"Weatherproofing the NAS" :

research towards reducing the impact of weather

friends and partners of aviation weather : summer 2011

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CAASD

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why "weatherproofing"?

- the NAS works quite well in good weather – all 5 days/year of it
  - networks operating near capacity react badly to disruptions!

- goal: reduce impact of weather in two areas
  - "equivalent visual operations" at airports : strive for VMC rates in IMC
  - alleviate convective weather impact through improved planning tools

- a key element of a larger NextGen goal: build a robust, resilient NAS
  - reduce *delay variability*
  - increase flexibility

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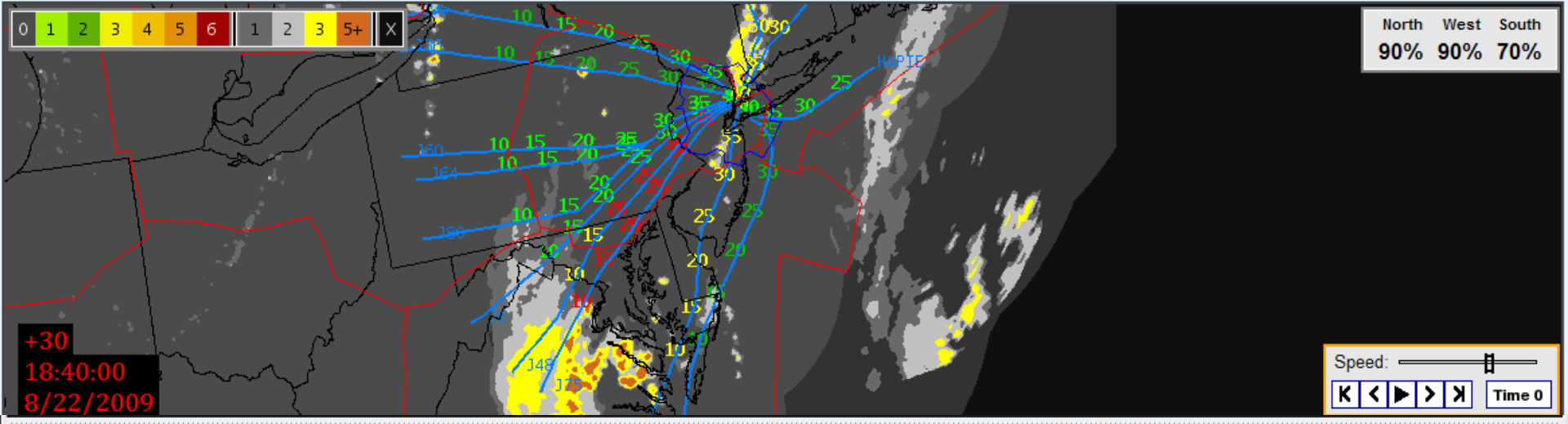
three examples in eight minutes

- Integrated Departure Route Planning (IDRP) [CAASD and MIT LL]
  - tactical pre-departure route planning in convective weather
  - in prototype operation at ZNY, ZOB, ZBW, ATCSCC, N90, LGA, JFK, EWR, TEB, JetBlue, and Delta

- En route Flow Planning Tool (EFPT)
  - tactical en route convective weather avoidance
  - doing HITL evaluation of prototype : mid-term TFMS capability

- Flow Contingency Management (FCM)
  - concept for strategic TFM : 2-15 hour planning horizon
  - far-term

common thread : integration of advanced digital weather products with ATM automation to improve situation awareness, planning, and collaboration



Precip | Wntr Precip | Echo Tops | Forecast | Satellite | Lightning | Storm Motion | Echo Tops Tags | G&D Trends | Fcst Contours | Verification | Accuracy | RAPT | IDRP Demand

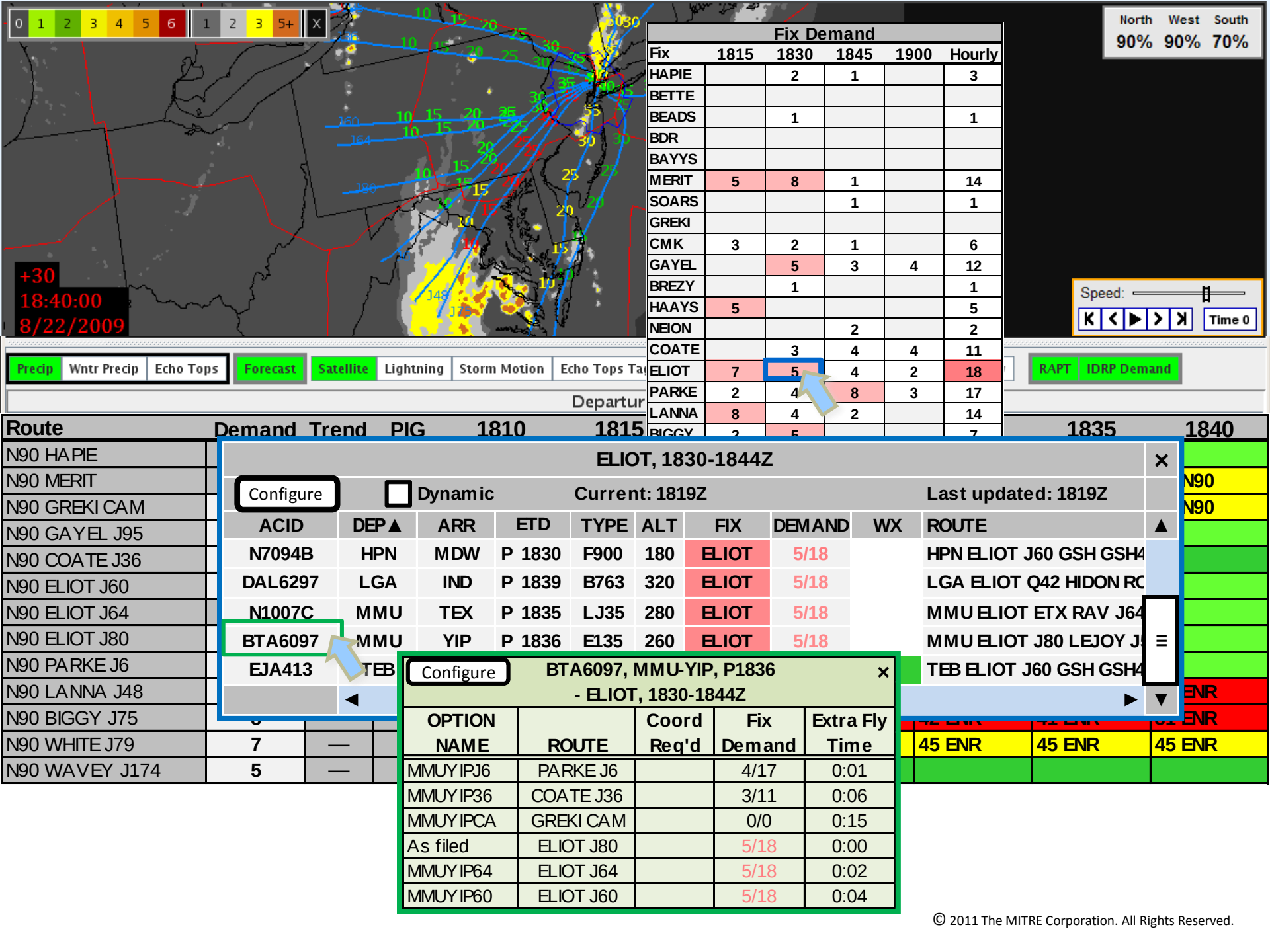
Departure Time

Route	Demand	Trend	PIG	1810	1815	1820	1825	1830	1835	1840
N90 HAPIE		—								
N90 MERIT		—		35 N90	34 N90	34 N90	35 N90	38 N90	40 N90	45 N90
N90 GREKI CAM	1	—		34 N90	34 N90	35 N90	35 N90	37 N90	39 N90	42 N90
N90 GAYEL J95	6	▲	25							
N90 COATE J36	5	▼	40							
N90 ELIOT J60	5									
N90 ELIOT J64										
N90 ELIOT J80	4									
N90 PARKE J6	8									
N90 LANNA J48	16									
N90 BIGGY J75	8									
N90 WHITE J79	7									
N90 WAVEY J174	5									

N90_BIGGY_J75, 1815-1844Z

Configure | Dynamic | Current: 1819Z | Last updated: 1819Z

ACID	DEP	ARR	ETD▲	TYPE	ALT	FIX	DEMAND	WX	ROUTE
COA2699	EWR	BWI	A 1818	E135	120	BIGGY	5/12		EWR BIGGY J75 MXE V37
AWI57	LGA	BWI	P 1821	DN8C	120	BIGGY	5/12		LGA BIGGY J75 MXE V37
OPT706	TEB	MIA	P 1822	C750	340	BIGGY	5/12	32 ENR	TEB BIGGY J75 BINKS OT
USA3075	LGA	RIC	P 1825	E135	140	BIGGY	5/12		LGA BIGGY J75 MXE V37
USA4069	HPN	DCA	P 1826	CRJ9	120	BIGGY	5/12		HPN BIGGY J75 MXE CLIF
COA3343	EWR	DCA	P 1830	DH8D	120	BIGGY	3/12		EWR BIGGY J75 MXE CLIF
OPT782	TEB	BWI	P 1840	GLF4	100	BIGGY	3/12		TEB BIGGY J75 MXE V378
COA450	EWR	AUS	P 1844	B735	360	BIGGY	3/12	31 ENR	EWR BIGGY J75 GVE J37



Fix Demand

Fix	1815	1830	1845	1900	Hourly
HAPIE		2	1		3
BETTE					
BEADS		1			1
BDR					
BAYYS					
MERIT	5	8	1		14
SOARS			1		1
GREKI					
CMK	3	2	1		6
GAYEL		5	3	4	12
BREZY		1			1
HAAYS	5				5
NEION			2		2
COATE		3	4	4	11
ELIOT	7	5	4	2	18
PARKE	2	4	8	3	17
LANNA	8	4	2		14
BIGGY					

Route	Demand	Trend	PIG	1810	1815	1835	1840
N90 HAPIE							
N90 MERIT							N90
N90 GREKI CAM							N90
N90 GAYEL J95							
N90 COATE J36							
N90 ELIOT J60							
N90 ELIOT J64							
N90 ELIOT J80							
N90 PARKE J6							
N90 LANNA J48							ENR
N90 BIGGY J75							ENR
N90 WHITE J79	7	—				45 ENR	45 ENR
N90 WAVEY J174	5	—					

ELIOT, 1830-1844Z

Configure ☐ Dynamic Current: 1819Z Last updated: 1819Z

ACID	DEP▲	ARR	ETD	TYPE	ALT	FIX	DEMAND	WX	ROUTE
N7094B	HPN	MDW	P 1830	F900	180	ELIOT	5/18		HPN ELIOT J60 GSH GSH4
DAL6297	LGA	IND	P 1839	B763	320	ELIOT	5/18		LGA ELIOT Q42 HIDON RC
N1007C	MMU	TEX	P 1835	LJ35	280	ELIOT	5/18		MMU ELIOT ETX RAV J64
BTA6097	MMU	YIP	P 1836	E135	260	ELIOT	5/18		MMU ELIOT J80 LEJOY J
EJA413	TEB								TEB ELIOT J60 GSH GSH4

Configure **BTA6097, MMU-YIP, P1836 - ELIOT, 1830-1844Z**

OPTION NAME	ROUTE	Coord Req'd	Fix Demand	Extra Fly Time
MMUY IPJ6	PARKE J6		4/17	0:01
MMUY IP36	COATE J36		3/11	0:06
MMUY IPCA	GREKI CAM		0/0	0:15
As filed	ELIOT J80		5/18	0:00
MMUY IP64	ELIOT J64		5/18	0:02
MMUY IP60	ELIOT J60		5/18	0:04

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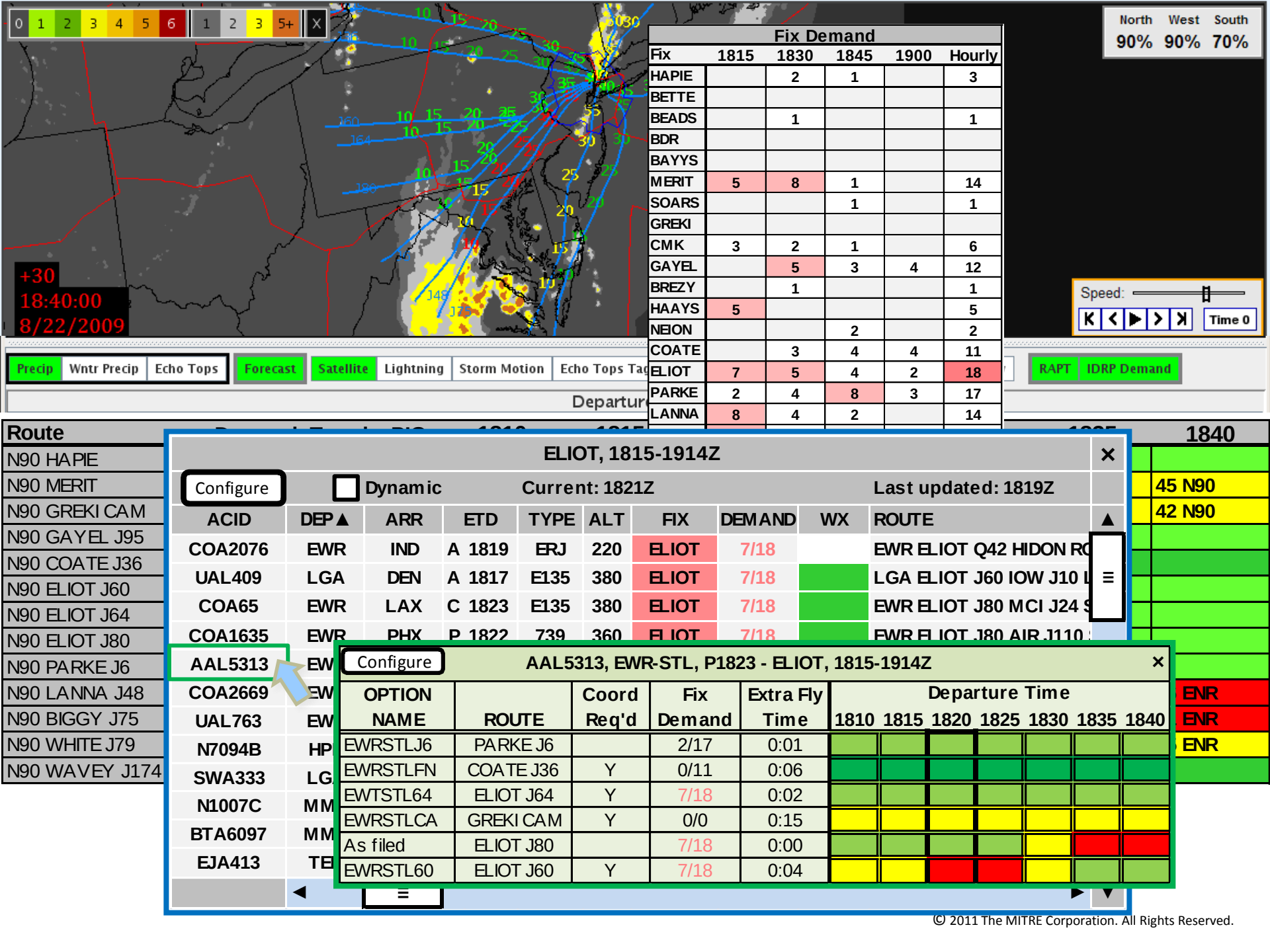

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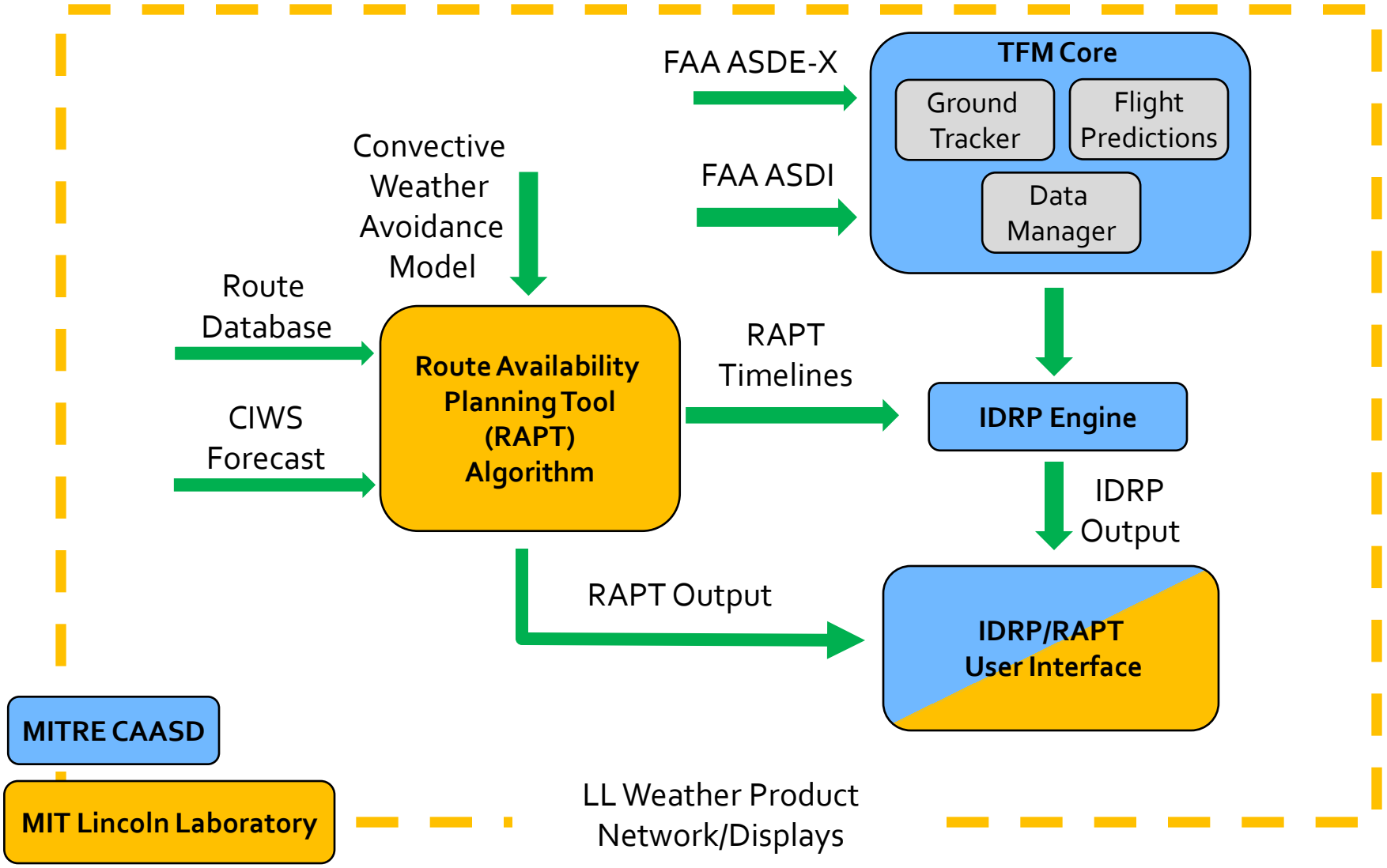
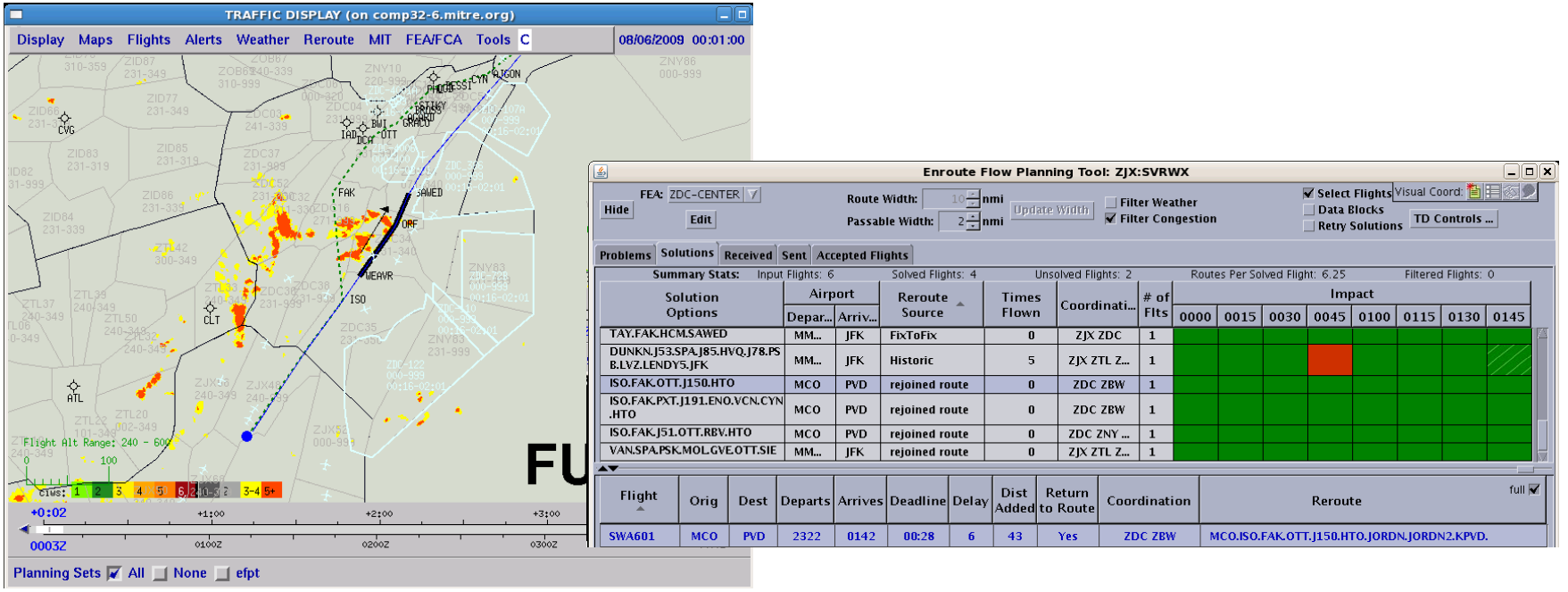
IDRP: near-term ATM-weather integration



En route Flow Planning Tool (EFPT)

- Tactical TFM Rerouting: 15 – 90 minute lookahead allows fine tuning of strategic TMIs (AFP,CTOP,GDP) – incremental decision-making
- Automatic detection of weather impact on traffic flows
- Automation generates reroute options to avoid severe weather
- Electronic coordination of reroutes facilitates rapid execution
- Predictability of flights on clear routes will increase throughput in wx area and allow less restrictive TMIs and less delay



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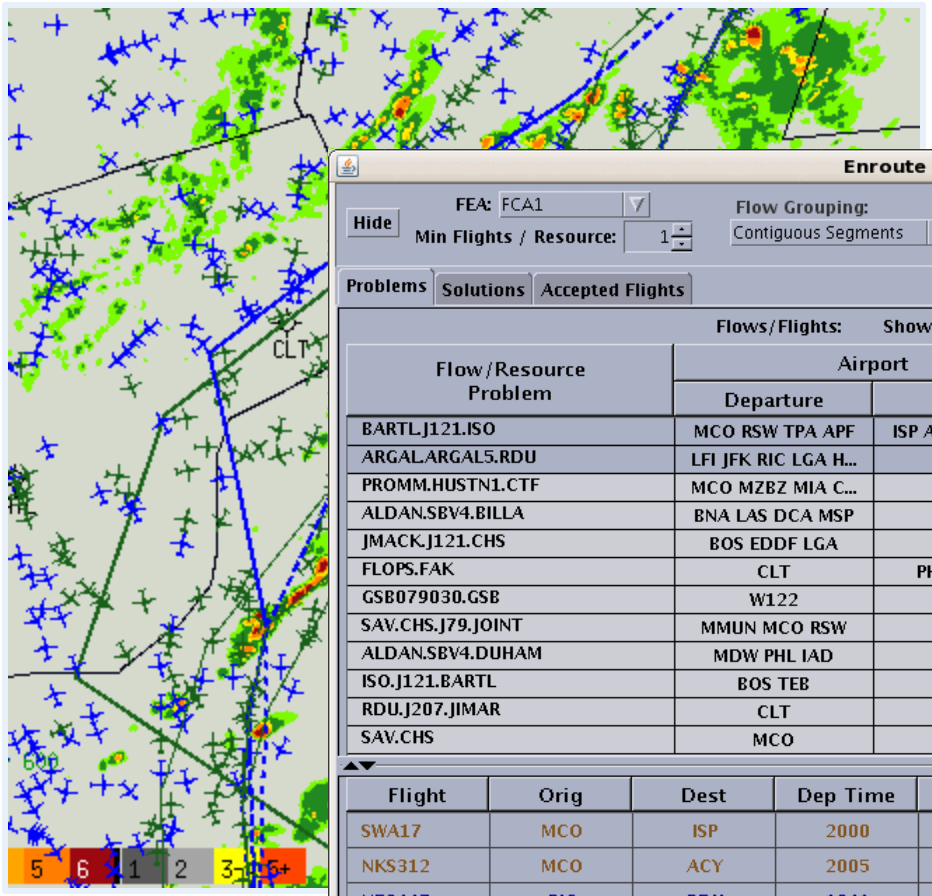
problem identification



Enroute Flow Planning Tool: ZDC: SVRWX

Hide | FEA: FCA1 | Min Flights / Resource: 1 | Flow Grouping: Contiguous Segments | Route Width: 10 nmi | Passable Width: 2 nmi | Update Width | Select Flights | Data Blocks | Retry Solutions | Visual Coord: | TD Controls ...

Problems | Solutions | Accepted Flights

Flows/Flights: Shown: 89/113 Selected: 2/12 Filtered Out: 0/0

Flow/Resource Problem	Airport		Alt (Tops)	# of Flts	Impact							
	Departure	Arrival			2000	2015	2030	2045	2100	2115	2130	2145
BARTL.J121.ISO	MCO RSW TPA APF	ISP ACY JFK HPN ...	360	6				4	1	1		
ARGAL.ARGAL5.RDU	LFI JFK RIC LGA H...	RDU	300	6				3	1	2		
PROMM.HUSTN1.CTF	MCO MZBZ MIA C...	CLT	250	4			2	2				
ALDAN.SBV4.BILLA	BNA LAS DCA MSP	RDU	350	4				2	1	1		
JMACK.J121.CHS	BOS EDDF LGA	MCO PBI	380	3					2	1		
FLOPS.FAK	CLT	PHL EWR IAD	360	3				3				
GSB079030.GSB	W122	GSB	340	3				2	1			
SAV.CHS.J79.JOINT	MMUN MCO RSW	BOS BWI	380	3				1	1	1		
ALDAN.SBV4.DUHAM	MDW PHL IAD	RDU	350	3			3					
ISO.J121.BARTL	BOS TEB	MCO PBI	360	2					1	1		
RDU.J207.JIMAR	CLT	BOS BDL	290	2						2		
SAV.CHS	MCO	ISP ACY	380	2			2					

Flight	Orig	Dest	Dep Time	Arr Time	Blocked	Route
SWA17	MCO	ISP	2000	2200	2031	KMCO.MCOY9.SAV.CHS.J121.SARDI.CCC.KISP.
NKS312	MCO	ACY	2005	2143	2034	KMCO.MCOY9.SAV.CHS.J121.SWL.V139.SIE.KACY.
N52447	RIC	RDU	1941	2101	2042	RIC.HPW.ARGAL5.RDU.
EGF4736	LGA	RDU	1941	2053	2044	KLGA.WHITE.CYN.J37.CLASY.J191.PXT.V213.HPW.ARGAL5.KRDU.
COM742	JFK	RDU	1944	2057	2049	KJFK.WAVEY.EMJAY.J174.WARNN.SWL.ARGAL5.KRDU.
N604CR	APF	HVN	1944	2203	2054	APF./.CPP01.ORL.CRG.J121.SARDI.HVN.
JBU152	RSW	JFK	1951	2155	2057	KRSW./.RSW320011.ORL.J53.CRG.J51.SAV.CHS.J121.SIE.CAMRN4....
SWA143	TPA	ISP	2000	2207	2058	KTPA.TAY.DUNKN.J210.JMACK.J121.SARDI.CCC.KISP.
R10301	LFI	RDU	2045	2122	2112	KLFI.FKN.ARGAL5.KRDU.
N461QS	HPN	RDU	2015	2124	2115	KHPN.WHITE.CYN.J37.CLASY.J191.PXT.V213.HPW.ARGAL5.KRDU.

Find Solutions

resolution support

Enroute Flow Planning Tool: ZDC: SVR

Hide | FEA: FCA1 | Route Width: 10 nmi | Passable Width: 2 nmi | Update Width | Select Flights | Data Blocks | Retry Solutions

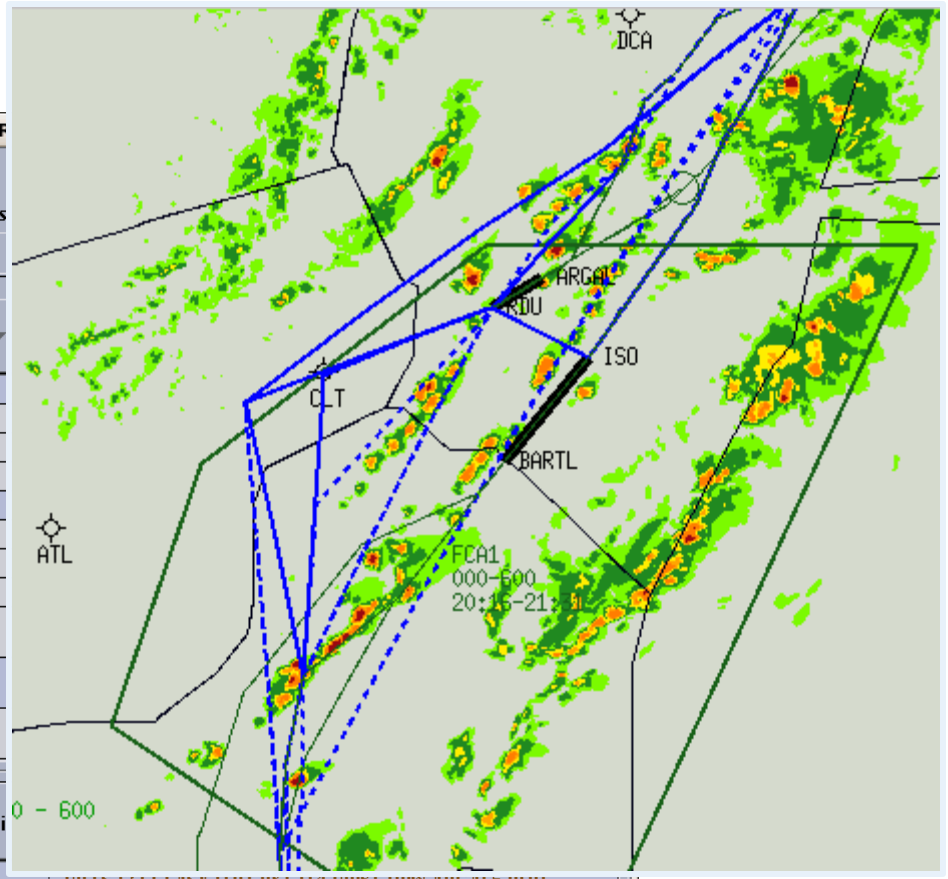
Problems | Solutions | Accepted Flights

Summary Stats: Input Flights: 12 Solved Flights: 10 Unsolved Flights: 2

Solution Options	Airport Departure	Airport Arrival	Reroute Source	Times Flown	Coordinati...	# of
VIYAP.SAV.RDU.ISO	MCO	ISP A...	FOG Route	0	ZJX ZDC	3
CRG.SPA.RIC.SIE	MCO AP...	ACY ...	FOG Route	0	ZJX ZTL...	3
SAV.SPA.RDU.ISO	MCO RS...	ACY J...	FOG Route	0	ZJX ZTL...	2
SAV.CLT.RDU.ISO	MCO RS...	ACY J...	FOG Route	0	ZJX ZTL...	2
SAV.SPA.RIC.SIE	MCO RS...	ACY J...	FOG Route	0	ZJX ZTL...	2
CRG.SPA.RDU.ISO	MCO RS...	ACY J...	FOG Route	0	ZJX ZTL...	2
HPW.RDU	HPN LGA	RDU	FOG Route	0	ZDC	2
PXT.TAPPA.HPW.ARGAL5.RDU	HPN LGA	RDU	FOG Route	0	ZDC	2
GARED.V229.PXT.V213.HPW.ARGAL5.RDU	HPN LGA	RDU	FOG Route	0	ZDC	2
VILLS.J37.CLASY.J191.PXT.J14.VIPKE.HPW.ARGAL5.RDU	HPN LGA	RDU	FOG Route	0	ZDC	2
CYN.V16.TAPPA.V213.HPW.RDU	HPN LGA	RDU	FOG Route	0	ZDC ZNY	2

Flight	Orig	Dest	Departs	Arrives	Deadline	Delay	Dist Added	Return to Route	Coordinati	
CHQ3037	LGA	RDU	2019	2128	00:39	-1	-5	Yes	ZDC	VILLS.J37.CLASY.J191.PXT.J14.VIPKE.HPW.ARGAL5.RDU
JBU152	RSW	JFK	1951	2205	00:36	9	65	Yes	ZJX ZTL ZDC	SAV.SPA.RIC.SIE
JBU596	MC...	HPN	2031	2242	00:54	7	54	Yes	ZJX ZDC	VIYAP.SAV.RDU.ISO
N461QS	HPN	RDU	2015	2123	00:35	-1	-5	Yes	ZDC	VILLS.J37.CLASY.J191.PXT.J14.VIPKE.HPW.ARGAL5.RDU
NKS312	MC...	ACY	2005	2150	00:27	7	54	Yes	ZJX ZDC	VIYAP.SAV.RDU.ISO
NKS312	MC...	ACY	2005	2153	00:33	9	67	Yes	ZJX ZTL ZDC	SAV.SPA.RIC.SIE
SWA17	MC...	ISP	2000	2208	00:23	7	54	Yes	ZJX ZDC	VIYAP.SAV.RDU.ISO

Accept Solutions



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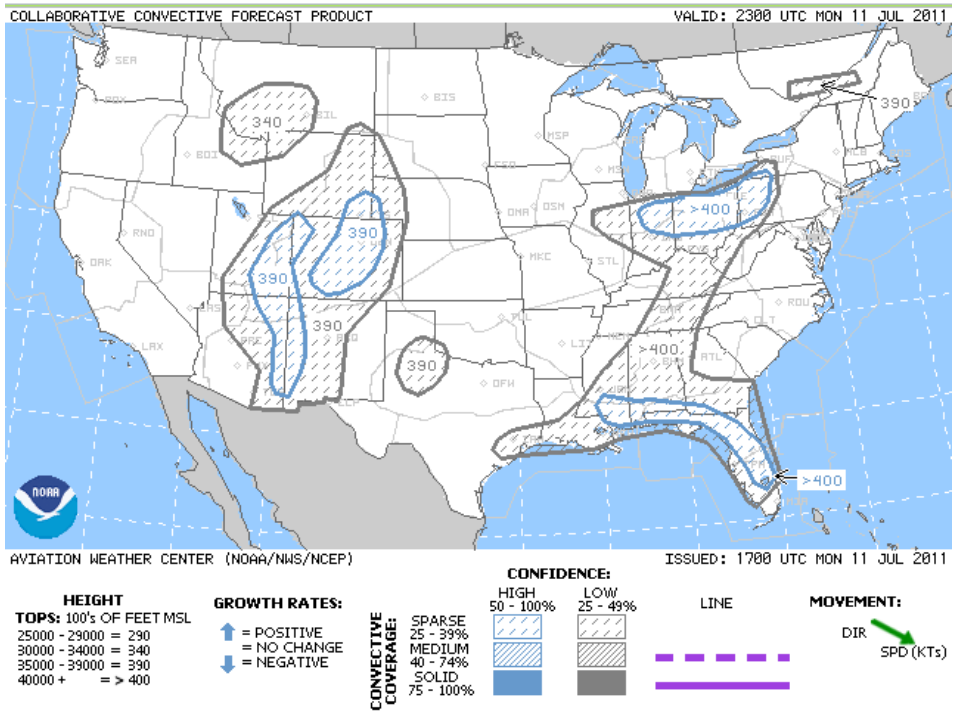
flow contingency management

Hours in advance, we know that there will be serious convective weather …

What is the range of possible weather scenarios, and how likely are these scenarios to occur?

What does the range of ATM impacts look like?

What options will we have available to alleviate congestion, and when do we have to act?



This is currently done by multi-stakeholder teleconference, with limited analytical information and few useful strategy assessment tools.

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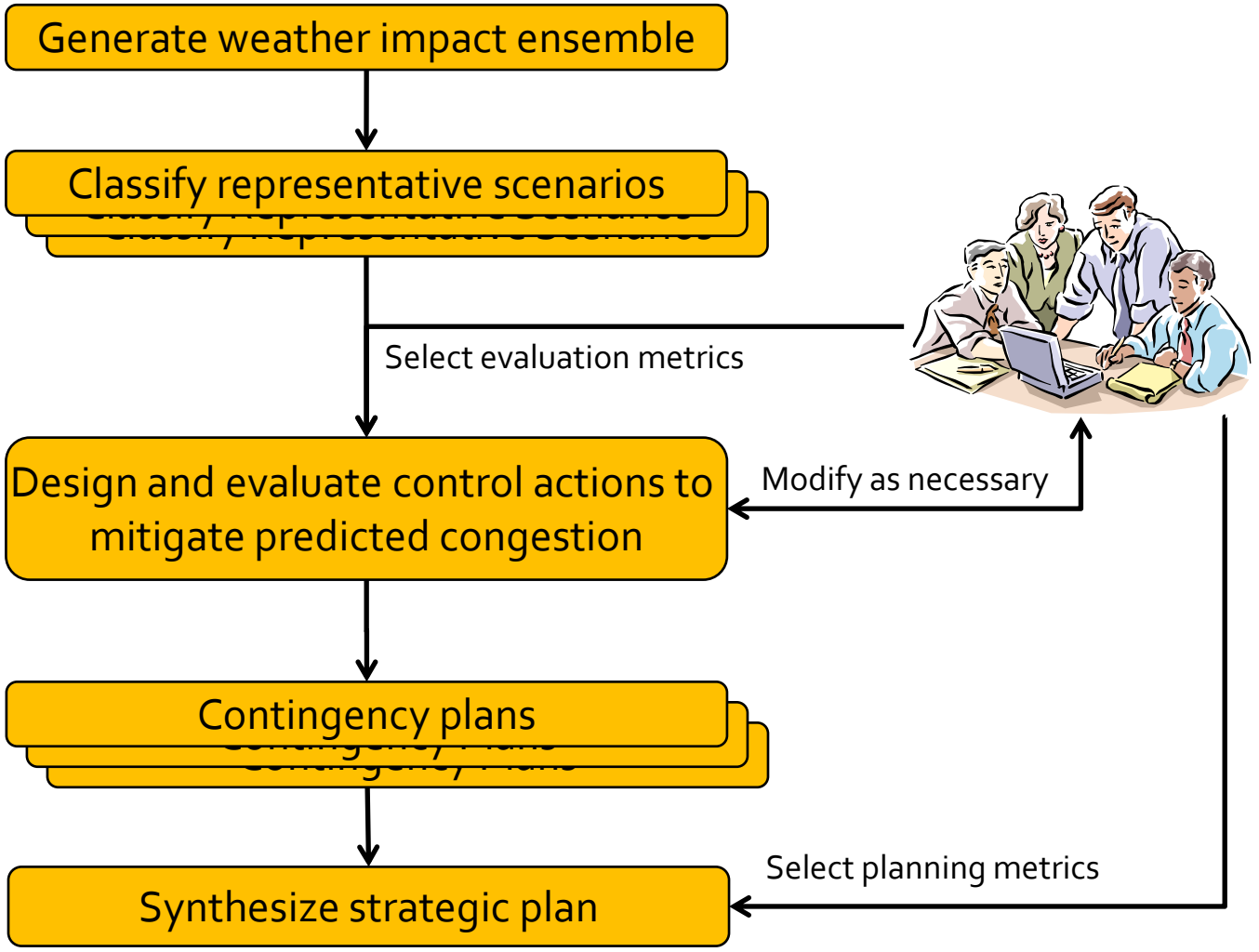
strategic planning framework for FCM



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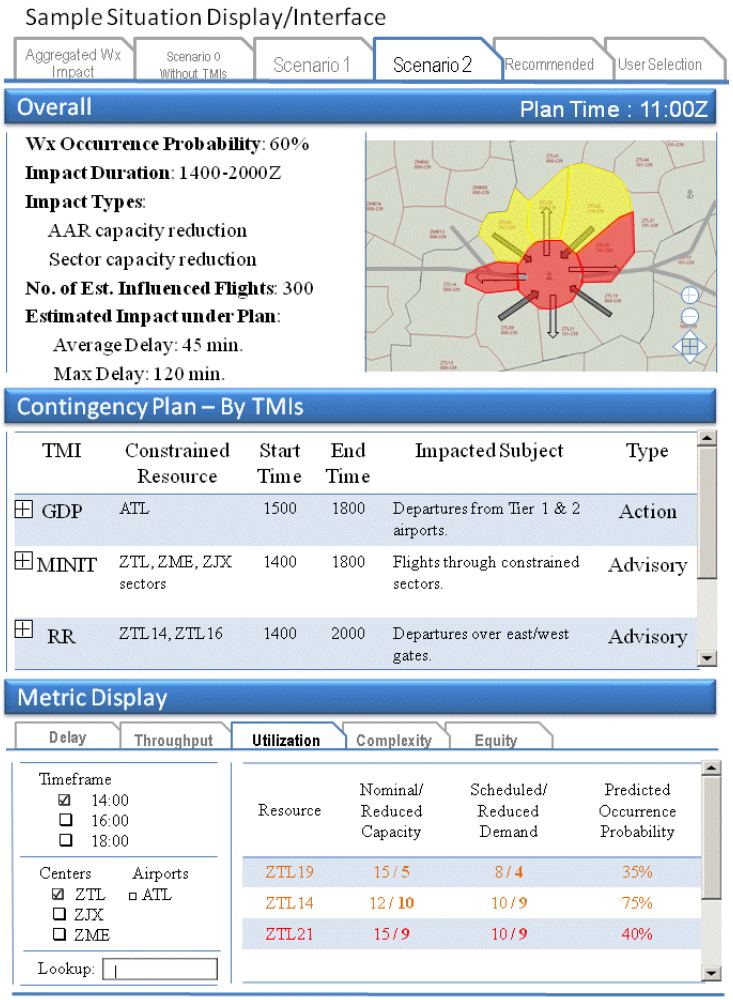
A conceptual example of FCM in action…

Developing the Strategic Plan

Sample Situation Display/Interface



- Provides analytical information in the form of contingency plans
  - Weather impact shown through representative scenarios
  - Coordinated controls provided to effectively mitigate congestion
- Enables simulation and evaluation capabilities
  - Assess performance of TMIs that mitigate congestion
  - Defines recommended management strategy based on user priorities, statistical information and deferability of decisions
  - Enables simulation and impact assessment of decision maker preferences
- Facilitates effective communication among decision makers
  - Common information shared among decision makers
  - Potential for automated implementation

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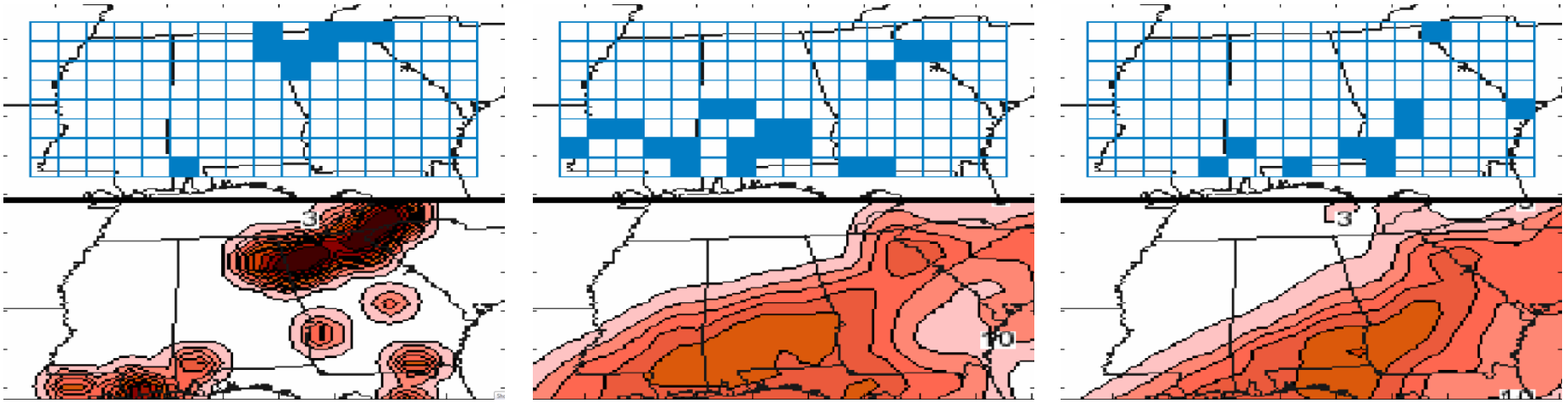
need : representative weather impact scenarios

- Strategic planners need approximate forecasts of likely impact scenarios
  - Some effective actions have long lead times
  - Need to weigh scenario likelihood against consequences to make the right call
- Current convective weather prediction products do not provide this info
  - Probabilistic forecasts are not correlated
  - Ensembles are too computationally-expensive for real-time
- We are developing a "weather impact simulator" to leverage existing forecast products, using spatio-temporal influence networks



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thoughts

- initial progress has been made in tactical ATM-weather integration
  - high-resolution products available, including impact forecasts
  - next wave of TFM tools integrates weather at some level
  - we have prototypes of true trajectory-based operations tools that integrate weather impact directly : but not all kinds of impact are captured
- integration for strategic day-of-operations planning is still a dream
  - need products that can provide decision-support under uncertainty
    - scenarios, impact outcomes, associated probabilities
    - include impact predictions for both airspace and airports
  - need simulation tools that are fast enough for real-time decision support

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