



*MIT International Center for Air Transportation*

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# **A Case Study of Delays and Response Strategies at Newark Airport**

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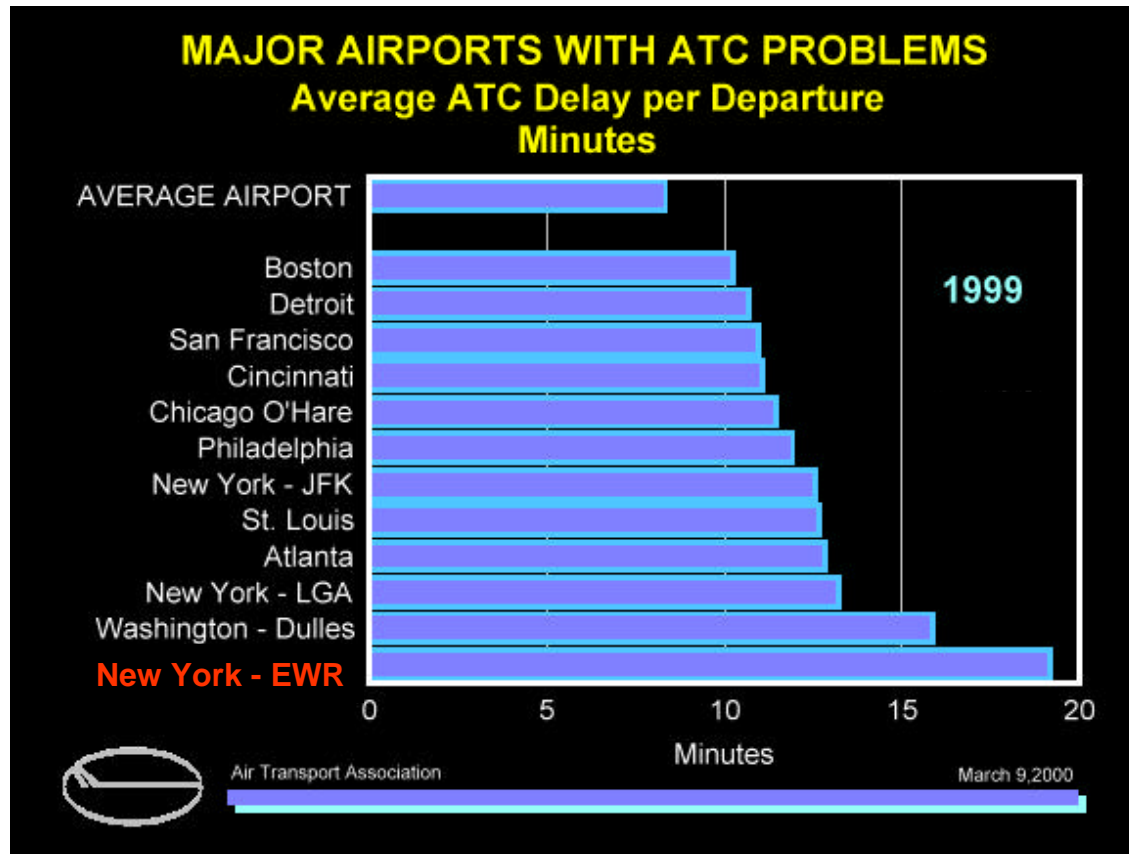
# Newark Airport - Background

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- 34.2 million passengers per year
- 458 thousand aircraft movements
- 1.2 million tons of cargo
- 7.2 million parked cars



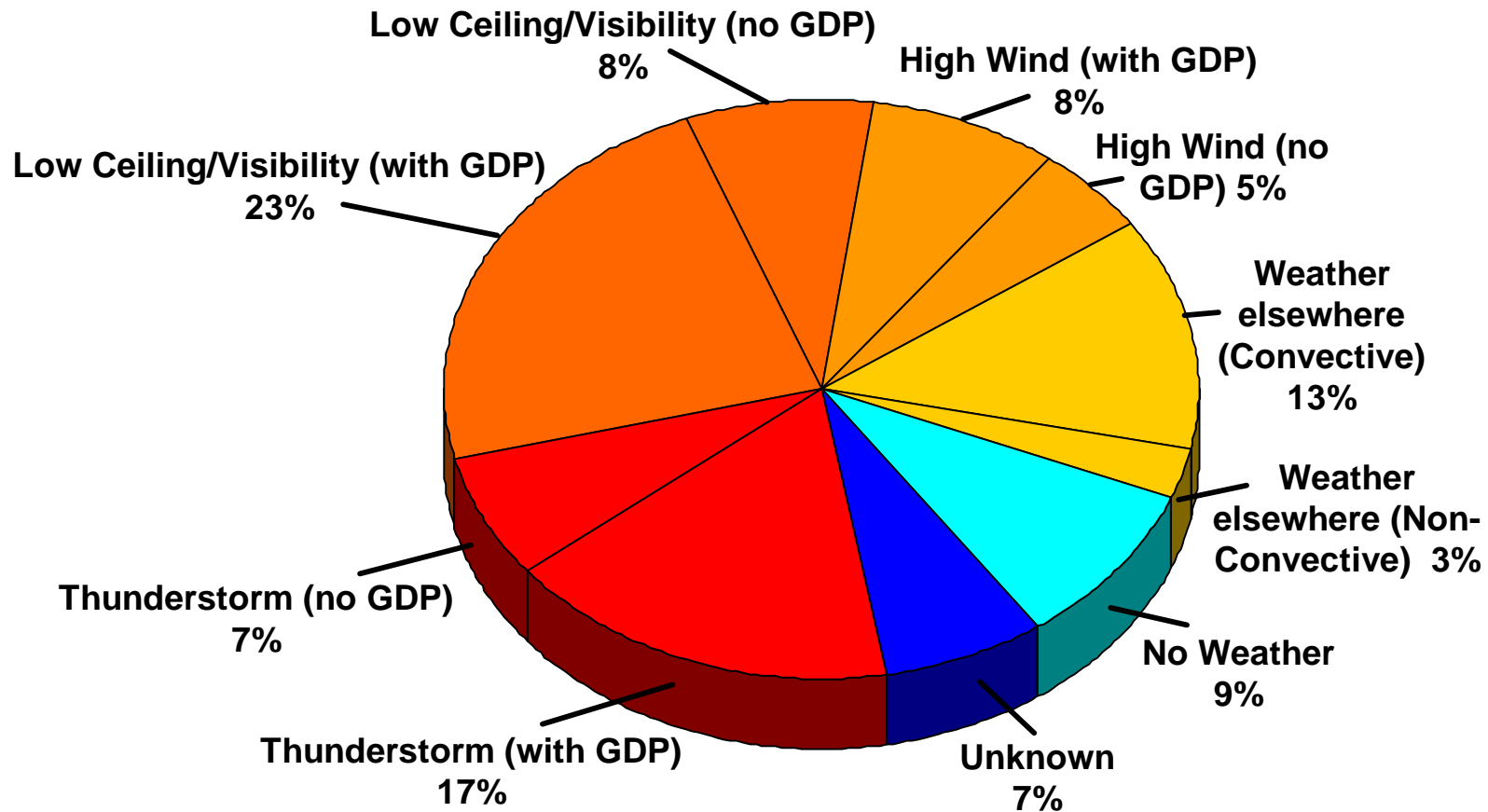
# Newark Airport - Delays



- 1999 – EWR highest average ATC delay
- 2000 – EWR second only to LGA



# Cause of Delays: EWR

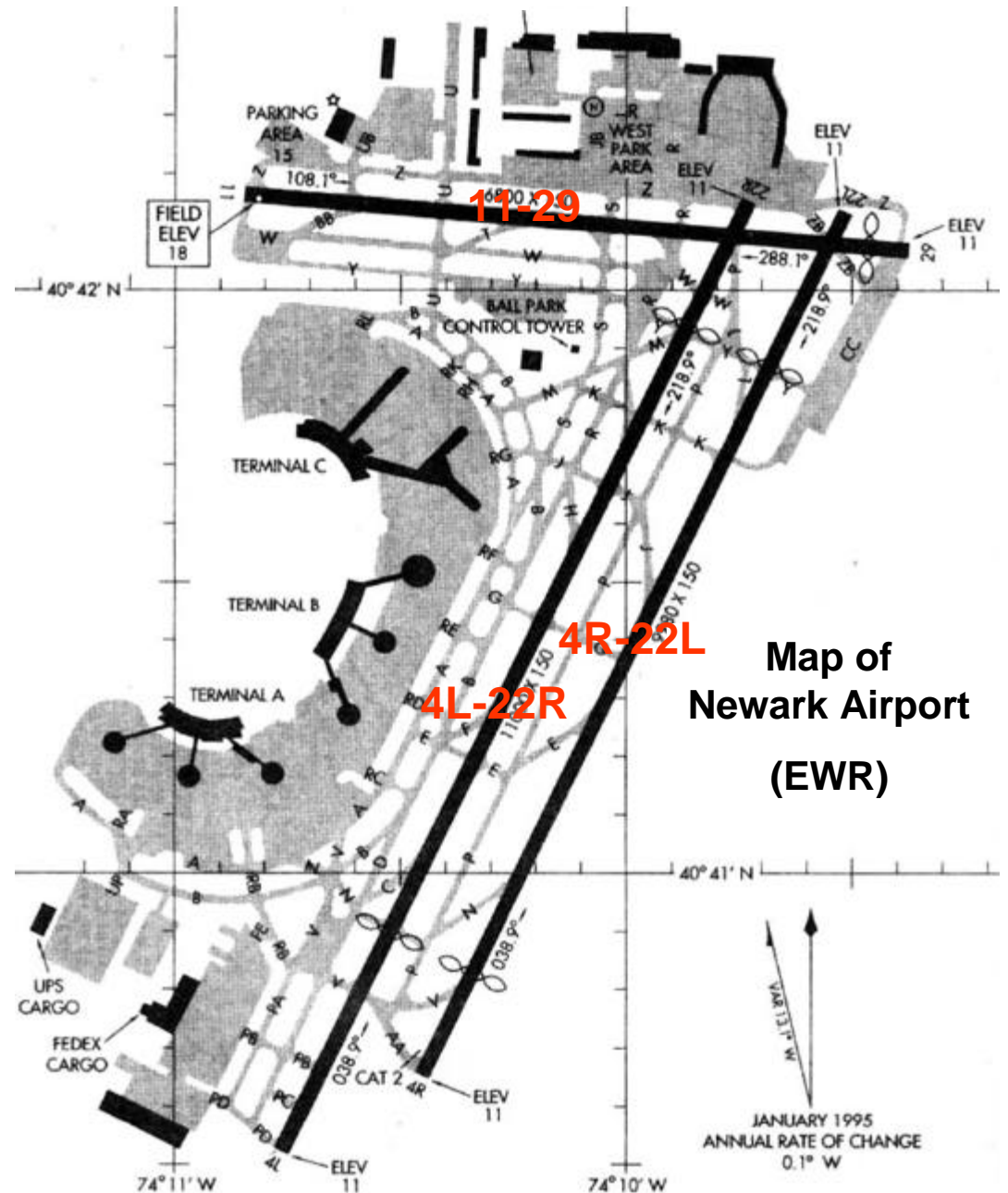


- 84% of delays related to Weather



# Newark Airport - Congestion

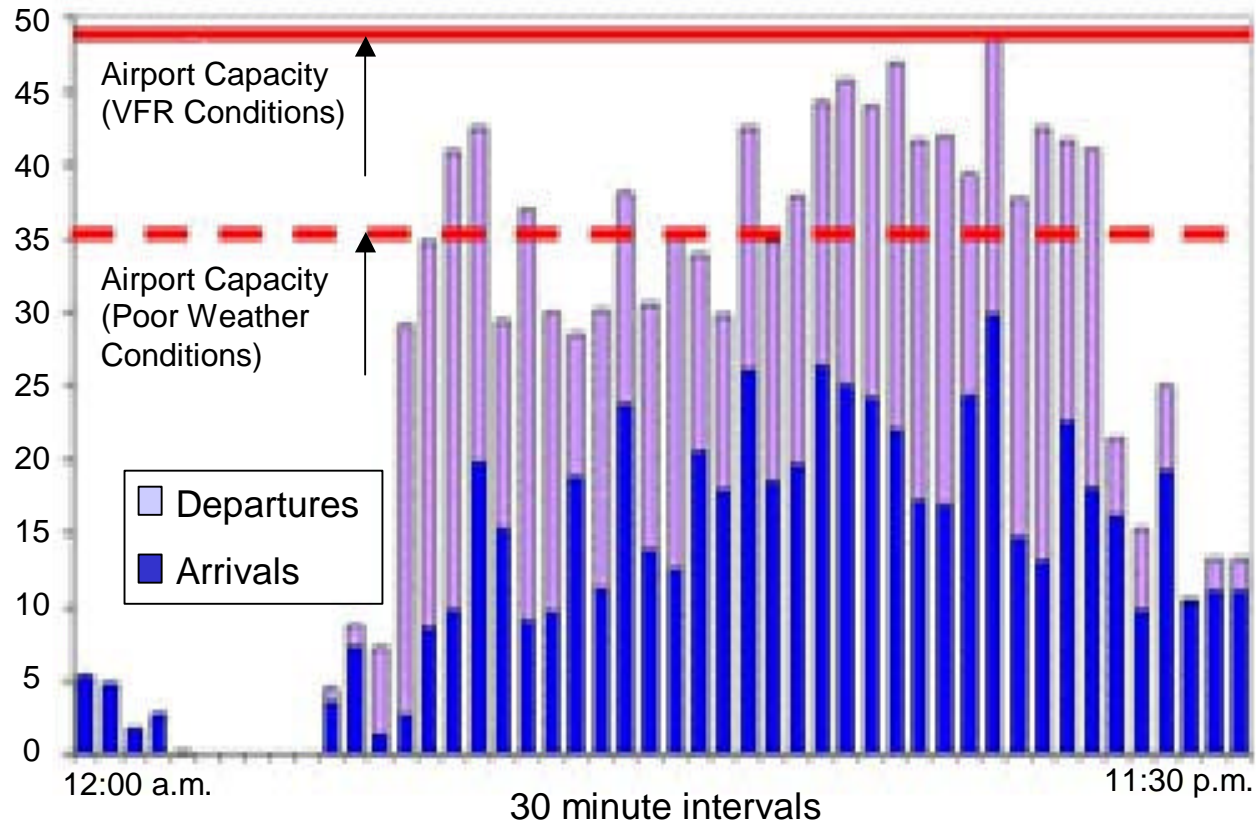
- EWR sensitivity to weather
- Runways limitations
- Limited gate space
- Airport scheduled beyond VFR capacity
- New York City airspace congested





# Airport Schedule beyond VFR Capacity

Average Daily Arrivals and Departures  
July 1999

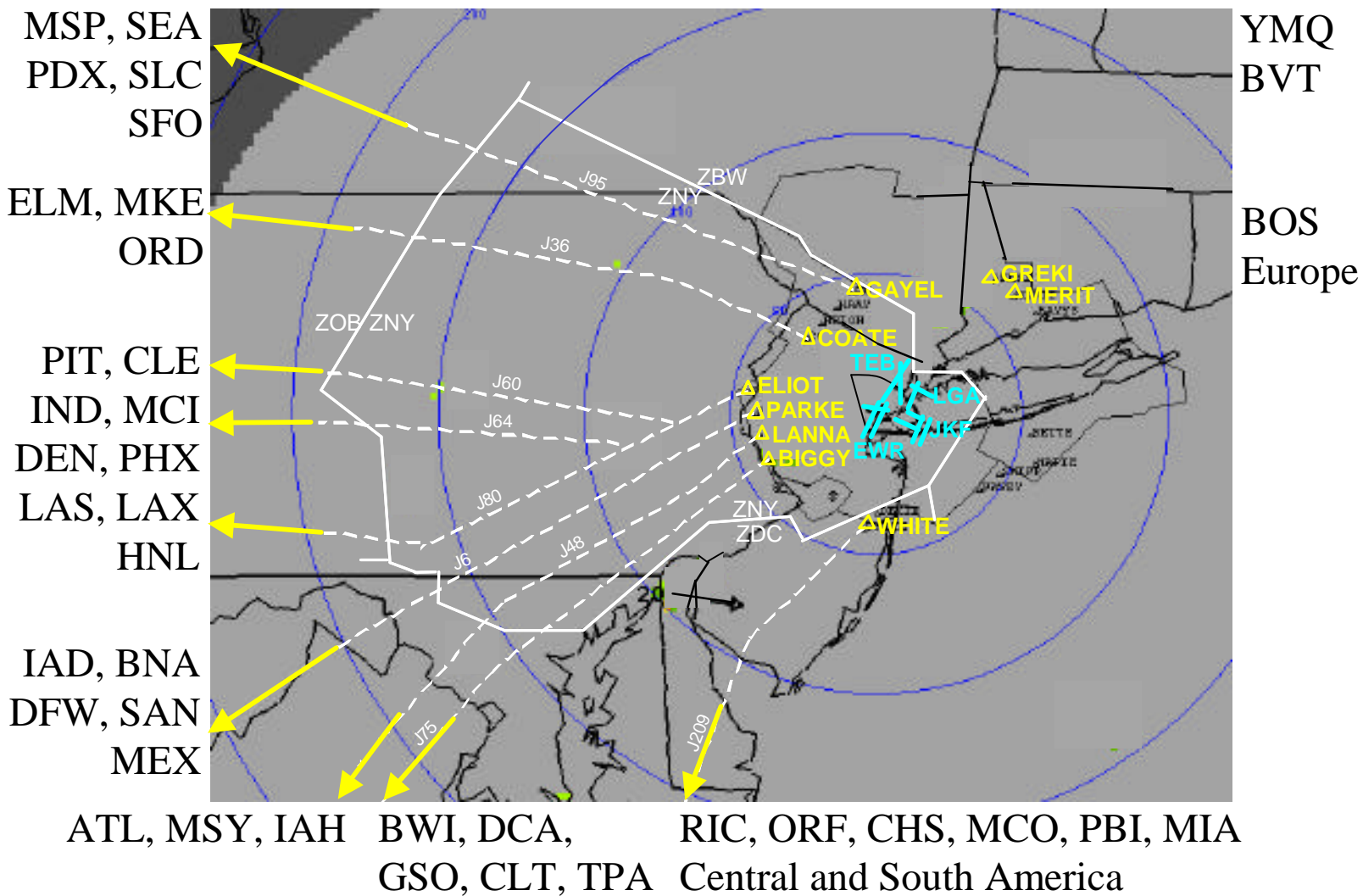


- In poor weather conditions – few recovery periods



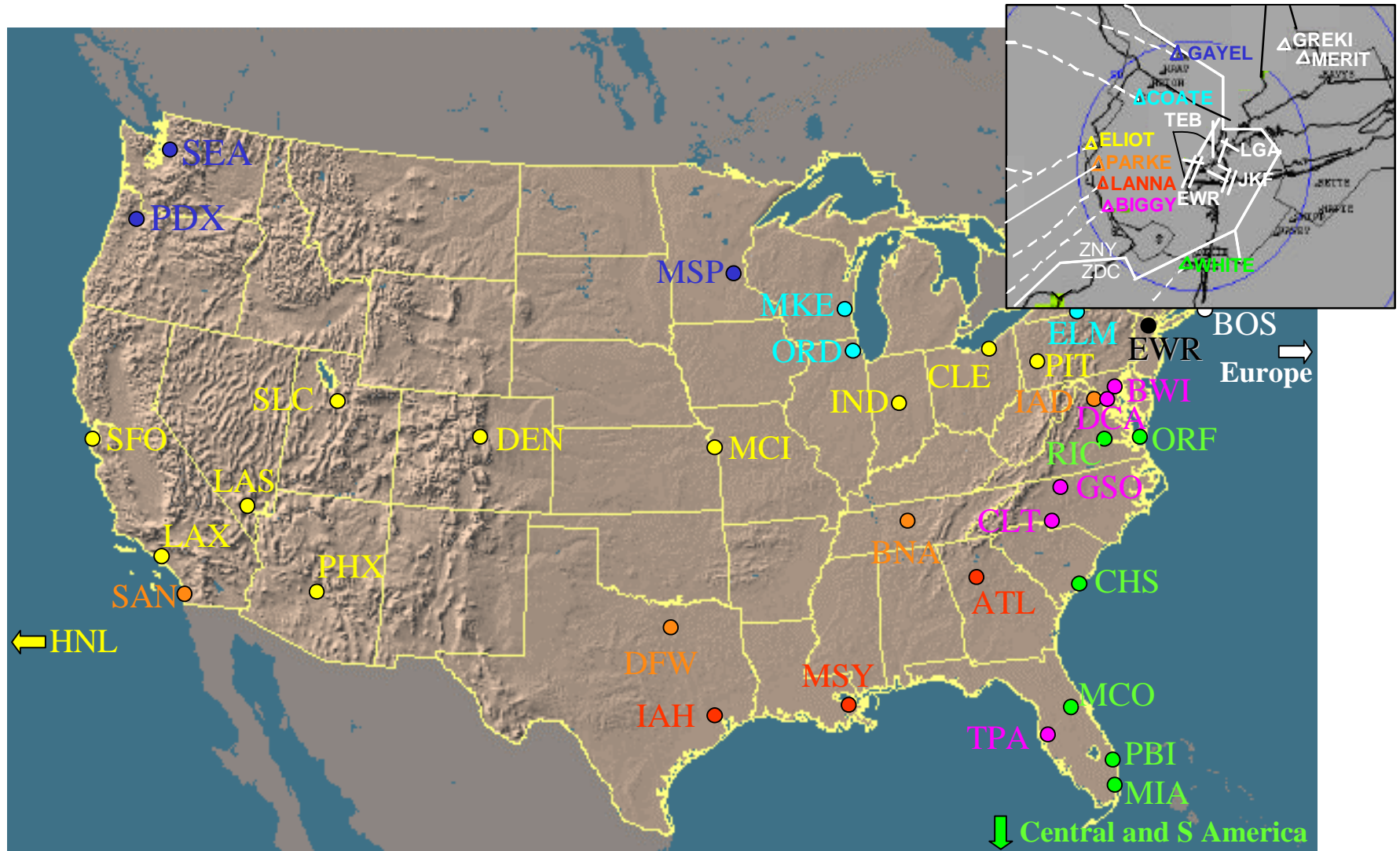
# New York Center Airspace

With Primary EWR Departure Fixes/Jet-routes



Based on Lincoln Laboratory ITWS Map

# Destinations



According to preferred routings





# Destinations

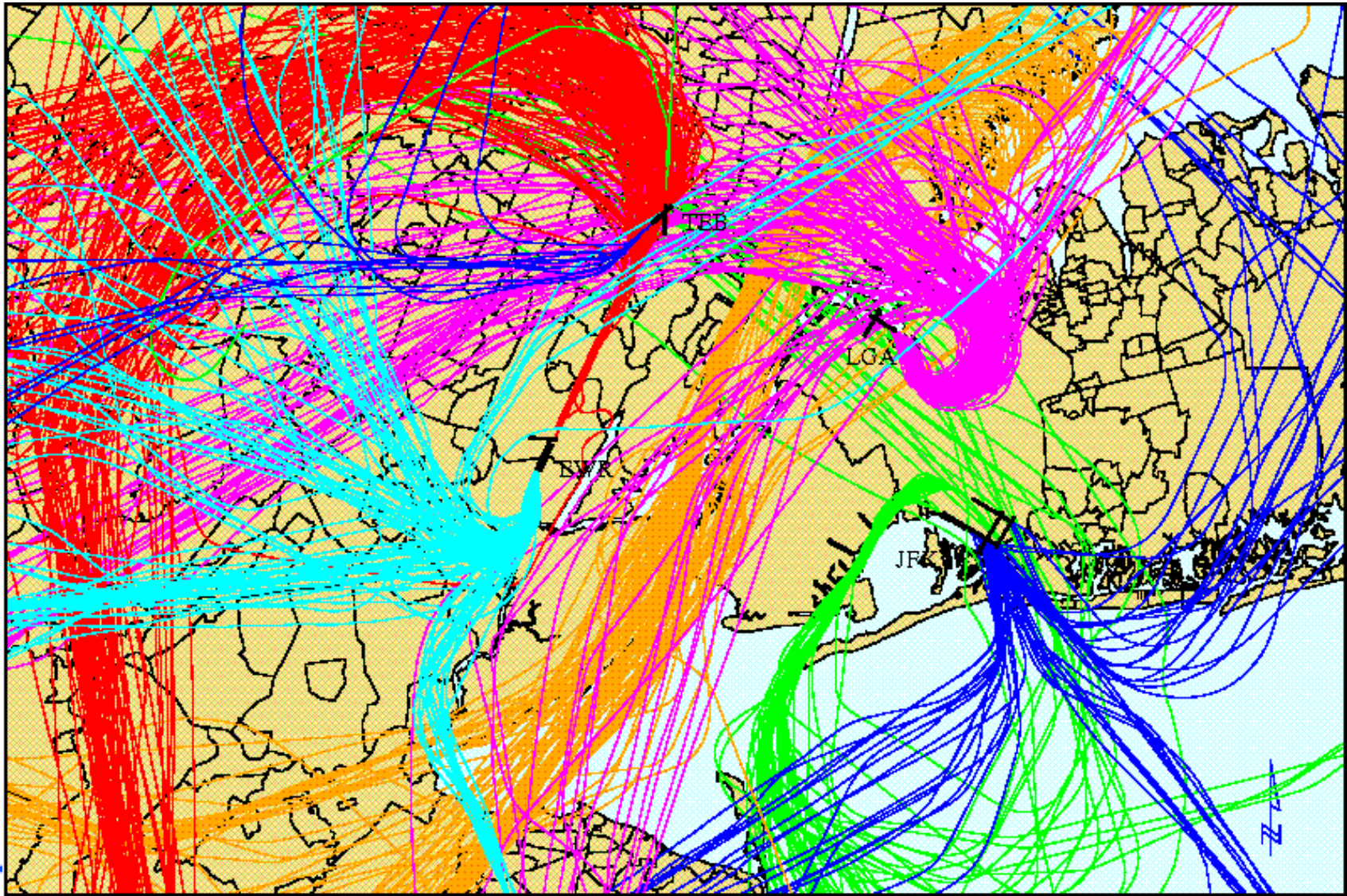
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- North fixes
  - GAYEL (J95) - Northwest (Minneapolis/St. Paul, Seattle, San Francisco)
  - COATE (J36) - Northwest (Chicago O'Hare)
- West fixes
  - ELIOT (J60 & J80) – Midwest and west coast (Cleveland, Denver, Los Angeles, Honolulu)
  - PARKE (J6) - Southwest, Washington DC (San Diego, Dallas/Fort Worth, Washington Dulles)
  - LANNA (J48) – Texas and the South (Houston, Atlanta)
  - BIGGY (J75) – The South (Washington National, Charlotte, Tampa)
- South Fixes
  - WHITE (J209) – The South, Florida, Central and South America (Norfolk, Fort Lauderdale, Miami, Coast Rica, Venezuela)
- East fixes
  - MERIT – North and Europe (Boston, Europe)
  - GREKI – North (Montreal, Burlington, VT)



# New York City Airspace Congestion

Departure and Arrival routes into EWR, JFK, LGA, TEB



Source: Port Authority of NY and NJ



# Typical Departure Restrictions

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- Miles in Trail (MIT)
    - Separation between aircraft in miles
  - Minutes in Trail (MINIT)
    - Separation between aircraft in minutes
  - Approval Request (APREQ)
    - Used instead of MIT
    - Aircraft must request approval before it can take off
    - Case by case basis
  - Fix closures
  - Delay programs at destination/arrival airports
-



# Reroutes

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- Dynamic rerouting difficult
    - Require all facilities affected to be in agreement
    - Generally many facilities affected
    - Coordinated by System Command Center
    - Interfacility communication & cooperation required
  - National Playbook
    - A set of preplanned reroutes for specific fix and jetroute closures
    - To be used in conjunction with other strategies
    - Limitations
    - Not fully developed
-



# EWR Case Study

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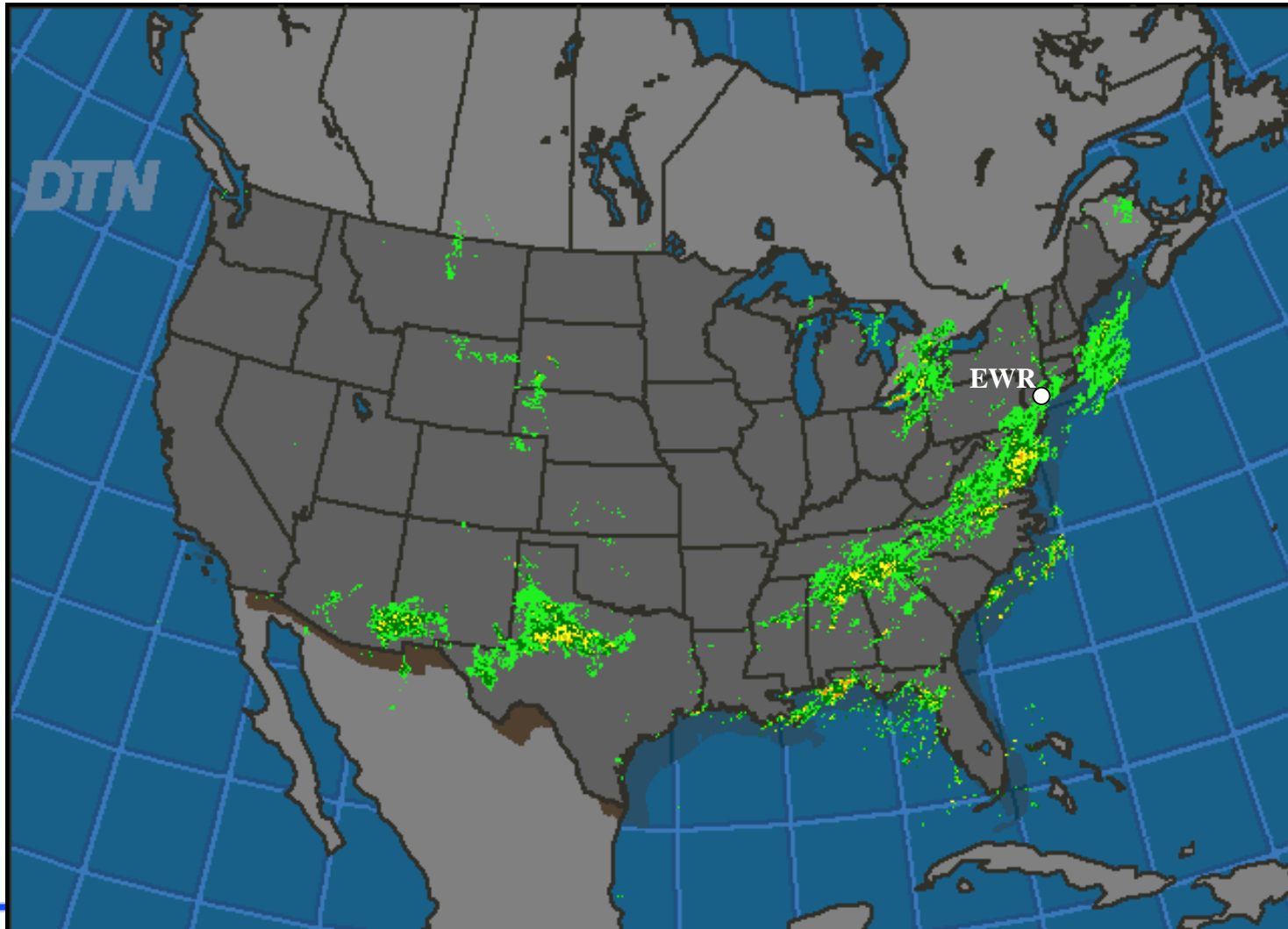
- Site visit Thursday, June 29, 2000
  - ⇒ Observations at NY TRACON, EWR Tower, CO Ramp Tower
  - ⇒ Middle of a difficult summer
  - ⇒ Just before July 4<sup>th</sup> weekend
  - ⇒ Large delays the previous day
  - ⇒ Severe Weather Avoidance Program (SWAP) active, 1pm – 10:30pm EDT
  - ⇒ Data collected focuses on departures





# June 29, 2000 – National Weather

National Doppler Radar Map



9:30:00 EDT (13:30:00 Zulu)

Source: Data Transmission Network



# June 29, 2000 – National Weather

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- Key features affecting EWR
    - Front extending from coast off Maine to Mississippi
      - Moving east, just to south of NYC
      - Affecting EWR through morning and afternoon
    - Front over Lake Huron
      - Moving East toward NYC
      - Affecting EWR through afternoon and evening
-



# June 29, 2000 – 7:15 am

## EWR Departure Fix Restrictions

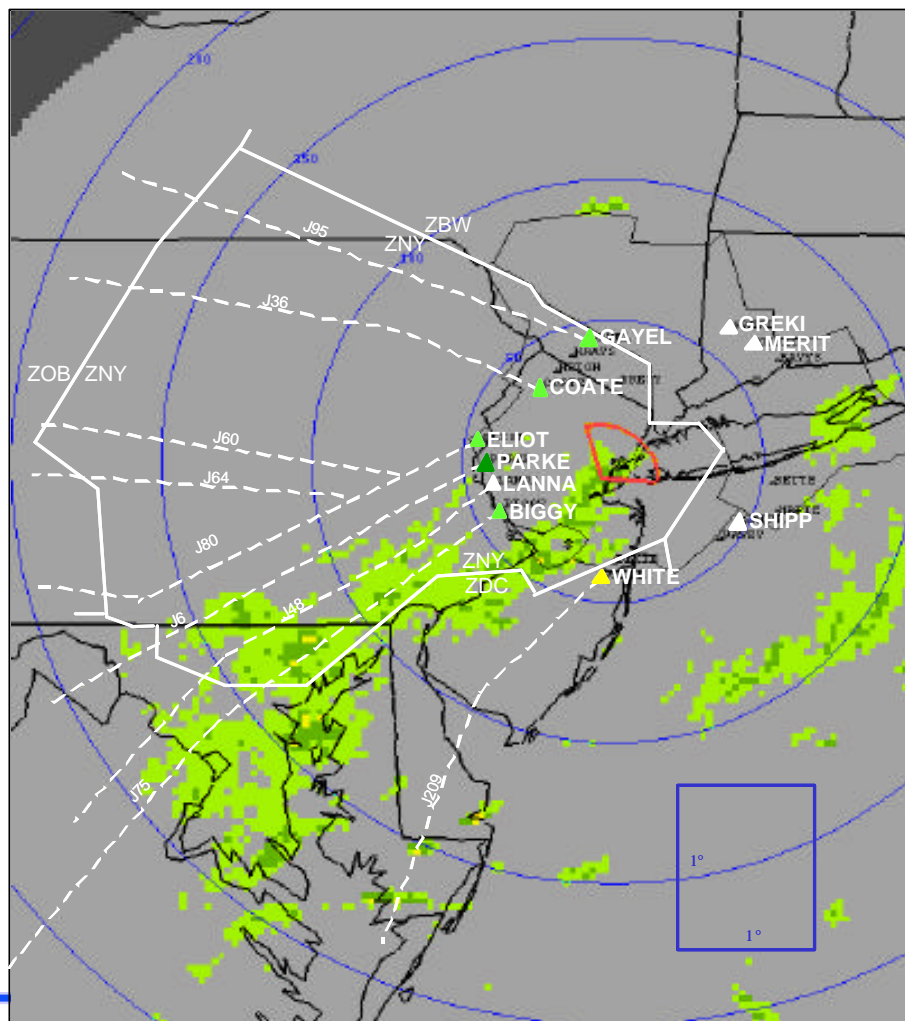
	EDT													
	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Zulu Time	9	10	11	12	13	14	15	16	17	18	19	20	21	22
GAYEL			█											
COATE			█											
			ORD at 20 MIT											
ELIOT		█	█											
		ORD CLE, CVG on APREQ												
PARKE		█	█											
		IAD Pops on APREQ												
LANNA														
BIGGY			█											
WHITE														
ZNY Programs														

EWR Departure Delays: 0min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## Local Doppler Radar Map

7:16:23 EDT (11:16:23 Zulu)



Source: Lincoln Laboratories ITWS

North-east fixes unrestricted throughout day





# June 29, 2000 – 7:15 am

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- Mild weather impacting:
    - Southern west fixes
    - South fixes
  - Initial Restrictions
    - Historically Validated Restrictions (HVR)
      - Based on historical data
      - Not based on weather forecast
      - Can be dynamically modified, as required
      - Sent out at 6:00 am, and 2:30 pm, daily
  - No EWR departure delays
-





# June 29, 2000 – 9:00 am

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- Weather front moving east, to coast
  - HVRs still in place for:
    - North fixes
    - Northern west fixes
  - PARKE restriction modified to 20 MIT
  - BIGGY and WHITE restricted – 20 MIT
    - Local & downstream weather to south
  - LANNA unrestricted
    - Light morning traffic
  - No EWR departure delays
-



# June 29, 2000 – 11:00 am

## EWR Departure Fix Restrictions

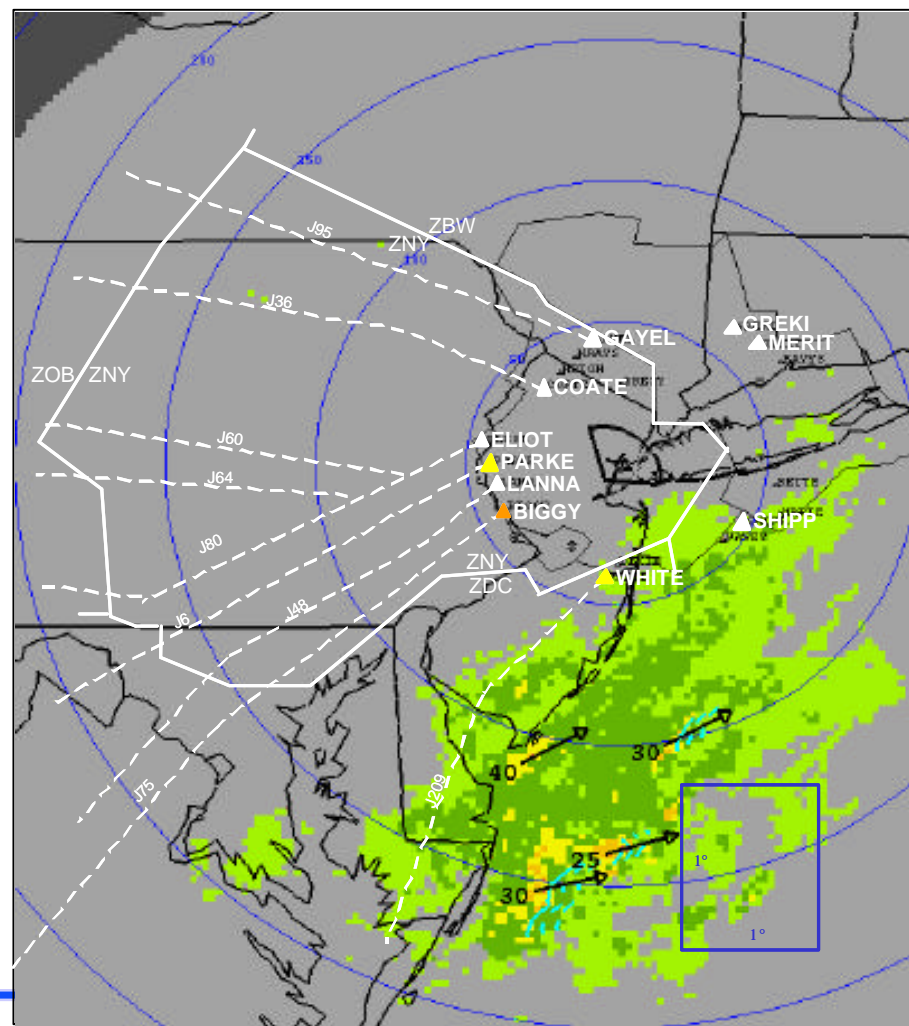
	EDT																				
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Zulu Time						
	9	10	11	12	13	14	15	16	17	18	19	20	21	22							
GAYEL			█	█	█																
COATE			█	█	█													ORD at 20 MIT			
ELIOT			█	█	█													ORD, CLE, CVG on APREQ			
PARKE			█	█	█	█												IAD Props on APREQ			
LANNA																		ATL on 20 MIT			
BIGGY			█	█	█	█												CLT on APREQ			
WHITE			█	█	█	█															
ZNY Programs																					

EWR Departure Delays: 0min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## Local Doppler Radar Map

10:58:34 EDT (14:58:34 Zulu)



Source: Lincoln Laboratories ITWS

North-east fixes unrestricted throughout day



# June 29, 2000 – 11:00 am

## EWR Departure Fix Restrictions

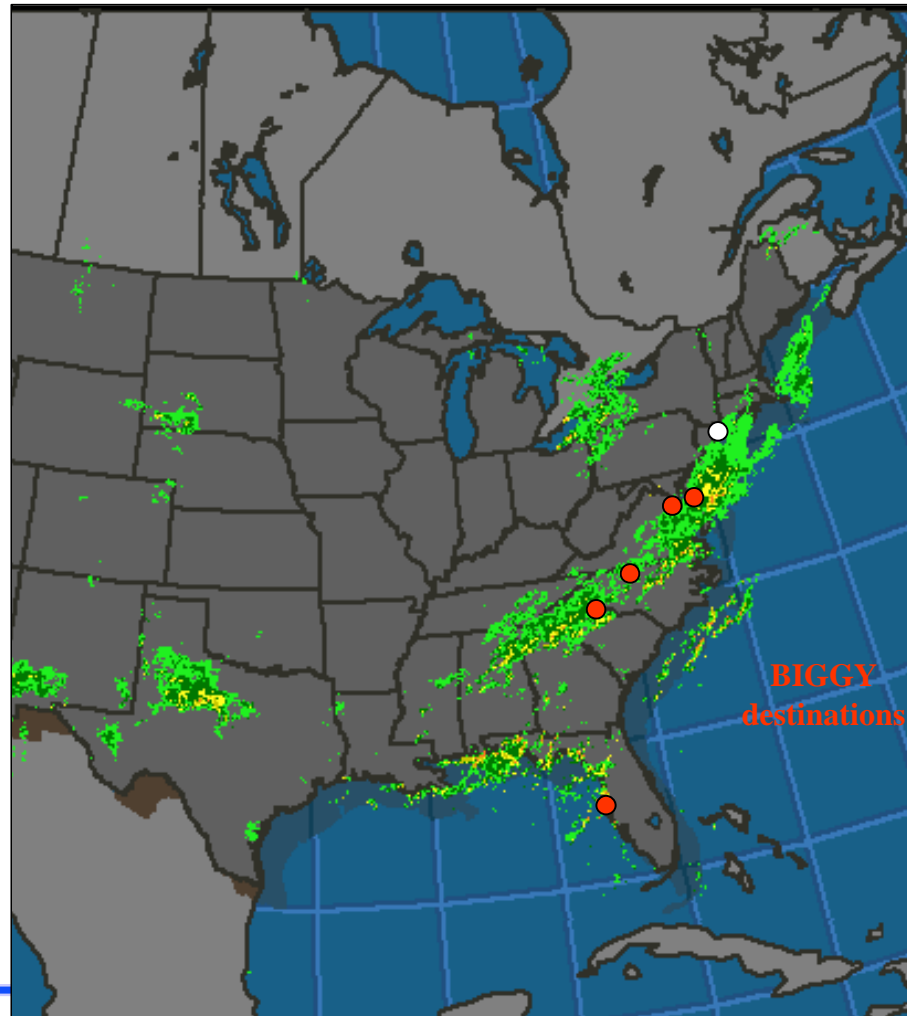
	EDT																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Zulu Time			
	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
GAYEL			█															
COATE			█															
			ORD at 20 MIT															
ELIOT			█															
			ORD, CLE, CVG on APREQ															
PARKE			█															
			IAD Props on APREQ															
LANNA																		
BIGGY			█		█													
			ATL on 20 MIT		CLT on APREQ													
WHITE			█															
ZNY Programs																		

EWR Departure Delays: 0min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## National Doppler Radar Map

10:30:00 EDT (14:30:00 Zulu)



North-east fixes unrestricted throughout day

Source: Data Transmission Network



# June 29, 2000 – 11:00 am

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- Weather front moves off the coast
  - HVRs completed
    - North fixes
    - Northern west fixes
  - PARKE - 20 MIT
  - BIGGY closed briefly, then 40 MIT
    - Downstream weather to south west
  - WHITE - 20 MIT
    - Local and downstream weather to south
  - LANNA still unrestricted
  - No EWR departure delays
-



# June 29, 2000 – 1:00 pm

## EWR Departure Fix Restrictions

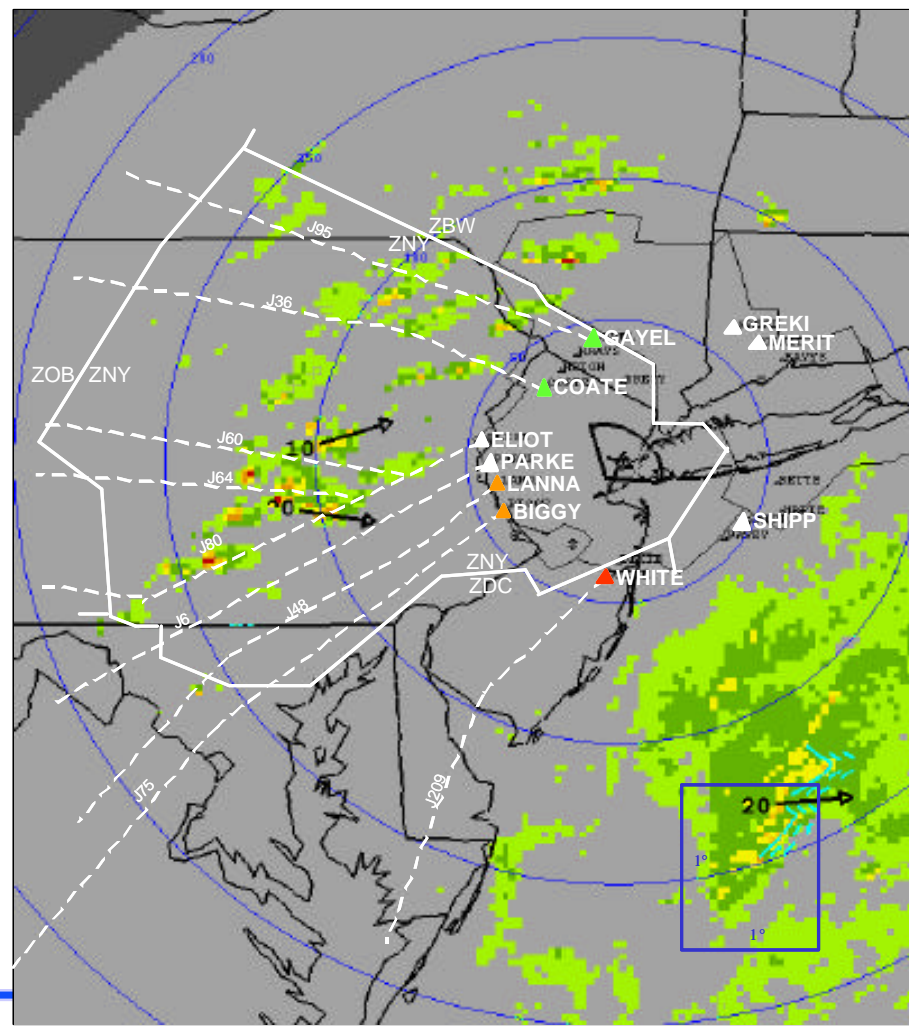
	EDT																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Zulu Time			
	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
GAYEL			█	█	█				█									
COATE			█	█	█				█						ORD at 30 MIT			
ELIOT			█	█	█										ORD, CLE, CVG on APREQ			
PARKE			█	█	█	█	█								IAD Props on APREQ			
LANNA															IAD closed, CVG on APREQ			
BIGGY			█	█	█	█	█	█							ATL on 20 MIT			
WHITE			█	█	█	█	█	█	█	█	█	█	█	█	CLT on APREQ			
WHITE			█	█	█	█	█	█	█	█	█	█	█	█	Due to ZDC WX			
ZNY Programs															█			

EWR Departure Delays: 0min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## Local Doppler Radar Map

12:58:45 EDT (16:58:45 Zulu)



North-east fixes unrestricted throughout day

Source: Lincoln Laboratories ITWS



# June 29, 2000 – 1:00 pm

## EWR Departure Fix Restrictions

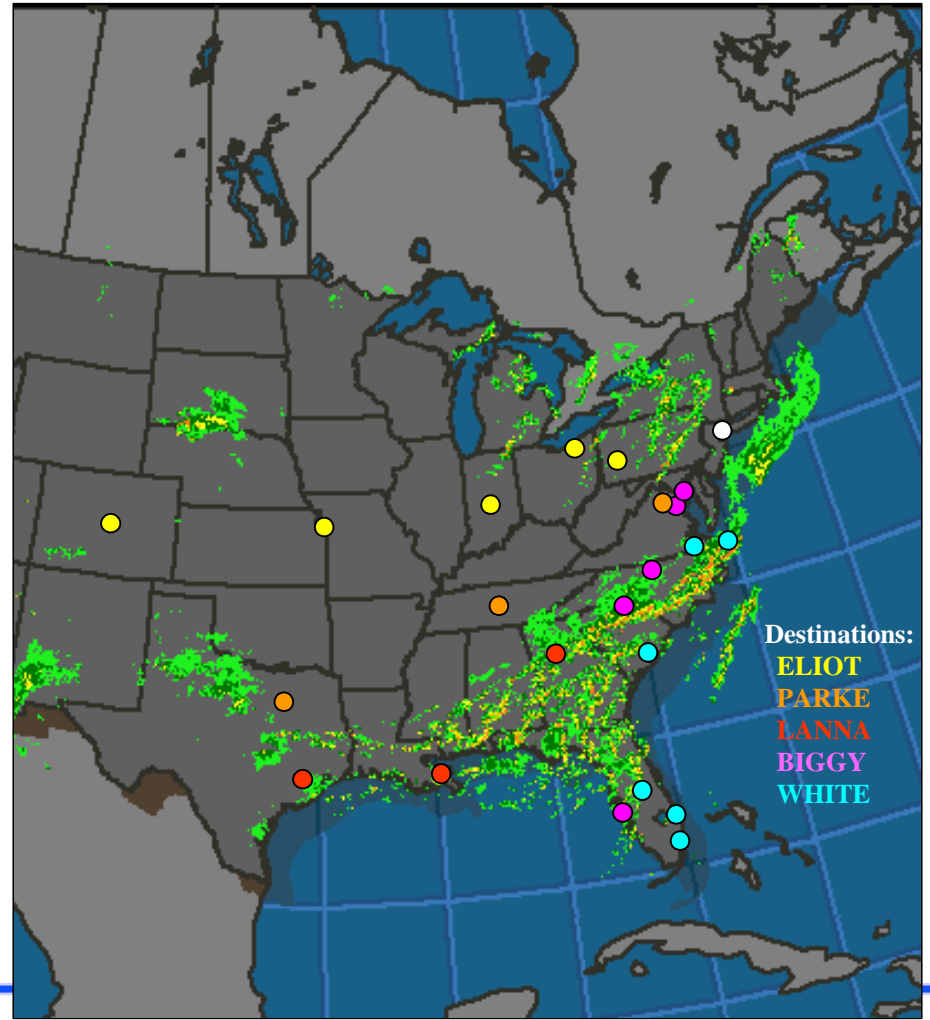
	EDT		Zulu Time																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
GAYEL			[Green]						[Green]											
COATE			[Green]						[Green]											
			ORD at 20 MIT																	
ELIOT			[Green]																	
			ORD, CLF, CVG on APREQ																	
PARKE			[Green]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]	[Yellow]		
			IAD Props on APREQ																	
LANNA																				
BIGGY			[Green]	[Yellow]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]	[Orange]		
			ATL on 20 MIT																	
			CLT on APREQ																	
WHITE			[Yellow]										[Red]							
													Due to ZDC WX							
ZNY Programs																				

EWR Departure Delays: 0min

<b>ATC</b>	[Green]	10 MIT	[Dark Green]	15 MIT	[Yellow]	20 MIT	[Orange]	30 MIT
	[Orange]	40 MIT	[Red]	Stopped	[Cyan]	Reroute	[Teal]	APREQ
<b>ZNY Programs</b>	[Purple]	SWAP	[Black]	Hotline Activated	(Severe Weather Avoidance Plan)			

## National Doppler Radar Map

12:30:00 EDT (16:30:00 Zulu)



North-east fixes unrestricted throughout day

Source: Data Transmission Network





# June 29, 2000 – 1:00 pm

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- Front from north west impacting north and northern pair of west fixes
  - GAYEL and COATE – 10 MIT
    - Local weather to north west
  - ELIOT and PARKE unrestricted
    - Local weather, but light traffic
  - LANNA and BIGGY – 40 MIT
    - Weather downstream
  - WHITE closed
    - Weather downstream in Washington Center
  - SWAP implemented
  - No EWR departure delays
-



# June 29, 2000 – 3:00 pm

### EWR Departure Fix Restrictions

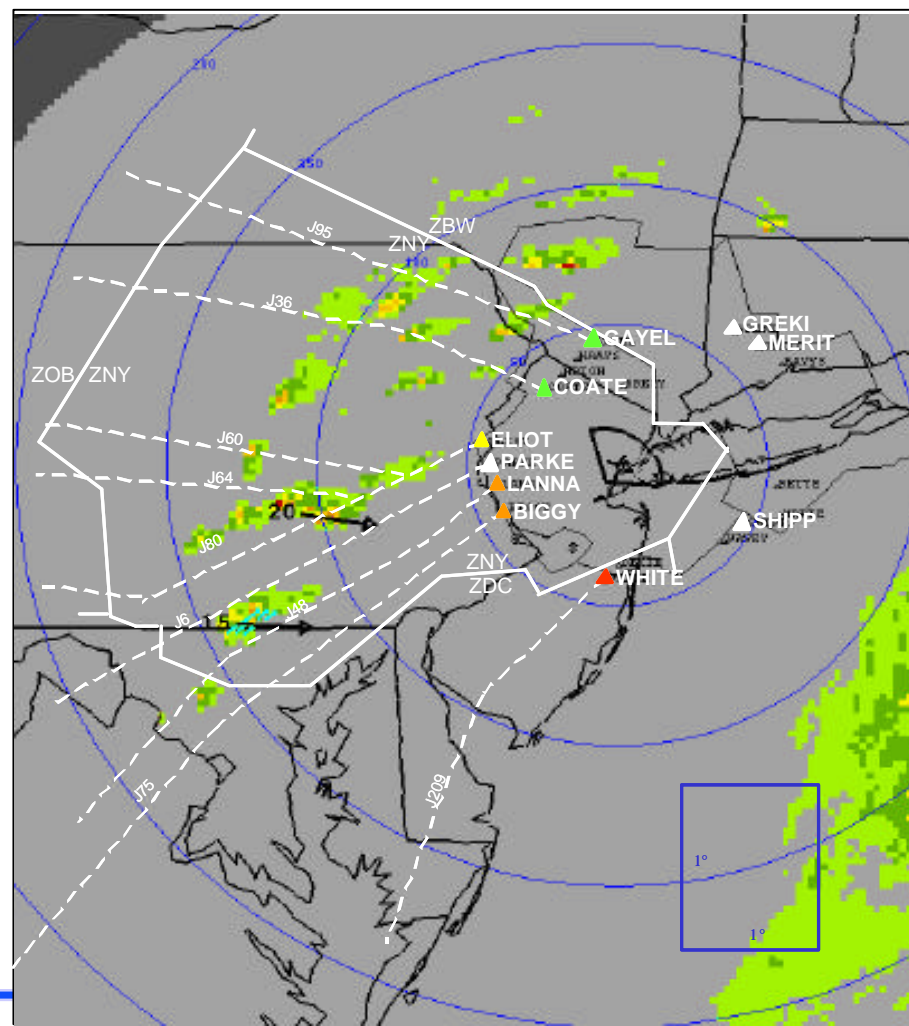
	EDT																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Zulu Time			
	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
GAYEL			█	█	█					█	█							
COATE			█	█	█					█	█				ORD at 20 MIT      ORD at 30 MIT			
ELIOT		█	█	█	█						█				ORD, CLE, CVG on APREQ      ORD on APREQ			
PARKE		█	█	█	█	█					█				IAD Props on APREQ      IAD closed, CVG on APREQ			
LANNA															ATL on 20 MIT      ATL rerouted PARKE			
BIGGY		█	█	█	█	█					█				CLT on APREQ			
WHITE		█	█	█	█	█	█	█	█	█	█	█	█	█	Due to ZDC WX			
ZNY Programs											█				SWAP			

EWR Departure Delays: 15min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

### Local Doppler Radar Map

14:58:36 EDT (18:58:36 Zulu)



Source: Lincoln Laboratories ITWS

North-east fixes unrestricted throughout day



# June 29, 2000 – 3:00 pm

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- Front continues to impact north and west fixes
  - GAYEL and COATE – still 10 MIT
  - ELIOT – 20 MIT
    - Local weather to north west
    - Increased traffic
  - PARKE unrestricted
    - Traffic still light
  - LANNA and BIGGY still 40 MIT
  - WHITE still closed
    - Appears to be gap between two fronts to depart west through WHITE
    - Would require interaction with IAD, DCA, BWI and PHL traffic
  - Hot line activated
  - EWR Departure delays – 15 min
-



# June 29, 2000 – 4:15 pm

## EWR Departure Fix Restrictions

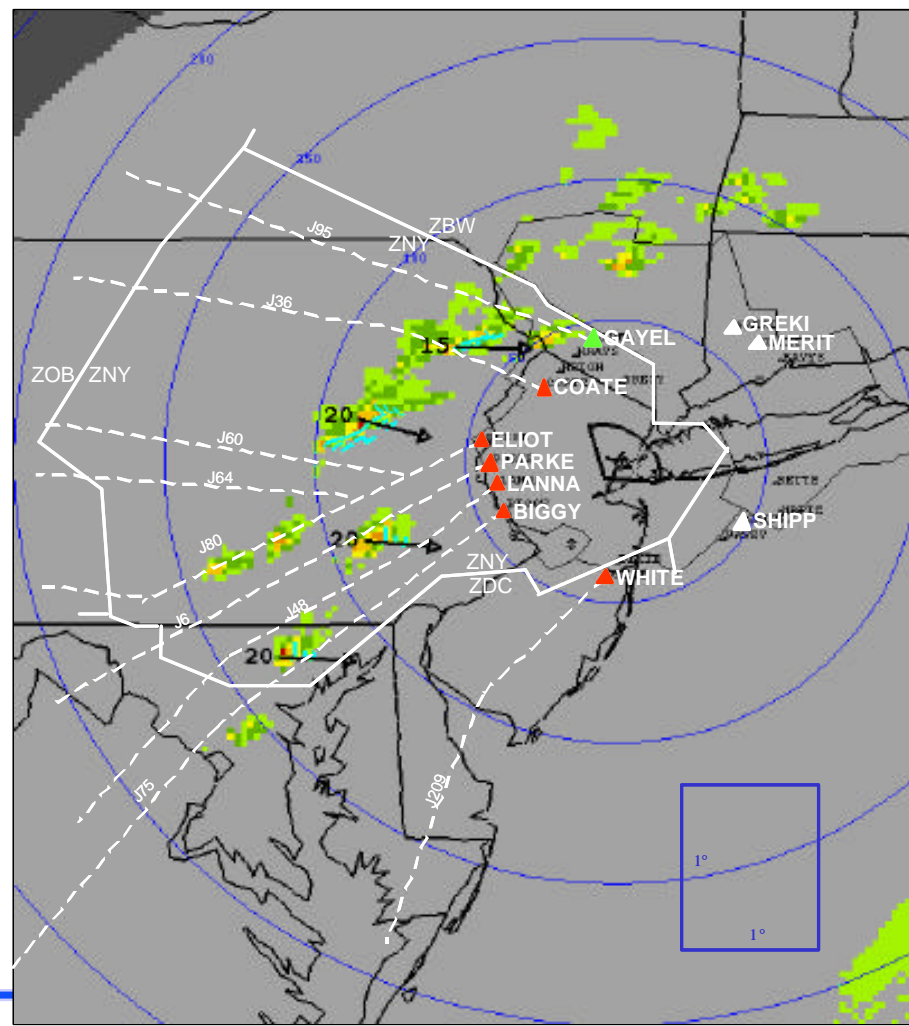
	EDT																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Zulu Time			
	9	10	11	12	13	14	15	16	17	18	19	20	21	22	9	10	11	12
GAYEL			█	█	█			█	█	█	█	█	█	█				
COATE			█	█	█			█	█	█	█	█	█	█	█	█	█	█
			ORD at 20 MIT						ORD at 30 MIT				Due to ZOB WX					
ELIOT			█	█	█						█	█	█	█	█	█	█	█
			ORD, CLE, CVG on APREQ						ORD on APREQ									
PARKE			█	█	█	█	█											
			IAD Props on APREQ						IAD closed, CVG on APREQ									
LANNA																		
			ATL on 20 MIT						ATL rerouted PARKE									
BIGGY			█	█	█	█	█											
			CLT on APREQ															
WHITE			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
									Due to ZDC WX				ORF, CLT, North traffic - allowed through					
ZNY Programs																		

EWR Departure Delays: 45min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## Local Doppler Radar Map

16:12:37 EDT (20:12:37 Zulu)



North-east fixes unrestricted throughout day

Source: Lincoln Laboratories ITWS



# June 29, 2000 – 4:15 pm

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- Front continues to impact north and west fixes
  - All west fixes closed
    - Local weather to north-west
  - COATE closed
    - Downstream weather in Cleveland Center
  - WHITE still closed
    - Some reroutes through gap – ORF, CLT
  - Only north fixes open
    - Heavy traffic – Europe
  - Playbook option to depart west through MERIT not implemented
  - BWI and DCA lightly restricted
  - EWR departure delays – 45 min
-



# June 29, 2000 – 5:00 pm

## EWR Departure Fix Restrictions

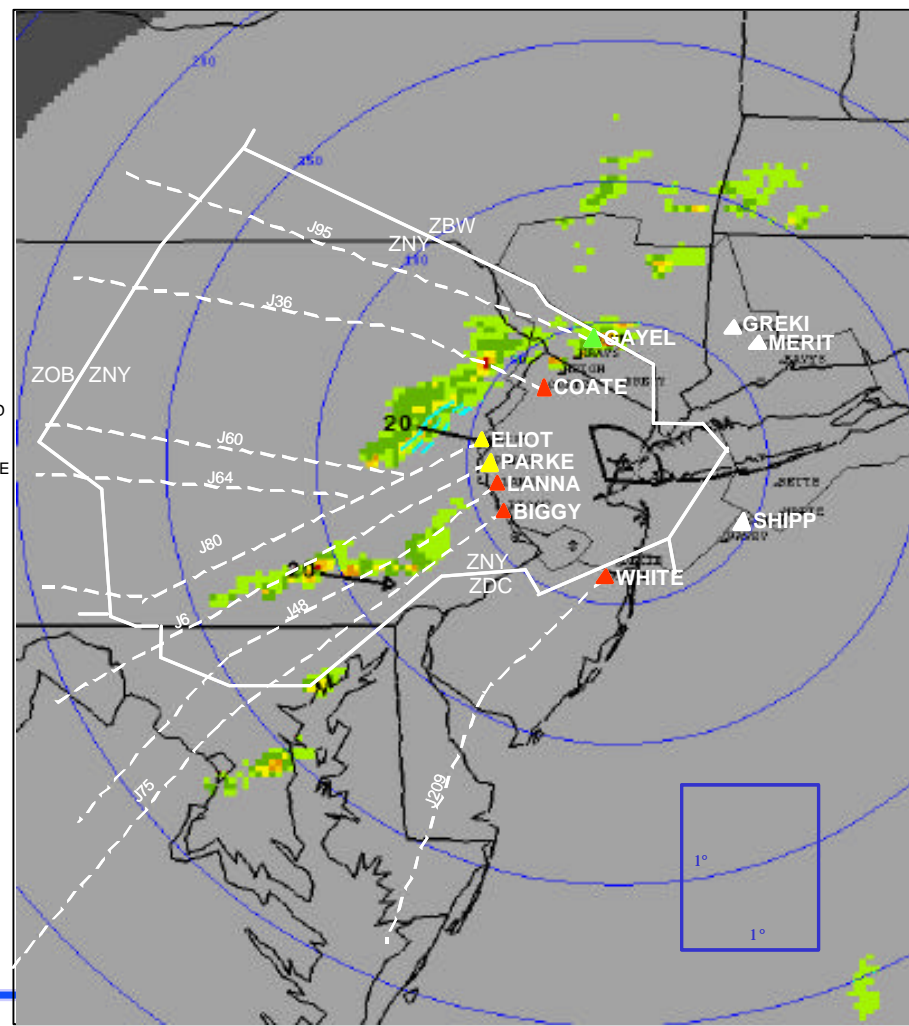
	EDT		Zulu Time															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
GAYEL			█	█	█							█	█	█	█	█	█	█
COATE			█	█	█							█	█	█	█	█	█	█
ELIOT			█	█	█													
PARKE			█	█	█	█	█	█										
LANNA																		
BIGGY			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
WHITE			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
ZNY Programs																		

EWR Departure Delays: 90min

<b>ATC</b>	█ 10 MIT	█ 15 MIT	█ 20 MIT	█ 30 MIT
	█ 40 MIT	█ Stopped	█ Reroute	█ APREQ
<b>ZNY Programs</b>	█ SWAP	█ Hotline Activated	(Severe Weather Avoidance Plan)	

## Local Doppler Radar Map

17:02:36 EDT (21:02:36 Zulu)



North-east fixes unrestricted throughout day

Source: Lincoln Laboratories ITWS



# June 29, 2000 – 5:00 pm

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- Front continues to impact north and west fixes
  - COATE still closed
  - ELIOT, PARKE reopened – 20 MIT
    - Airlines have rerouted aircraft off these routes
  - LANNA & BIGGY still closed
  - WHITE still closed
    - Limited reroutes continue through gap
  - EWR departure delays – 90 min
-







# June 29, 2000 – 7:00 pm

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- Front directly impacts north and west fixes
  - BIGGY reopened
  - ELIOT, PARKE, LANNA traffic rerouted onto BIGGY
    - National Playbook implemented
  - COATE still closed
  - WHITE still closed
    - Limited reroutes continue through gap
  - EWR departure delays – 135 min
-



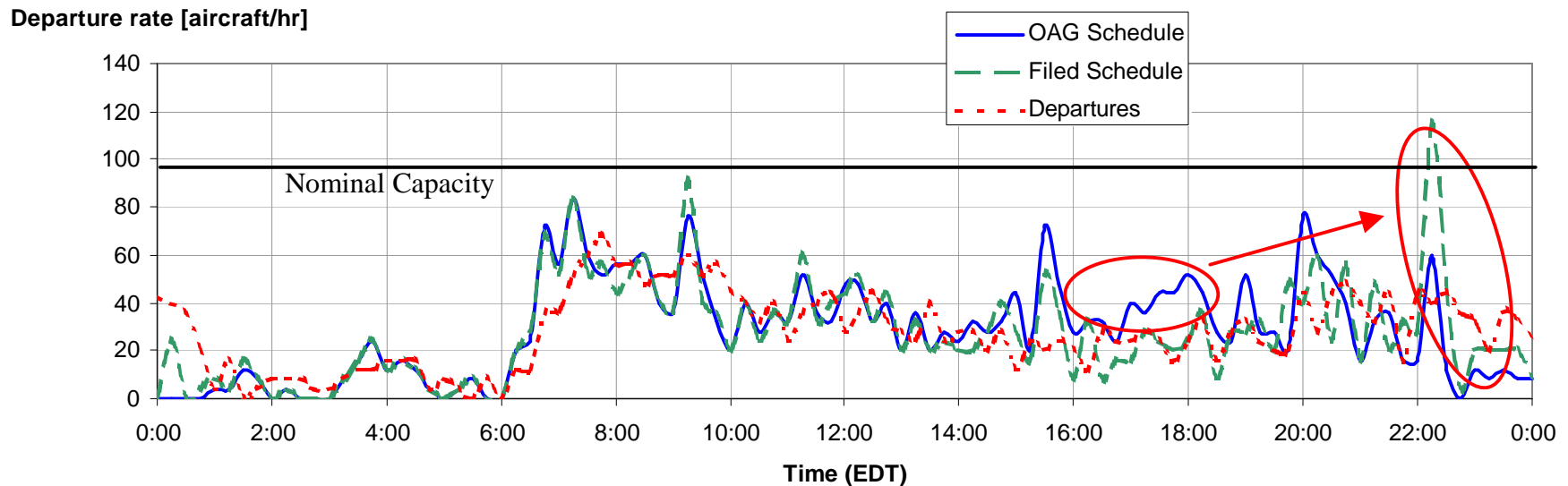
# Key Observations

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- Initial set of “Historically Validated Restrictions” implemented in morning
  - Restrictions caused by coupling of local weather, downstream weather and traffic demand
    - Some fixes impacted by local weather but unrestricted because of light traffic
    - Some fixes not impacted by local weather but restricted because of downstream weather
  - Opportunities for reroutes not utilized because of interfacility coordination required
    - Gap in weather to south not utilized for west reroutes because of coordination required with Washington Center & Cleveland Center
  - Playbook not used extensively
    - West traffic was not rerouted north-east because of high traffic to Europe
    - Only major play implemented at 6:30pm EDT
-



# Newark Departure Rate



- Airlines tactical responses to delays
  - Reschedule / Reroute
  - Cancellations

Total number of flights cancelled: 28

Source: CATER data from Port Authority of NY and NJ



# Airline Operations

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- Ramp Tower monitors all weather and restrictions
  - Prioritization of cancellations
    - Continental Express flights cancelled to reduce jet delays
      - Other forms of transportation available
      - 4<sup>th</sup> of July weekend, therefore trying to accommodate as many passengers as possible
  - Airline / ATC coordination used to address special Airline constraints
    - COA requirement to meet a curfew at John Wayne Airport (SNA)
      - aircraft skipped to front of departure queue
-



# Airline - ATC Coordination

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- COA167 to John Wayne Airport, Orange County, CA (SNA)
  - Scheduled Departure 6:50pm
  - 7:50pm COA167 calls Tower
    - COA167 will miss curfew at SNA unless it leaves
  - Tower gives calls Airline and gives permission for COA167 to skip to front of departure queue
    - on condition that another COA goes to back of queue
  - COA167 departs at 8:04pm  
(No COA is ever moved to back of queue)
-



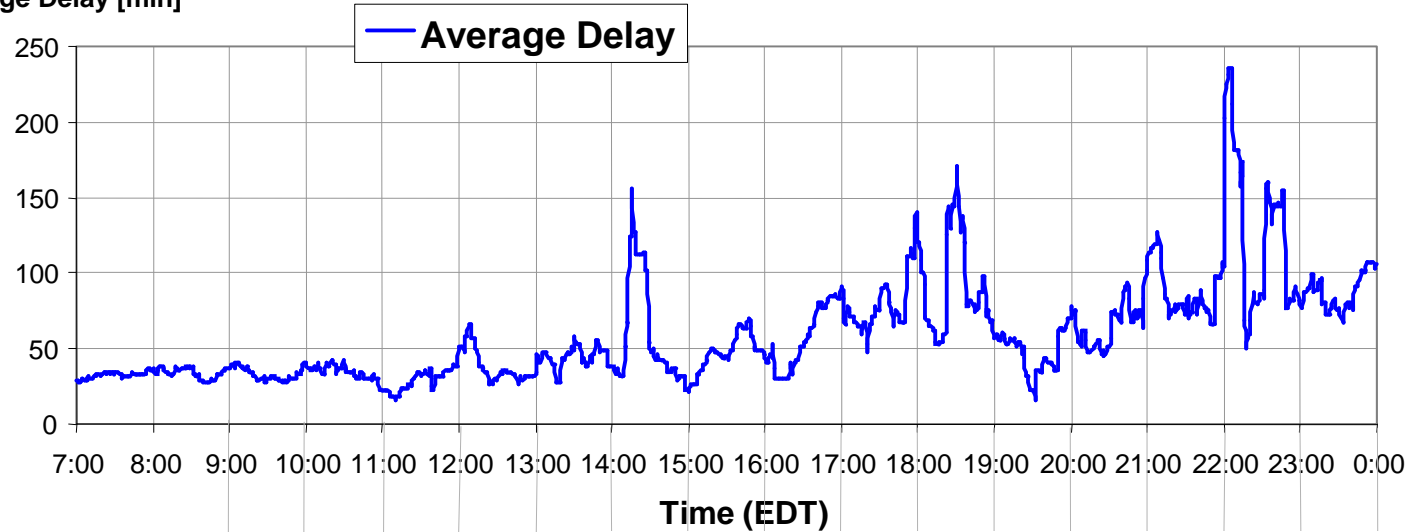
# Impact on Delays

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- Departure delay: actual wheels off time – scheduled wheels off time (as filed)
    - Includes taxi delays and delays at gate
    - Assumes average taxi time (12 min)
  - Average departure delay
    - Only recorded once, at take off
      - Only accounts for delay as aircraft departs
      - NOT during the period when it is delayed
  - Total departure delays of aircraft on airport surface at given time
    - At every given instant
      - Sum delay time of all aircraft waiting to take off
    - Measure of total frustration factor of passengers
    - Progressive, and can thus be compared to restriction charts
-

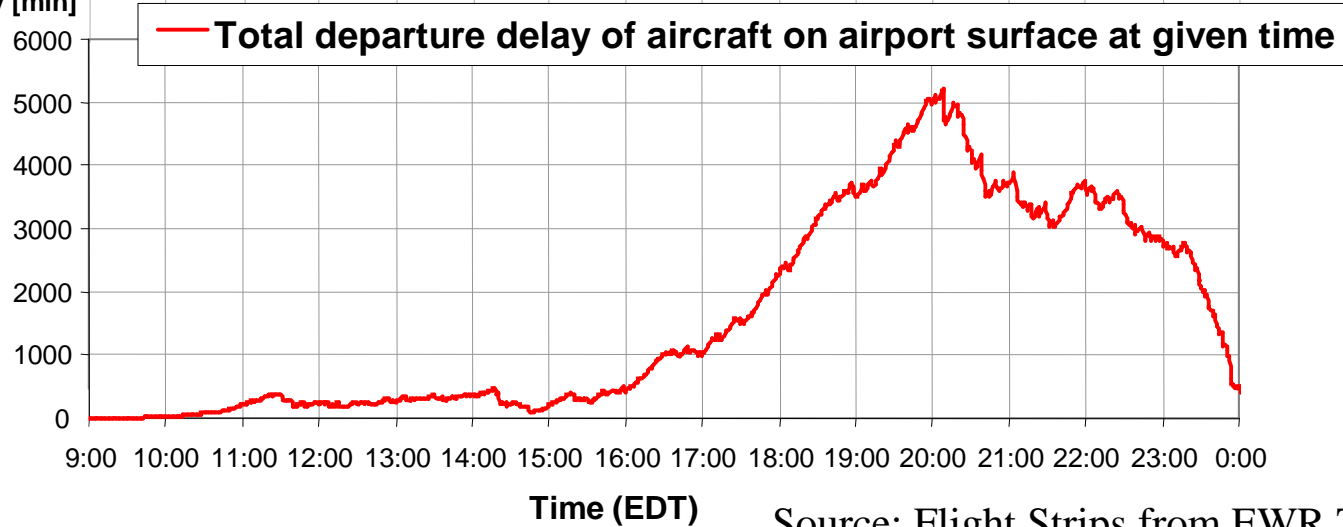
# Impact on Delays

Average Delay [min]



Source: CATER data from Port Authority of NY and NJ

Delay [min]



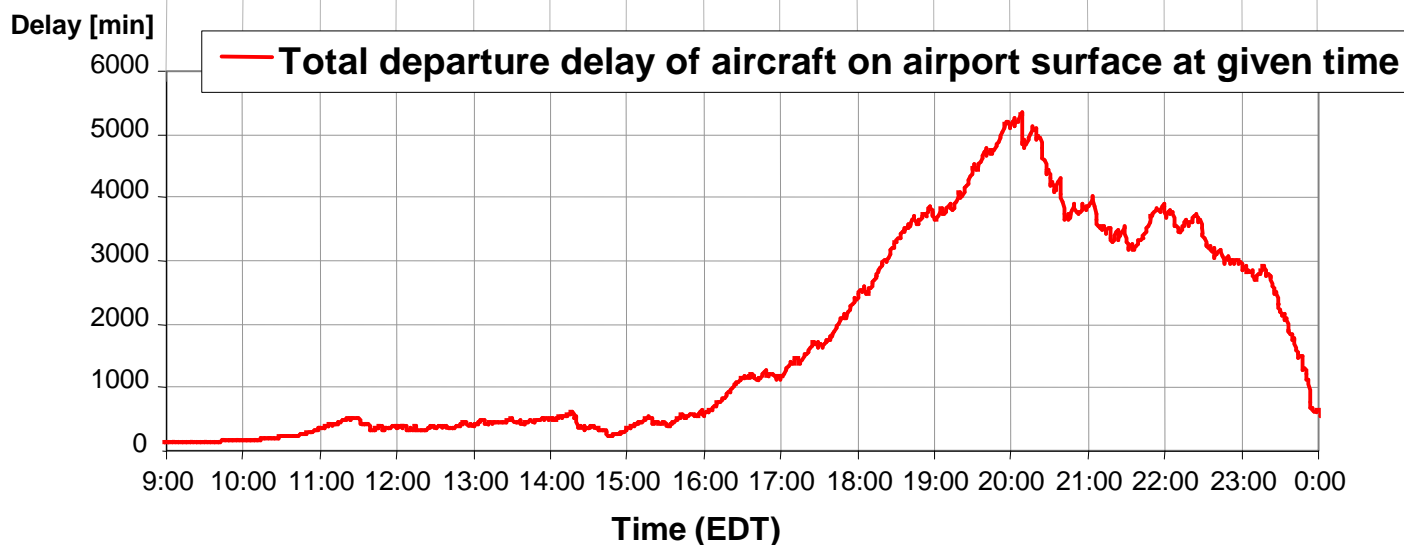
Source: Flight Strips from EWR Tower



# Impact on Delays

		Thursday 6/29/00																
Eastern Daylight Time:		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
North Restrictions																		
West Restrictions																		
South Restrictions																		

Restrictions Applied to Fix ■ Fix closed ■



Source: Flight Strips from EWR Tower





# Conclusions

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- Downstream capacity limitations were a primary flow constraint
    - Downstream restrictions were a primary cause of surface delays
  - Airline attempts to reroute and reschedule in response to capacity limitations may be improved by more information
  - Improved interfacility coordination may improve utilization of resources
    - Reroute opportunities through ZDC appear to have been missed
-



## Conclusions (2)

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- Airline rerouting / rescheduling may be improved by providing Airlines with:
    - More information about restrictions
      - Predictions of restrictions
    - Decision aiding
      - ETMS alert type system for when fixes are impacted or overloaded
    - More opportunity to reschedule departures based on the Airline's priorities
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## Conclusions (3)

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- Interfacility coordination may be improved by:
    - Improved coordination of restrictions between different facilities
      - Improved understanding of the influence of restrictions on overall system delays
    - Further development of National Playbook
      - Development of more plays
      - Improved robustness of current plays
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