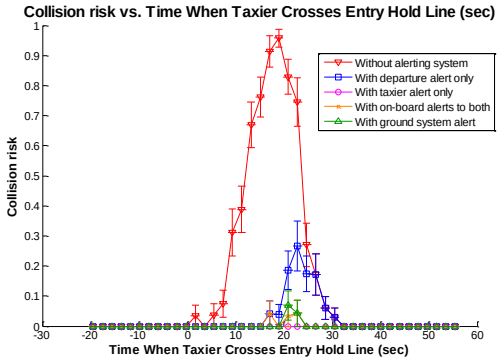
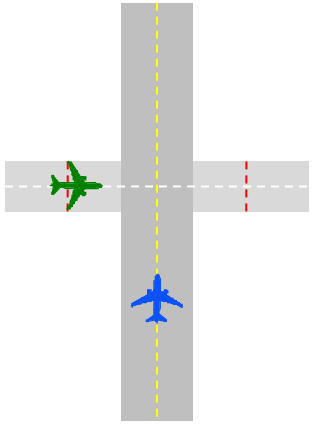
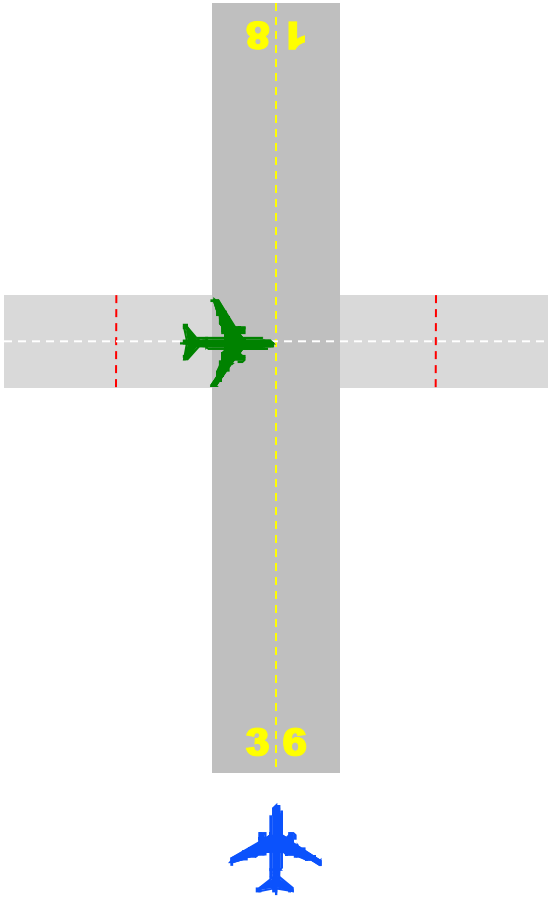


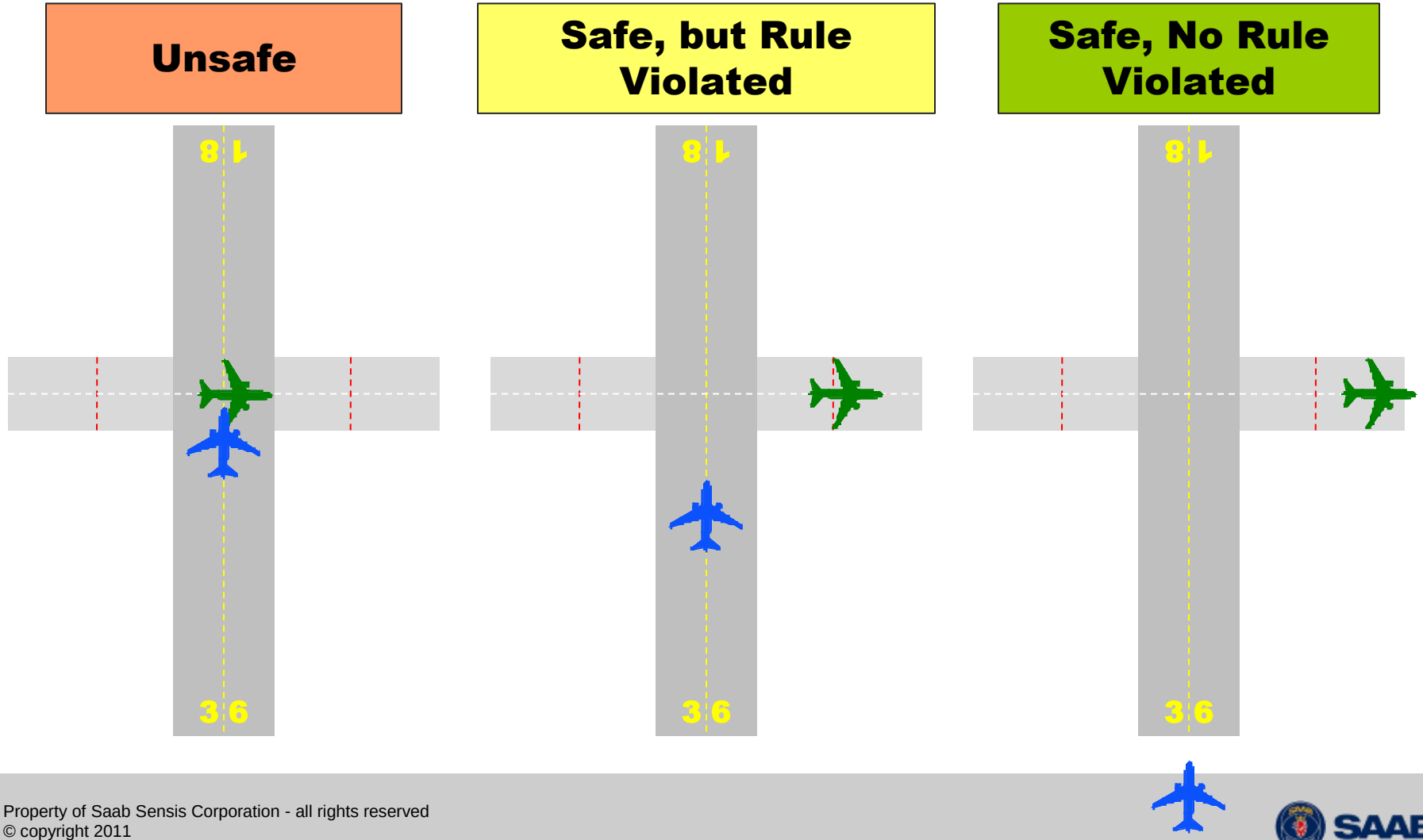


RUNWAY SAFETY SYSTEMS

- ASDE-X & similar systems give visible & audible alerts if a dangerous runway situation arises
- Must have:
  - Prompt detection of dangerous situations
  - Very low nuisance alert rate (~10^{-6}) in nominal situations
  - Sophisticated algorithms under the hood
- Simulations used to:
  - Estimate best possible performance (fraction of collisions prevented)
  - Determine potential benefit of technological improvements, such as more accurate surveillance



DANGEROUS, RULE-VIOLATING, & SAFE

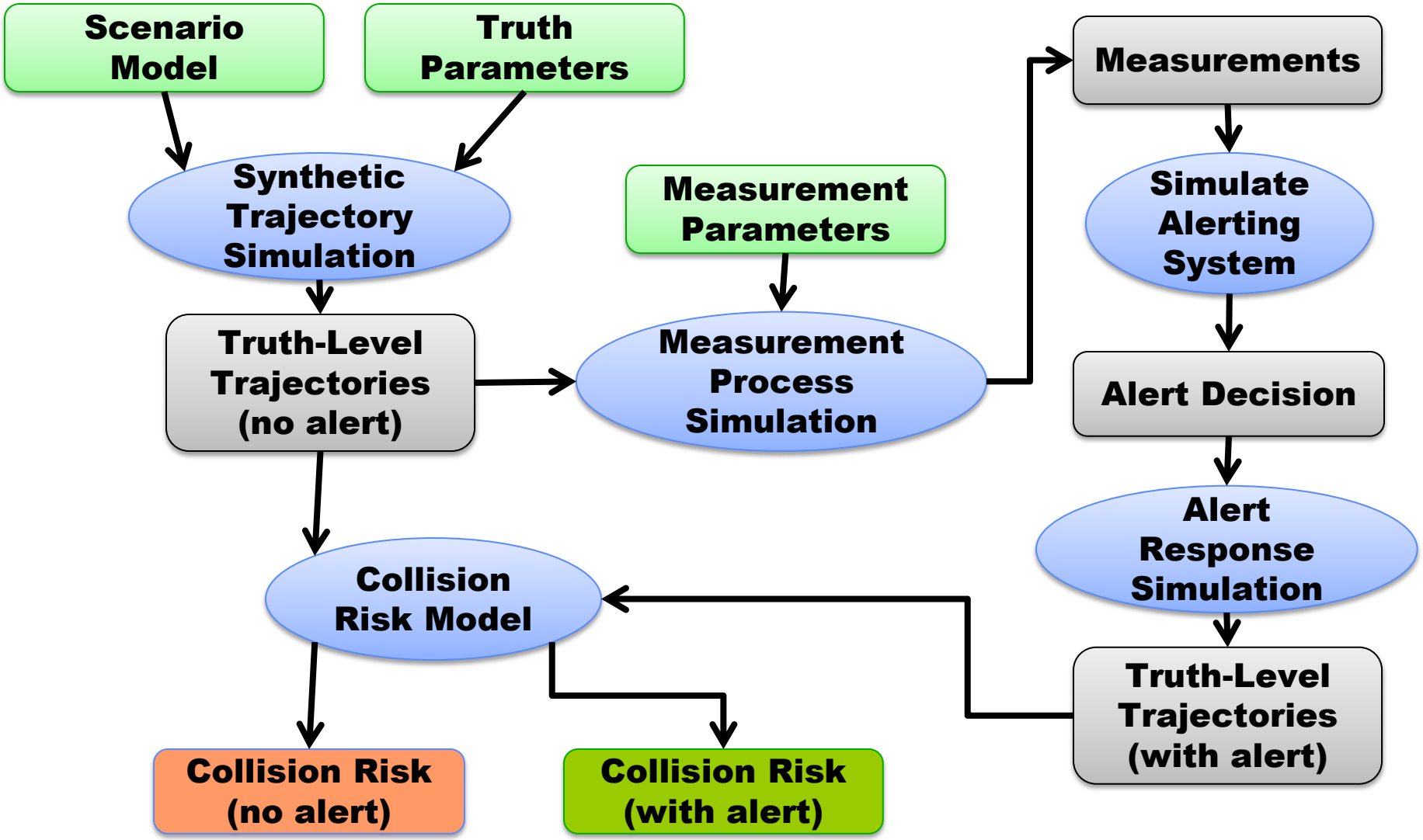


PARTICLE PHYSICS ANALYSIS VS. ALERT DECISION PROBLEM

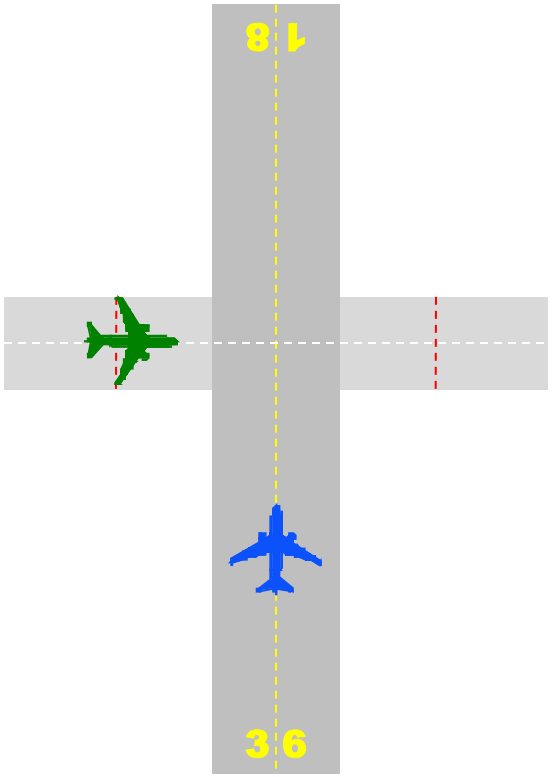
- From incomplete & noisy data, classify a situation as “interesting” or “not interesting”

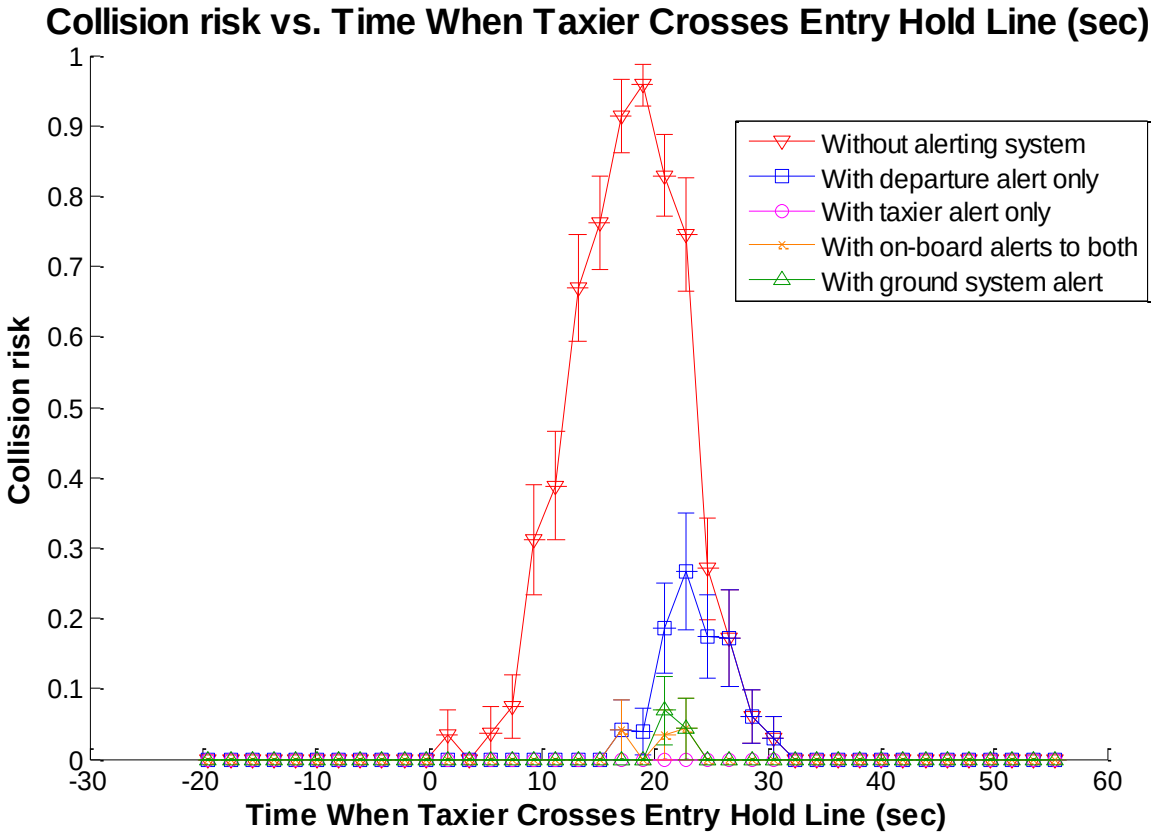
Particle Physics	Alert Decision
Signal event	Dangerous situation
Background event	Nominal situation
Signal efficiency	Near-100% rate to detect danger
Background efficiency	Near-100% rejection of nominal
Efficiencies must be precisely known	Efficiencies must be driven to 100/0%
“Unlimited” time to decide	Must decide in time to respond
One chance to make decision	Can wait for more information
Improve via detector & algorithm design	Improve via detector & algorithm design
Physical laws determine limit of sensitivity	Procedure rules determine achievable level of safety

SIMULATION APPROACH

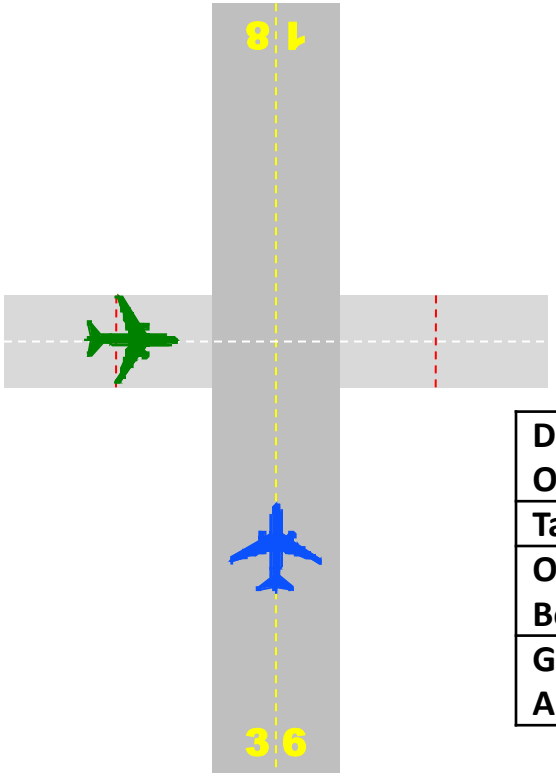


SOME RESULTS





SOME RESULTS



	Fraction of Collisions Prevented
Departure Alert Only	64.6 ± 1.3 %
Taxier Alert Only	98.6 ± 0.2 %
On-Board Alerts to Both	99.3 ± 0.2 %
Ground-Based Alerts to Both	98.1 ± 0.3 %

	Response times x½	Baseline	Response times x2
Departure Alert Only	67.4 ± 1.3 %	64.6 ± 1.3 %	51.6 ± 1.0 %
Taxier Alert Only	99.3 ± 0.2 %	98.6 ± 0.2 %	91.1 ± 0.9 %
On-Board Alerts to Both	99.9 ± 0.1 %	99.3 ± 0.2 %	91.2 ± 0.7 %
Ground-Based Alerts to Both	99.8 ± 0.1 %	98.1 ± 0.3 %	82.7 ± 0.6 %

	2.5m Accuracy	5m Accuracy	10m Accuracy
Departure Alert Only	70.2 ± 1.0 %	64.6 ± 1.3 %	64.5 ± 1.1 %
Taxier Alert Only	98.6 ± 0.2 %	98.6 ± 0.2 %	98.6 ± 0.2 %
On-Board Alerts to Both	99.9 ± 0.0 %	99.3 ± 0.2 %	99.0 ± 0.2 %
Ground-Based Alerts to Both	99.1 ± 0.2 %	98.1 ± 0.3 %	97.9 ± 0.4 %

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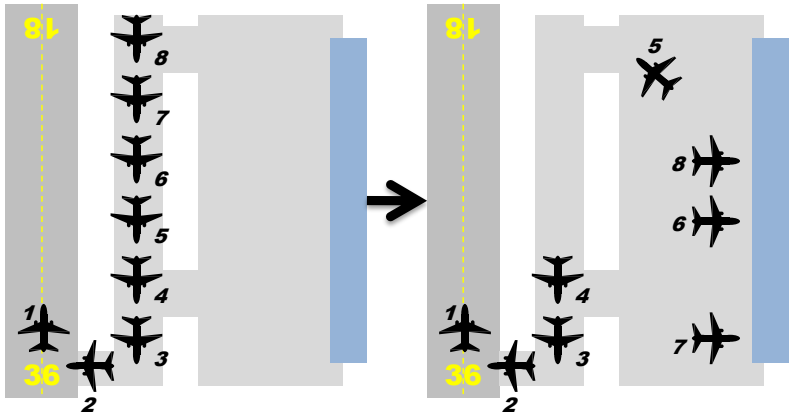
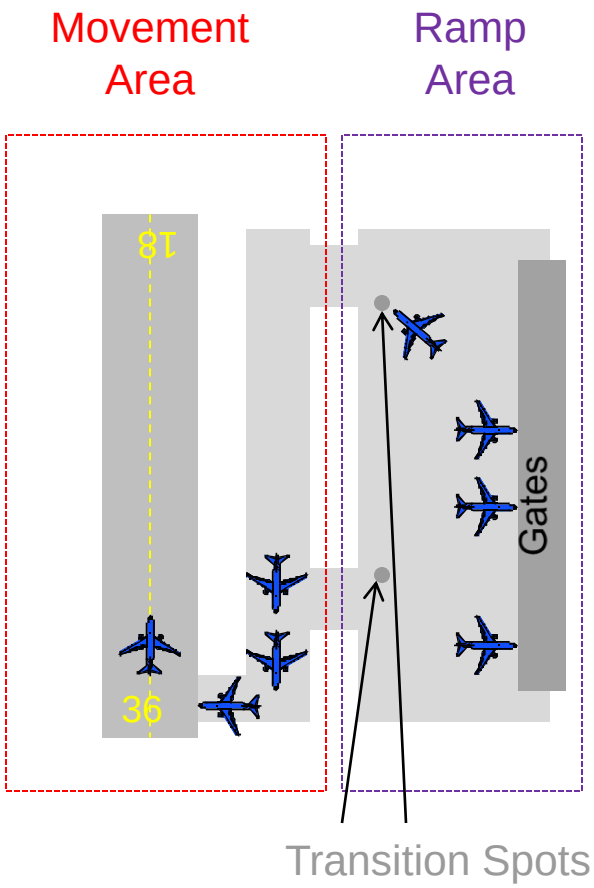
DEPARTURE QUEUE MANAGEMENT (DMAN)

- Operational concept (2009 & before)
- Benefits estimate (2009-2010)
- Prototype development (2010)
- Product development (2011-2012)
- Fielding at JFK (April 2012)
- Performance assessment (Dec 2012)



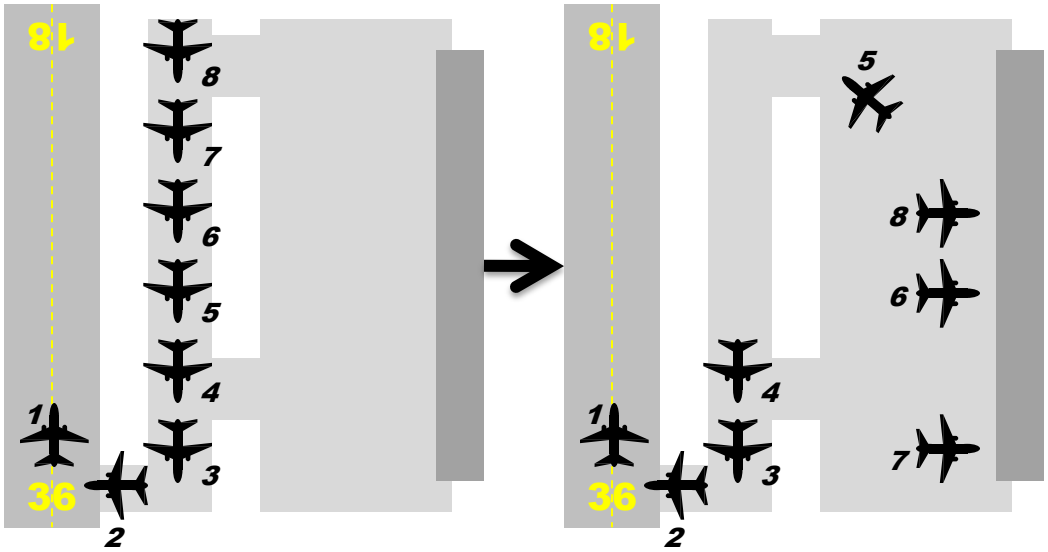
MOVEMENT AREA & RAMP AREA

- "Movement Area"
  - Areas controlled by FAA ATC Tower:
    - Runways and taxiways
- "Ramp Area"
  - a.k.a. "Non-Movement Area"
  - Controlled from ramp tower:
    - Gates, parking stands, & nearby tarmac
  - Managed by airline or terminal operator
- "Transition Spot"
  - Location where pilot calls ATC for clearance to enter the movement area



DMAN CONCEPT

- A virtual departure queue, rather than a physical queue, to reduce wasteful taxiing & holding
  - DMAN recommends spot release times

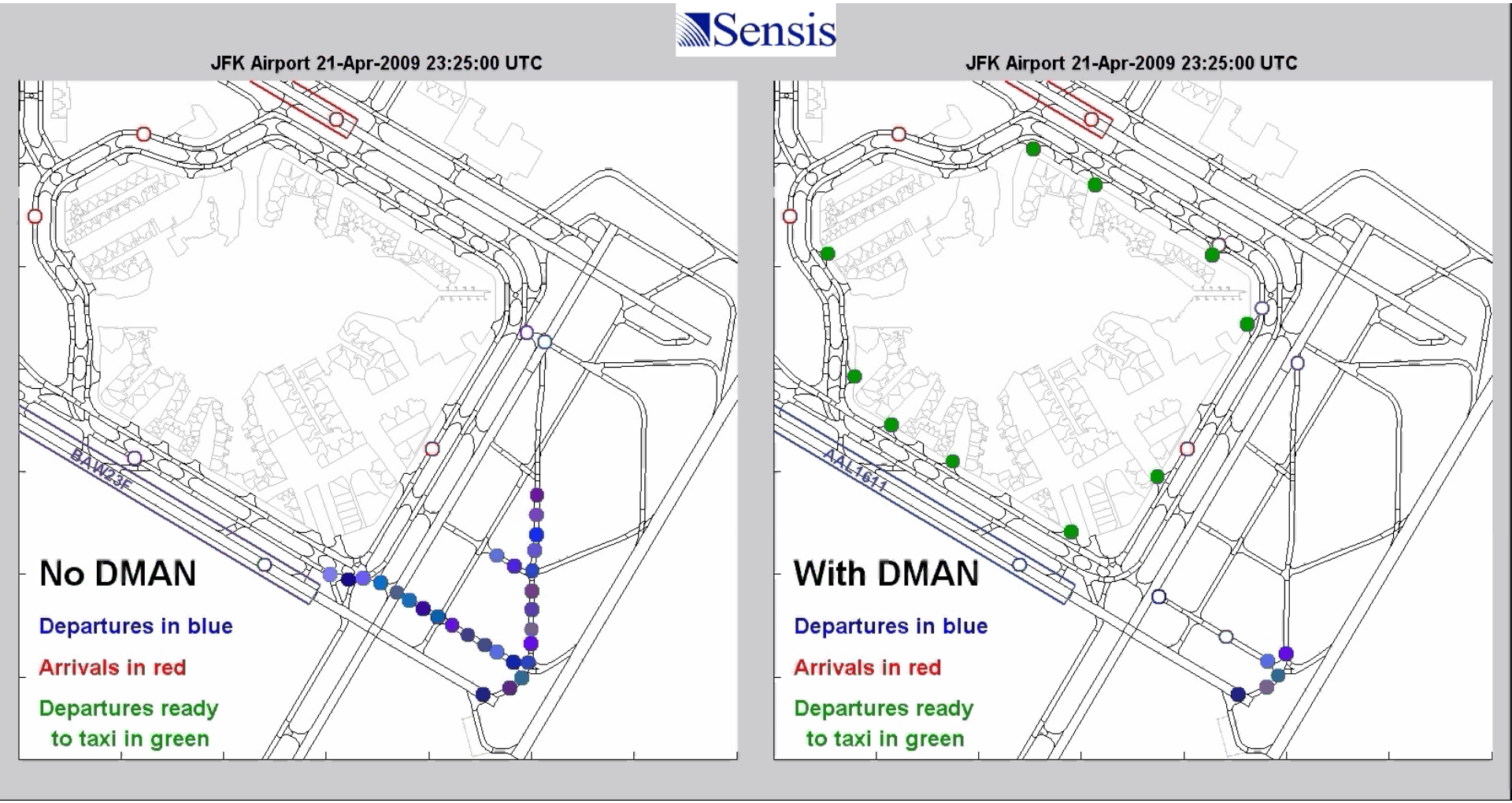


- Improved departure sequence to increase runway throughput & reduce delay

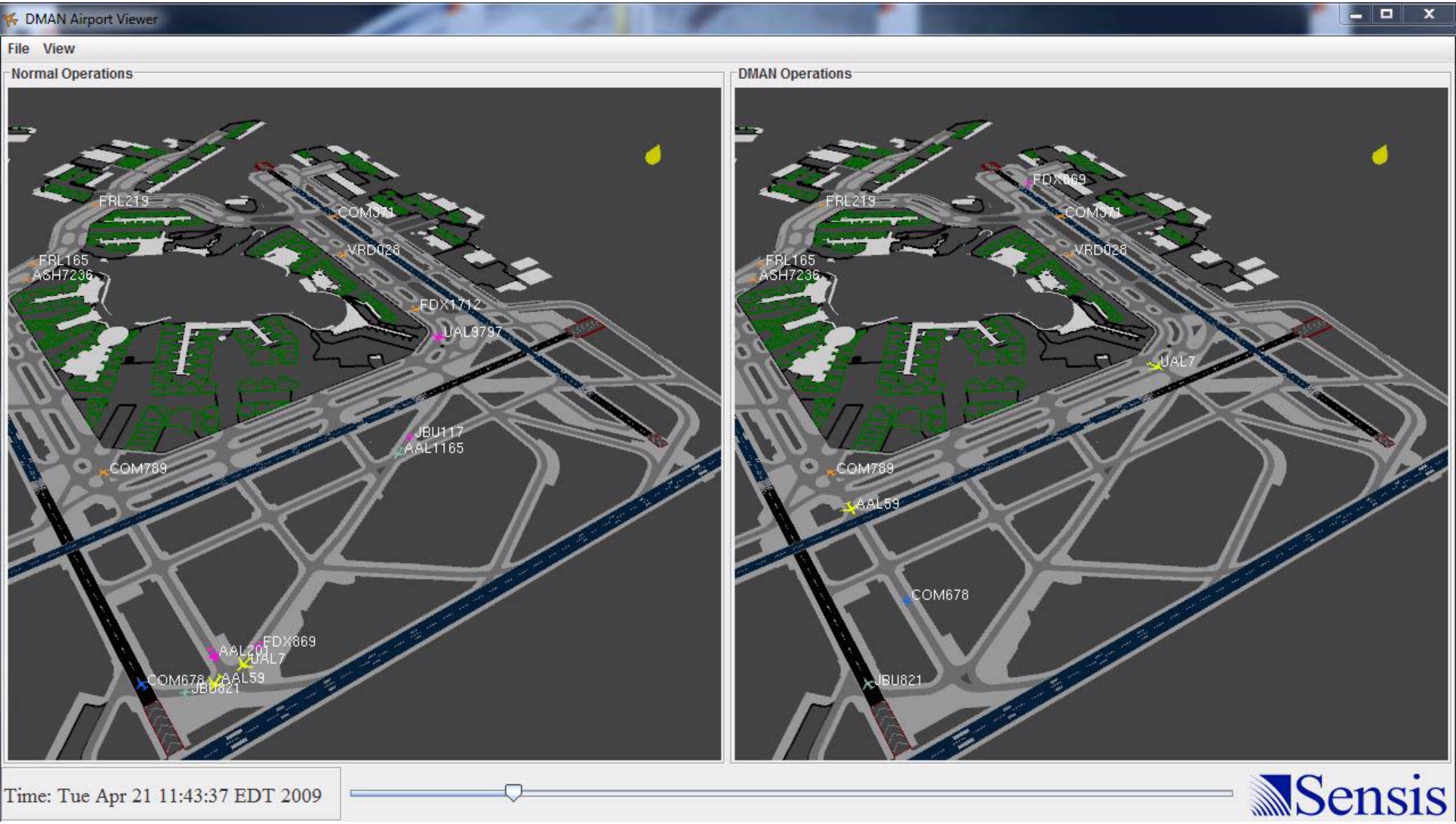
ORIGINAL SEQUENCE		
ACID	WC	DFIX
JBU87	L	WAVEY
DAL42	S	MERIT
DAL98	H	MERIT
AAL50	H	RBV
JBU11	L	RBV

MODIFIED SEQUENCE		
ACID	WC	DFIX
DAL42	S	MERIT
JBU87	L	WAVEY
JBU11	L	RBV
DAL98	H	MERIT
AAL50	H	RBV

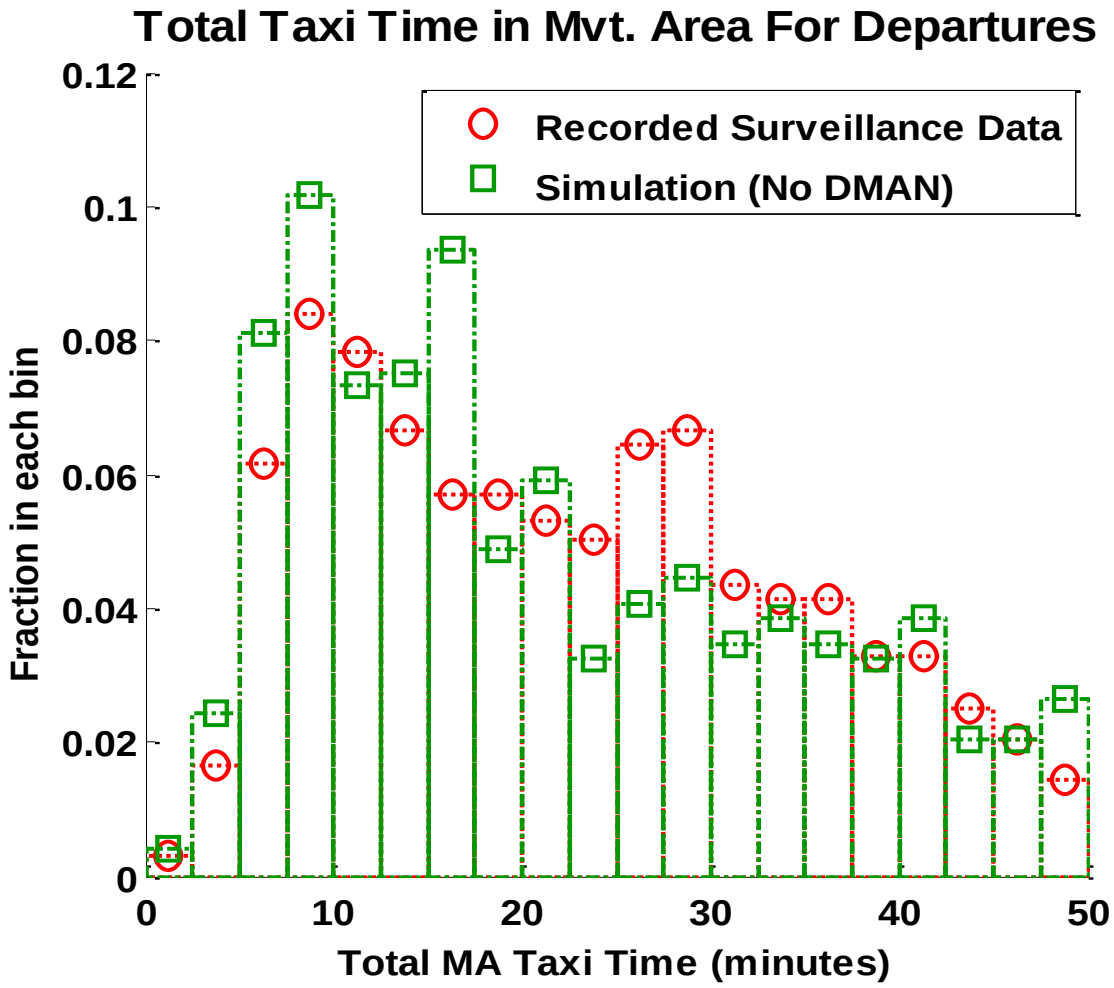
DMAN SIMULATION



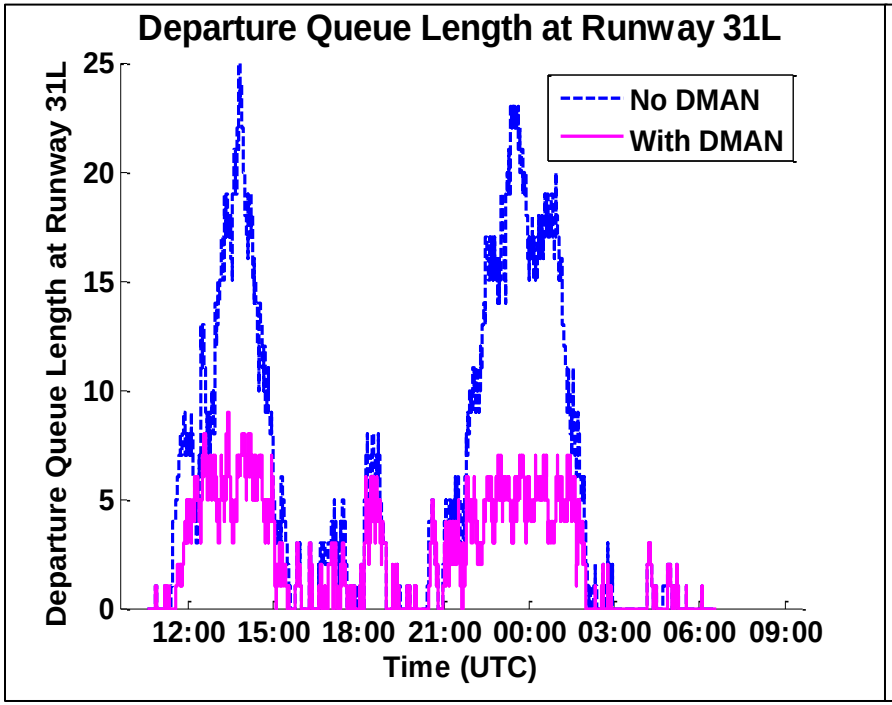
DMAN SIMULATION

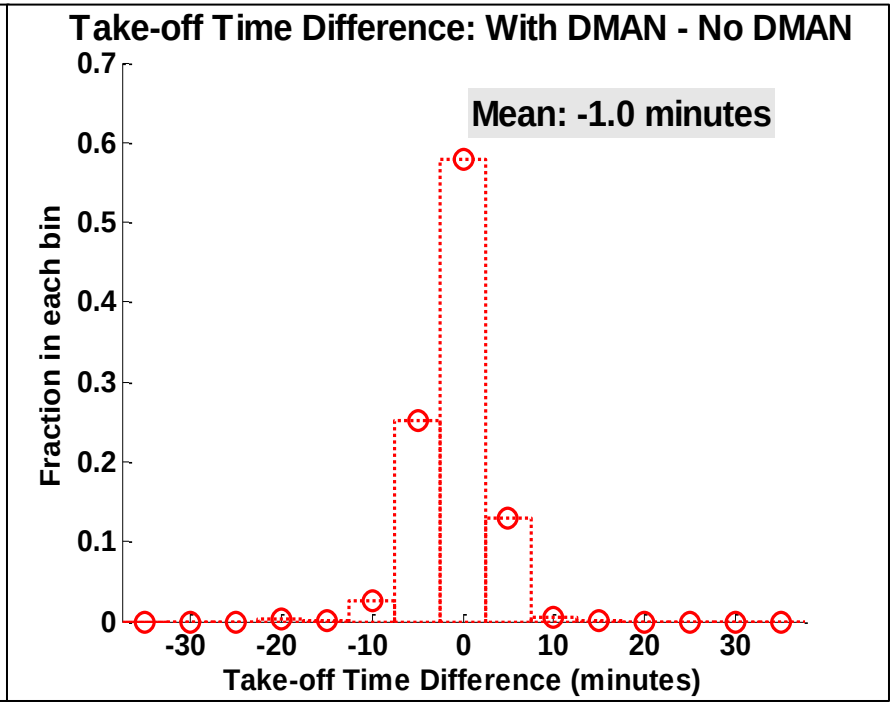


VALIDATING THE SIMULATION



DMAN BENEFITS IN SIMULATED DAY

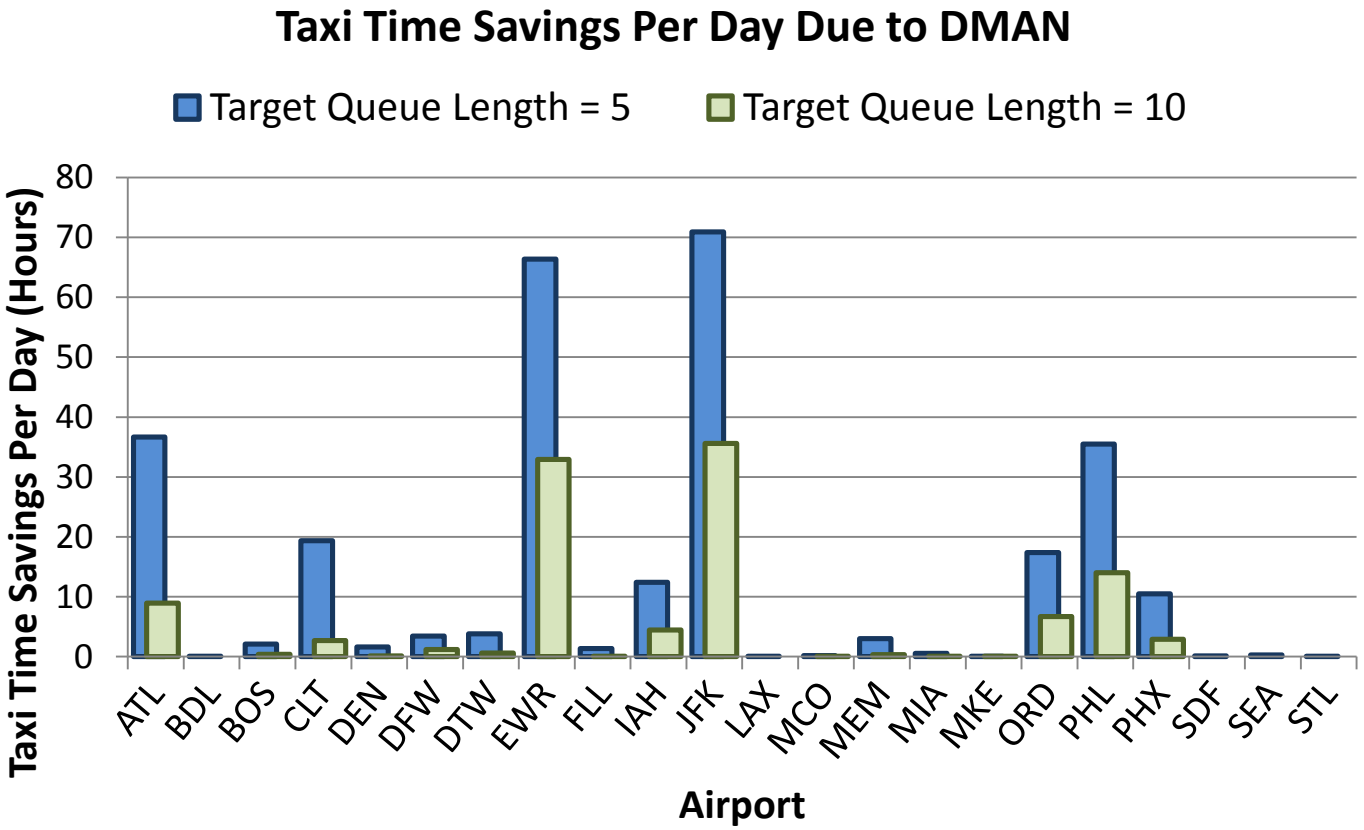




ANNUAL SAVINGS AT JFK DUE TO DMAN (SIMULATED)

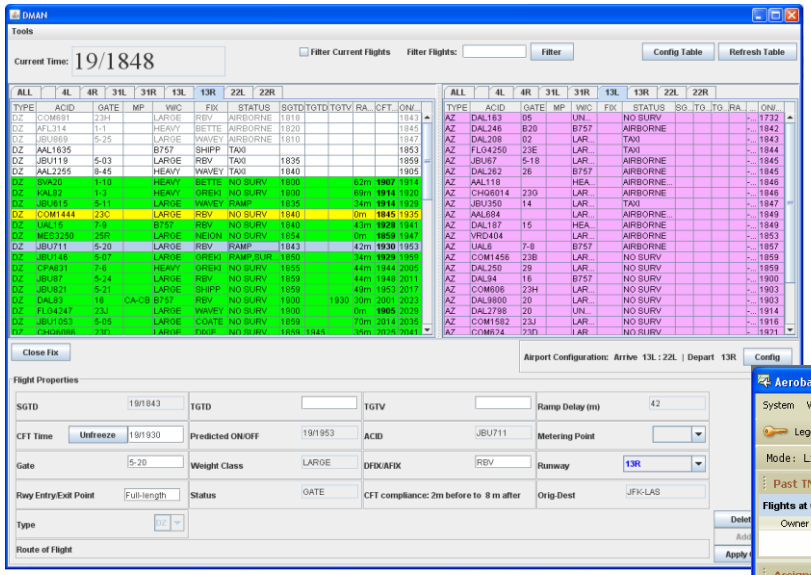
Savings Type	Annual Amount
Fuel	10.5 million kg
Fuel Cost	$10.2 million
CO_2 Emissions	33,500 metric tons
Take-off Delay	2,900 hours
Taxi-out Time	21,400 hours
Airlines	$24 million
Passengers	$33 million

POTENTIAL DMAN BENEFITS ACROSS 22 U.S. AIRPORTS



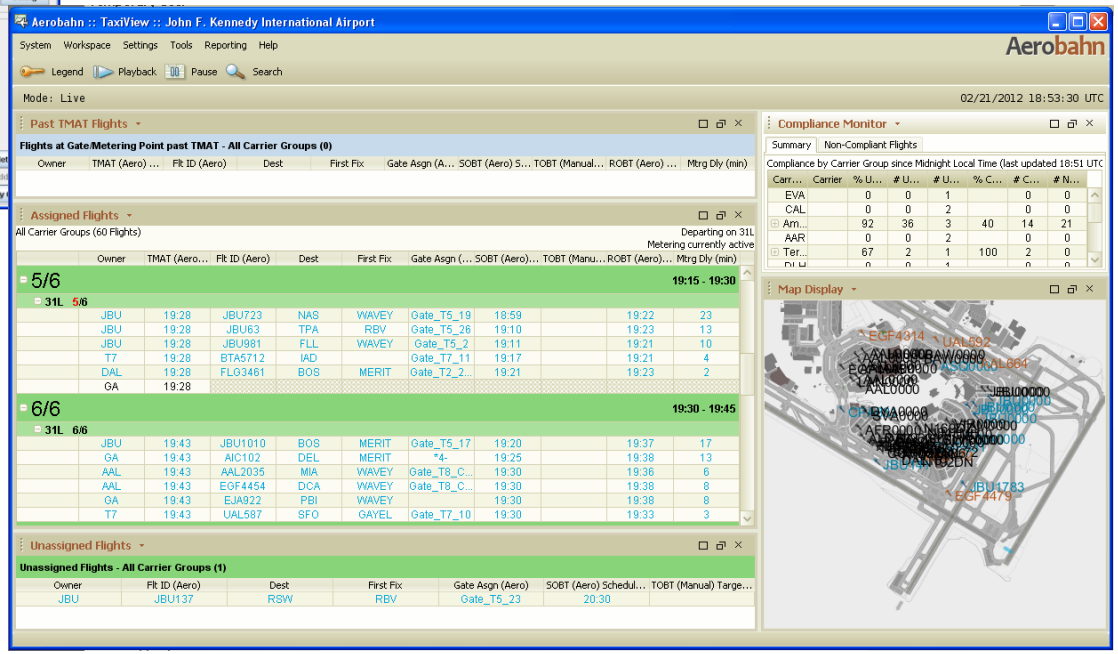
- Based on recorded ASDE-X surveillance data, 3/27 - 4/27/2009

PROTOTYPE & PRODUCT DEVELOPMENT



Advanced Development
DMAN Prototype (2010)

Aerobahn
Departure Metering (2012)

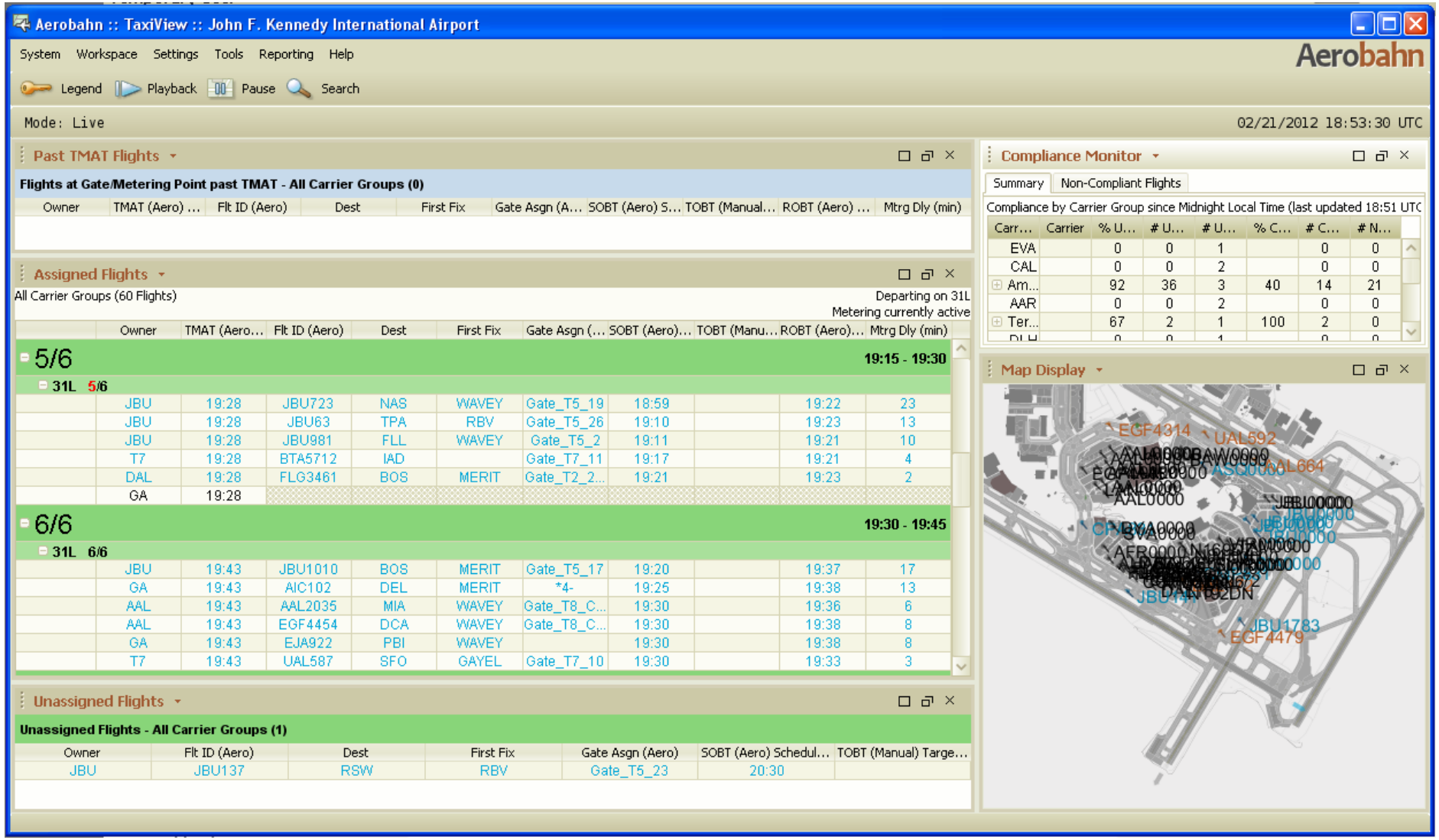


JFK GROUND MANAGEMENT PROGRAM

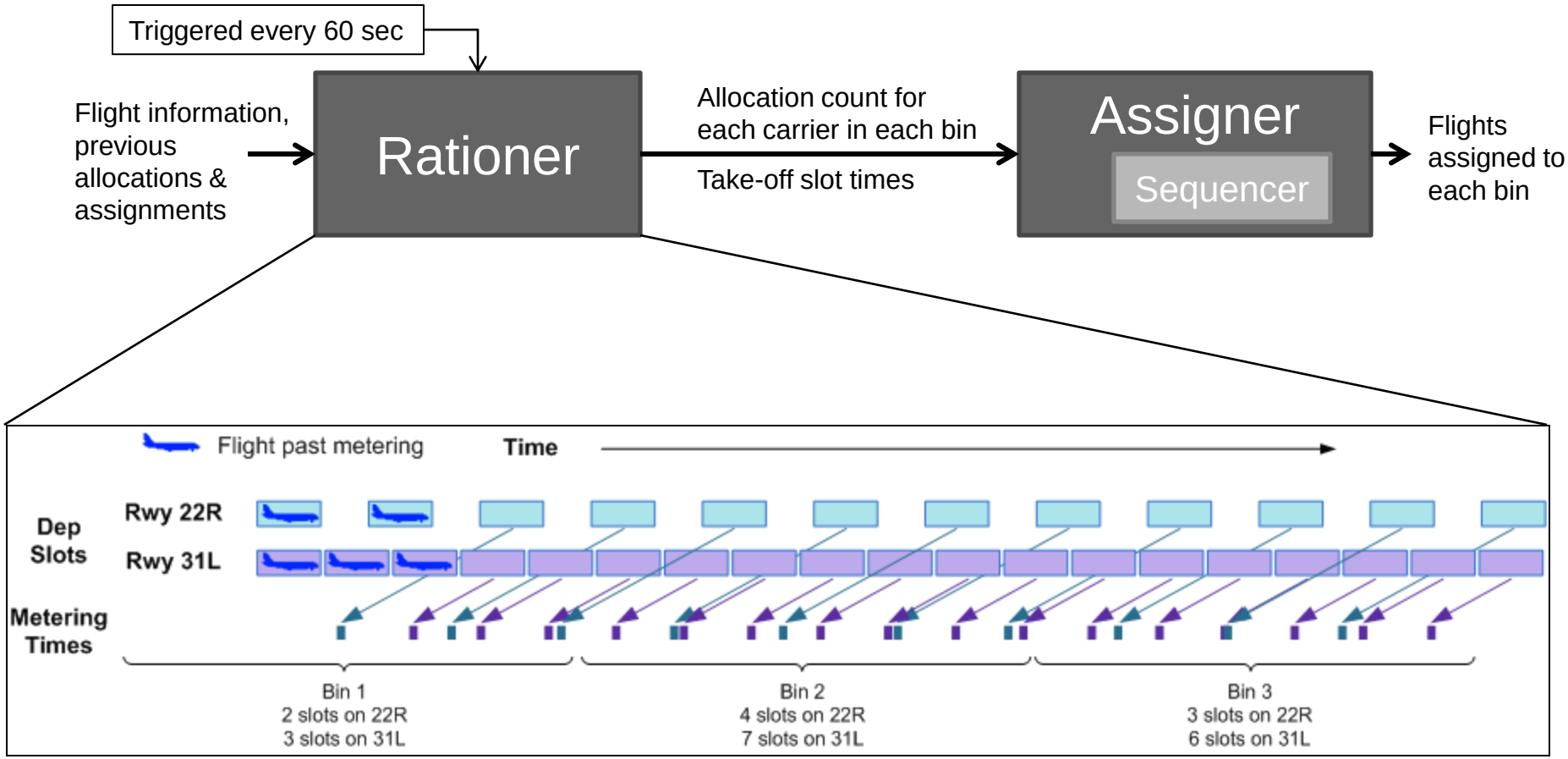
- Departure metering
  - System determines available capacity
  - System allocates capacity among carriers
  - System assigns a TMAT (spot release) to each departure
  - Carriers retain flexibility to swap flights and manage ramp
  - FAA manages the movement area as normal
- Shared information, common software platform & tools
- On-site staffed Coordination Center to coordinate among carriers and manage challenging conditions
- Regular, frequent discussions among stakeholders
- An ongoing process, not just technology

IN THE FIELD: JFK METERING COORDINATION CENTER

AEROBAHN DEP. METERING UI

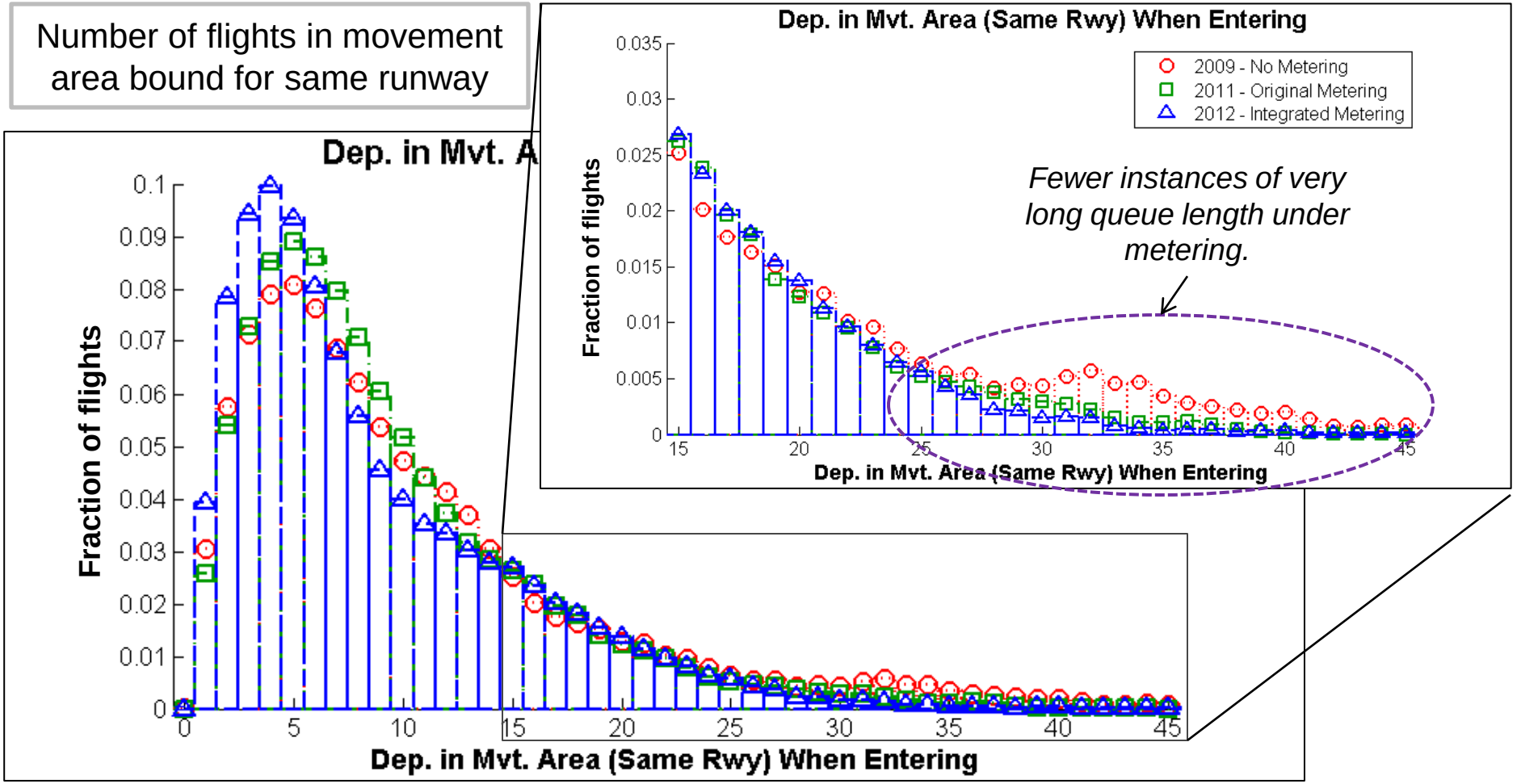


UNDER THE HOOD



PERFORMANCE ASSESSMENT: SHORTER DEPARTURE QUEUES

Number of flights in movement area bound for same runway



Departure Performance Improvement at JFK Compared to 2009

Improvement Per Month During Summer Compared to 2009

Approximately 20-40% of this is savings due to metering gate holds.

Improvement Type	Monthly Amount
Taxi-out Time	2,100 hours
Fuel	1.0 million kg
Fuel Cost	$1.0 million
CO_2 Emissions	3,200 metric tons
Take-off Delay	2,400 hours
Passenger Time	12,600 person-days
Passenger Time @ $30/hr	$9.0 million

Multiply by 10 for approximate annual value

ADDITIONAL BENEFITS

- Fewer missed passenger connections
- Ability for airlines to prioritize high-value flights through flight swapping
- Lower taxiway maintenance costs
- Reduced workload for controllers
- Smoother runway configuration changes
- Greater airport capacity
- Three-hour rule compliance
- Reduction in delays propagated to other airports

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GENERAL THOUGHTS ON MY TRANSITION

- Applicable skills:
  - Analysis of large data sets
  - Statistical reasoning
  - Simulation design & validation
  - Computer programming
  - Presentation & public speaking
  - Technical writing
- Not as applicable:
  - Physics
  - Advanced math
- What's different:
  - Shorter deadlines
  - Less rigorous
  - Windows ☹
- New skills:
  - Air traffic management domain knowledge
  - Artificial intelligence & optimization
  - Software development practices
  - Interaction with non-technical collaborators & audiences
- Perks:
  - Visiting air traffic control facilities
  - Talking with airport management & operations personnel
  - Influencing ongoing improvements

THANK YOU!

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SAAB

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