A decorative graphic on the left side of the slide consists of a blue and yellow triangular shape at the bottom, a white grid pattern representing a globe, and a white jet airplane flying through a blue sky with white clouds.

Rerouting as a Strategy for Collaborative Weather Problem Resolution

S.M. Zobell, C.G. Ball, and J.E. Sherry

F045-B-042

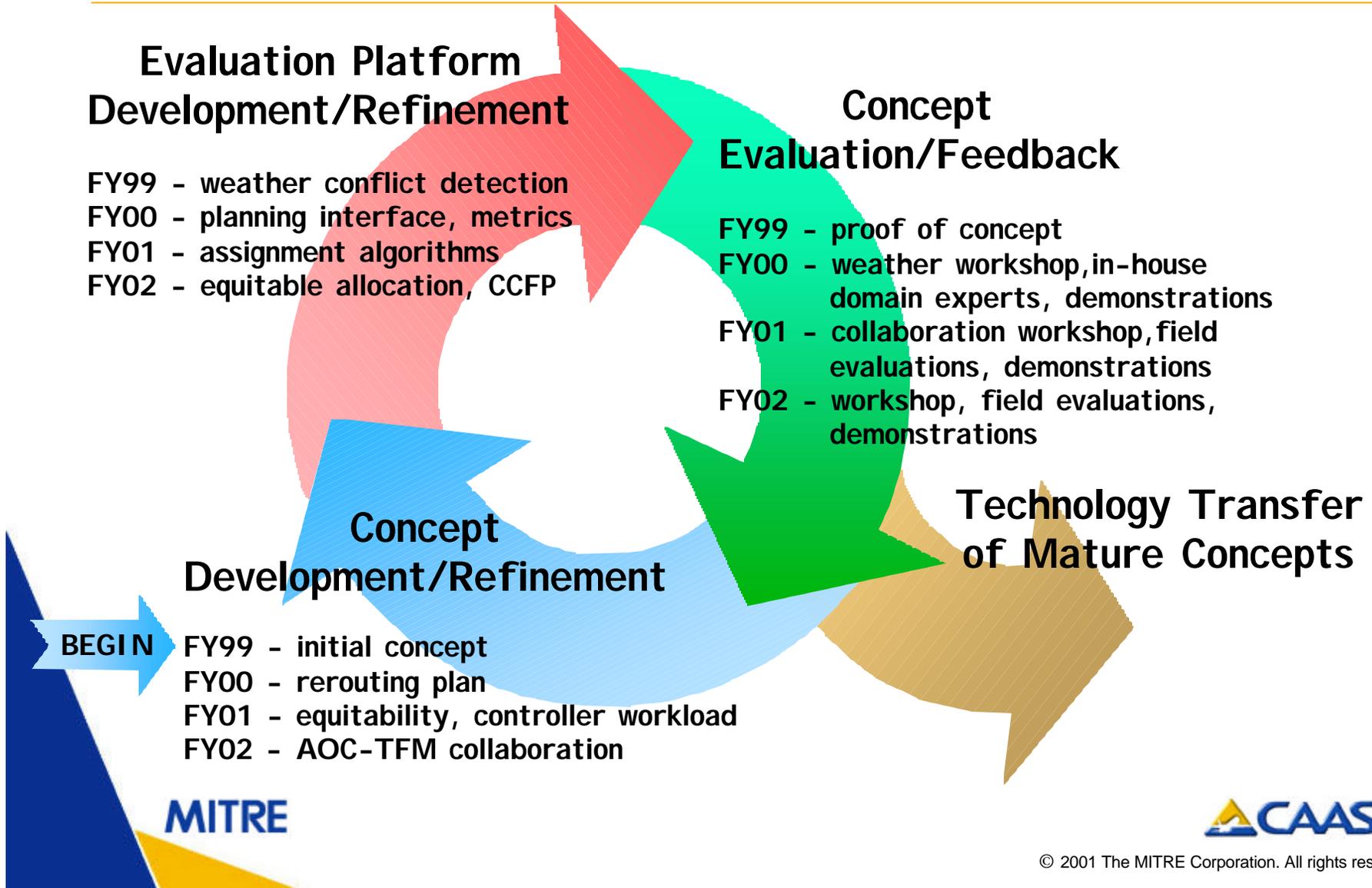
MITRE

Automation-assisted Weather Problem Resolution (AWPR) Operational Concepts

- **CAASD's TFM concept demonstration platform (CRCT) has been extended to include additional decision support capabilities for automation assisted rerouting around weather**
 - Automated weather FCAs
 - Automated allocation of reroutes
- **CRCT-AWPR capabilities are expected to be mature enough for integration into ETMS in the midterm**
 - However, some capabilities may be integrated sooner



CRCT-AWPR Concept Evolution

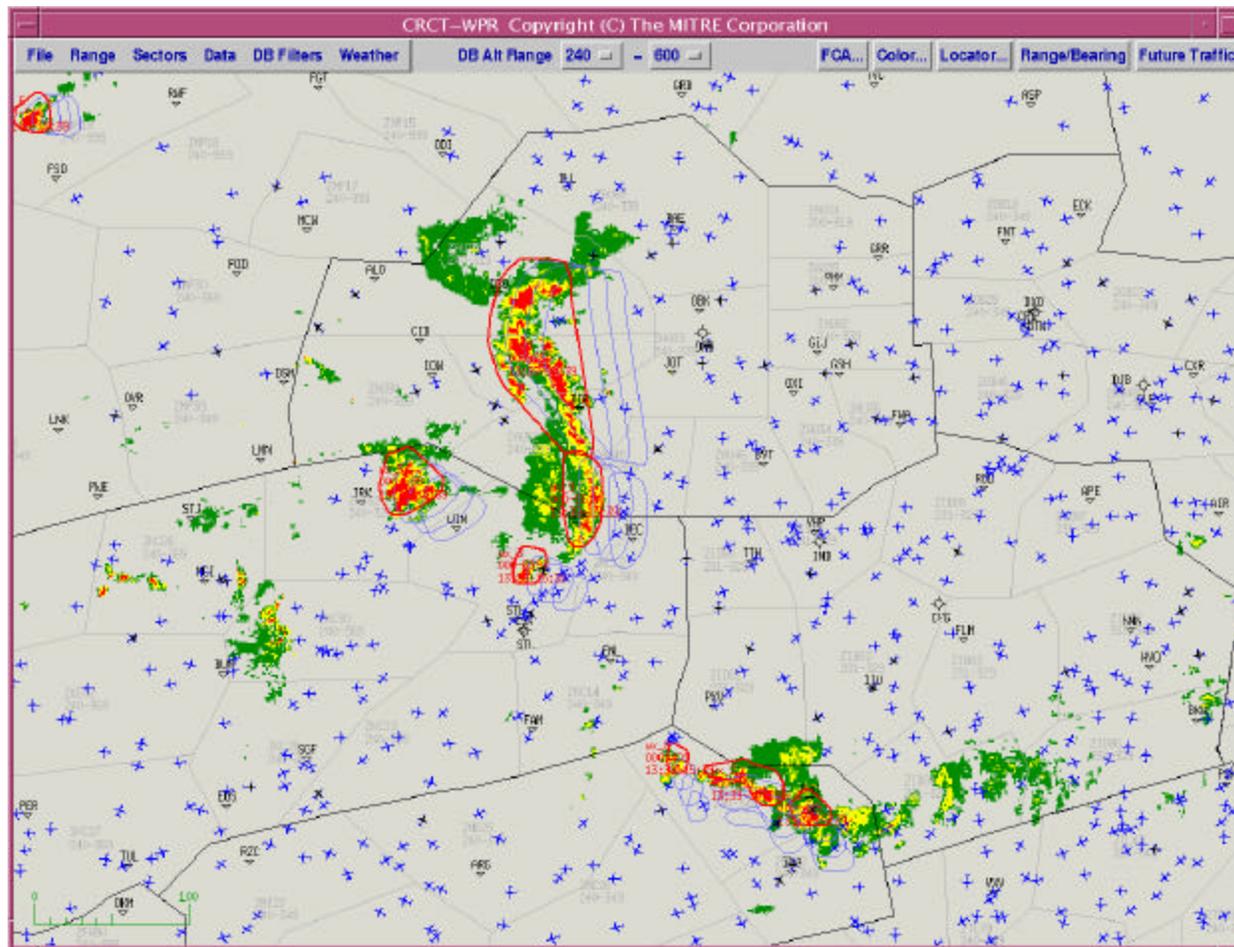


Advanced Weather Forecasts

- **CRCT-AWPR requires convective weather forecasts**
- **Researchers are developing improved convective weather forecast products**
 - **National Convective Weather Forecast (NCWF)**
 - **National Center for Atmospheric Research (NCAR)**
 - **Automated short-term (1-2 hour) national forecast**
 - **Corridor Integrated Weather System (CIWS)**
 - **MIT Lincoln Laboratory (MIT/LL)**
 - **Automated short-term regional forecast**
 - **Collaborative Convective Forecast Product (CCFP)**
 - **Human-generated long-term (2-6 hours) national forecast**



National Convective Weather Forecast



CRCT-AWPR is a Decision Support Capability

- **Users provide overall strategies for solving a TFM problem**
 - Called the “Plan”
- **Automation suggests solutions for each flight**
- **Users review the results and, if necessary, refine the Plan and try again until satisfied**
- **Although designed for weather, CRCT-AWPR can be used for other types of problems such as congested airspace**



Operational Steps in Plan Creation and Execution

- **Steps in solving TFM problems using CRCT-AWPR include:**
 - Identifying the flights to include in the Plan
 - Creating reroute corridors
 - Assign flights to reroute corridors
 - Analyzing the Plan
 - Collaborating
 - Refining the Plan
 - Implementing the Plan
 - Updating the Plan as time progresses
- **These steps will be discussed in detail**

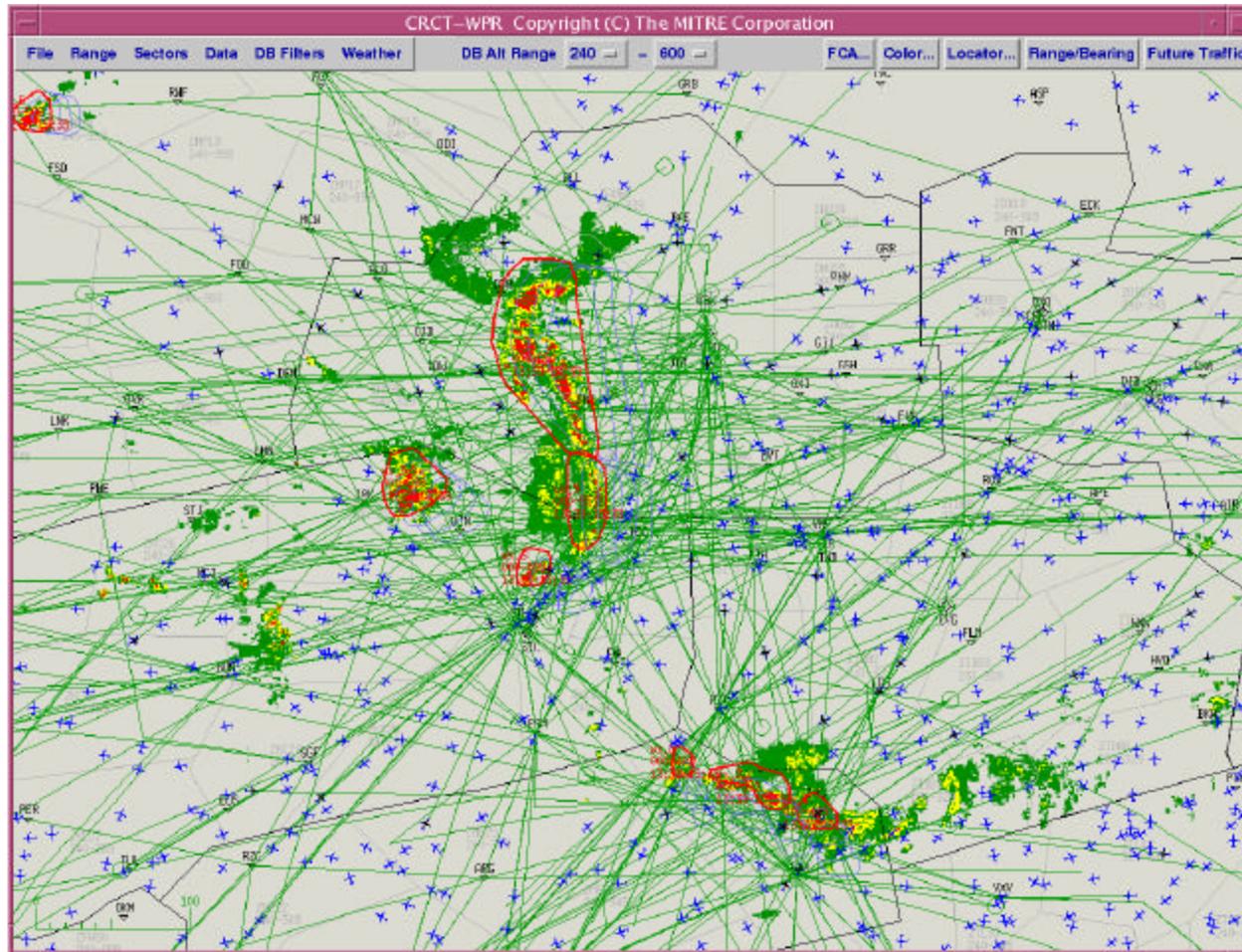


Identifying Flights to Include in the Plan

- **CRCT-AWPR allows various ways to select the flights to consider for rerouting**
 - Selection of flights that are projected to intersect the weather or other Flow Constrained Areas (FCAs)
 - Selection by flight origin or destination airport
 - Manual selection



Identifying Flights Whose Trajectories are Predicted to Intersect Weather



Creating Reroute Corridors: User Interface

The screenshot displays the CRCT-WPR software interface. The main window shows a weather radar map with various flight paths and reroute corridors. A dialog box titled "WX REROUTING" is open, providing controls for creating and managing reroute corridors (TDRs).

CRCT-WPR Copyright (C) The MITRE Corporation

File Range Sectors Data DB Filters Weather DB All Range 240 - 600

WX REROUTING

CREATE TDR Start Backspace Finish	DELETE TDR Delete TDR Select All Clear All	PLAN NAME: zobe11 Load Previous Plan Save Plan Accept Plan	TDR PARAMETERS Apply Alt Range: XXX - XXX Monitor Alert Exceed: 0 Minutes Until Start: 20 Minutes Duration: 90 Max Turn Angle: 80
---	--	--	--

1-zobe11: VIKNC.DREAR alt 000-999, start 20, duration 90, exceed 0, max turn 80
2-zobe11: FOW.NICOT alt 000-999, start 20, duration 90, exceed 0, max turn 80
3-zobe11: CHM.DOCKS.WEEDY alt 000-999, start 20, duration 90, exceed 0, max turn 80
4-zobe11: MYERZ.PKV alt 000-999, start 20, duration 90, exceed 0, max turn 80
5-zobe11: MEMAC.SKE.WORKE alt 000-999, start 20, duration 90, exceed 0, max turn 80
6-zobe11: GREES.SKE.WORKE alt 000-999, start 20, duration 90, exceed 0, max turn 80
7-zobe11: MEMAC.SKE.ELIOE alt 000-999, start 20, duration 90, exceed 0, max turn 80

Evaluate Evaluate Selected Flights Use Only Selected TDRs Close

Assign Flights to Reroute Corridors

- **Automated, using efficiency and equitability algorithms**
 - **Current software attempts to maximize throughput and minimize arrival delays without regard to air carrier (i.e., blind/random method)**
 - **Different rationing criteria will be considered as a part of the equitable allocation assessments being done by Metron, MITRE, and the University of Maryland**

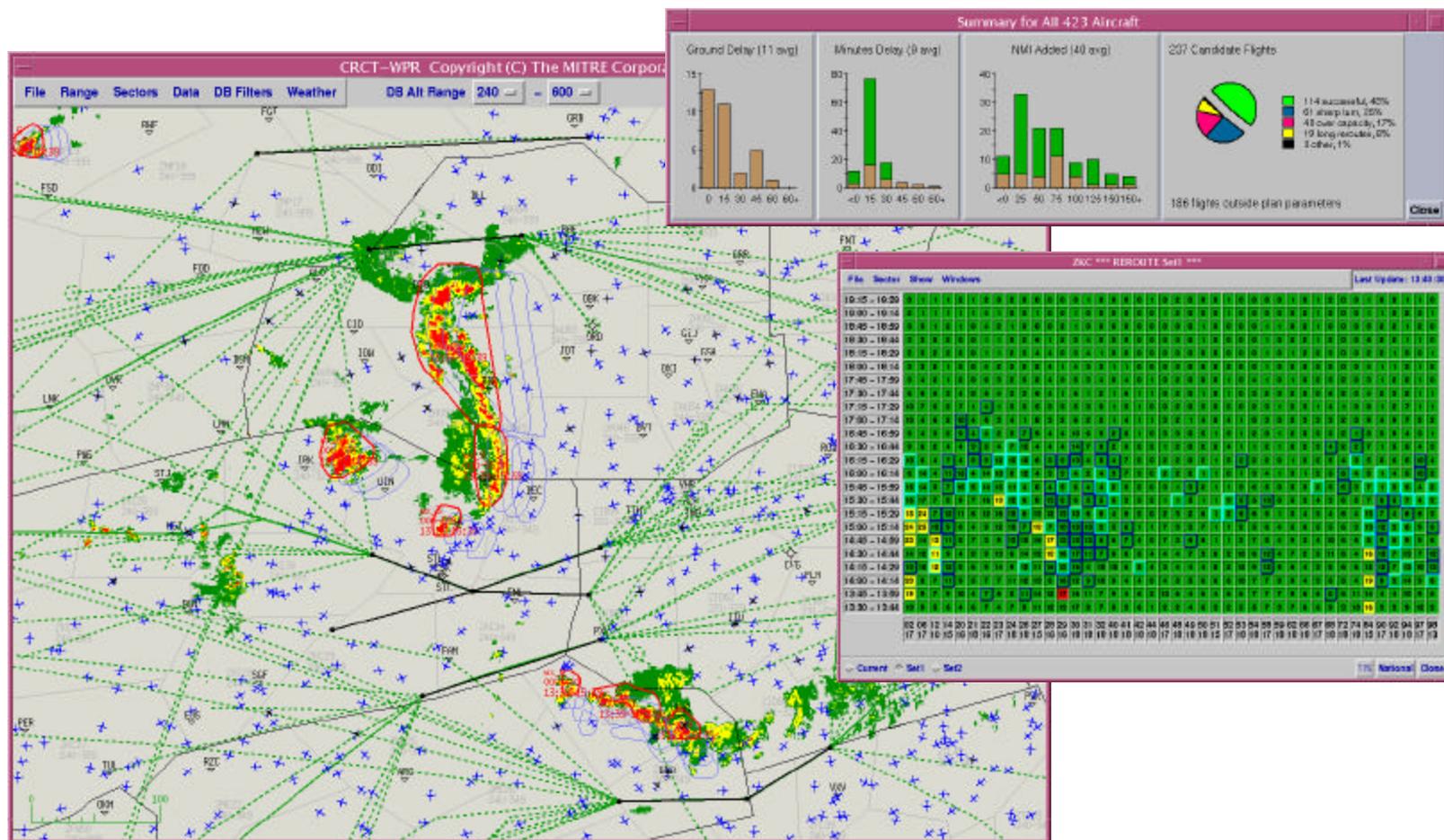


Analyzing the Plan: Sector Workload Limits Are Not Exceeded

- **CRCT-AWPR uses Volume Management concepts to maintain safe sector workload levels**
- **If assigning a flight to a Reroute Corridor would cause sector workload limits to be exceeded, the assignment will not be allowed**
 - **If the flight can be delayed on the ground, the assignment algorithm will search for the number of minutes of ground delay that will allow the flight on the corridor without exceeding the sector workload limits**
 - **Otherwise, the flight will not be allowed on the given Reroute Corridor and any reroute for the flight must use a different corridor**



Analyzing the Plan: Reroutes, Summary, and Impact Assessment



Results of Plan Analysis: Sortable Flight Specific Information

FLIGHT SELECTOR

Load Conflicts Origin Destination Add Cities Clear All

Update Tracks 00:00:01 Invert Selection Delete Selected Show Routes Undo

ACID	ORG	DEST	DEP TIME	ARR TIME	NRP	TOTAL DELAY	GROUND DELAY	NMI	FINAL STATUS	CAN BE DELAYED	TDR	1st CONF
N351SC	9A1	MSP	12:39	15:54	-	-	-	-	Into FCAs	F	-	wx_9*
COM496	CHA	CVG	14:38	15:51	-	-	-	-	Sharp turn	T	-	wx_1*
COM667	CVG	JAN	13:50	15:38	-	6	0	43	Success	F	3-zobell	wx_1
CGXCO	HSV	JXN	13:00	14:44	-	-	-	-	Before plan time	F	-	wx_1
LN48WA	SRQ	RPD	12:55	15:16	-	-	-	-	Before plan time	F	-	wx_1*
N228JA	MEM	HLG	12:00	16:27	-	-	-	-	Before plan time	F	-	wx_1
CAA215	ATL	EVV	13:18	14:39	-	-	-	-	Before plan time	F	-	wx_1
HMA485	CVG	MEM	13:22	14:47	-	-	-	-	Before plan time	F	-	wx_1
N620A	AUS	LNS	12:30	15:53	-	14	0	103	Success	F	4-zobell	wx_1
UAL1532	DEN	IAD	13:25	16:25	-	6	0	76	Success	F	1-zobell	wx_1
UPS2773	EPD	SDF	12:59	14:43	-	-	-	-	Before plan time	F	-	wx_1
COA1916	IAH	PIT	13:05	15:19	-	-	-	-	Sector capacity	F	-	wx_1
N400CK	ADS	K24	12:41	14:34	-	-	-	-	Before plan time	F	-	wx_1
NWA433	BNA	DTW	13:35	14:43	-	-	-	-	Before plan time	F	-	wx_1
ACA371	YYZ	BNA	12:55	14:52	-	-	-	-	Before plan time	F	-	wx_1
CAA704	DFW	SDF	13:00	15:19	-	-	-	-	Sector capacity	F	-	wx_1
ACA372	BNA	CYYZ	15:10	17:37	-	-	-	-	Sharp turn	T	-	wx_1
EJA377	BNA	PSF	13:20	15:47	-	-	-	-	Before plan time	F	-	wx_1
DAL1083	CVG	BHM	13:10	14:28	-	-	-	-	Before plan time	F	-	wx_1
N53GH	TEB	DAL	12:10	15:19	-	-	-	-	Before plan time	F	-	wx_1
SWA546	BNA	CLE	13:20	14:34	-	-	-	-	Before plan time	F	-	wx_1
DAL831	IND	ATL	14:30	15:41	-	-	-	-	Sharp turn	T	-	wx_1*
SWA1255	BNA	MDW	13:35	14:43	-	-	-	-	Before plan time	F	-	wx_1
N339BC	DAL	OQU	13:30	17:21	-	2	0	11	Success	F	3-zobell	wx_1
CCP640	ORD	MYNN	14:00	16:59	-	-	-	-	Sharp turn	F	-	wx_1
ACA993	YYZ	MMMX	13:18	17:20	-	-	-	-	Sector capacity	F	-	wx_1
N280JR	MRC	LOU	13:20	14:11	-	-	-	-	Before plan time	F	-	wx_1
N421MF	BNA	LEX	14:00	15:04	-	-	-	-	Sharp turn	F	-	wx_1
COM510	CVG	BNA	13:15	14:15	-	-	-	-	Sharp turn	F	-	wx_2
ABX1405	DAL	ILN	13:10	14:58	-	6	0	48	Success	F	4-zobell	wx_2
ABX1415	AUS	ILN	13:20	15:25	-	5	0	39	Success	F	4-zobell	wx_2
ABX2109	MSY	ILN	14:00	15:53	-	5	0	50	Success	F	3-zobell	wx_2
N1743E	EVV	NEW	13:30	16:29	-	-	-	-	Before plan time	F	-	wx_8*
AAL1479	PHL	DFW	13:21	16:09	-	0	0	2	Success	F	4-zobell	wx_2
UPS2077	EWR	DFW	12:37	15:26	-	5	0	38	Success	F	4-zobell	wx_2*
N75AP	MEM	CAK	13:30	15:58	-	17	0	70	Success	F	3-zobell	wx_2

423 Flights, 0 Selected Summarize when selected Summarize All Summarize Selected Close

Collaborating

- **Collaborative requirements for AWPR are being investigated**
 - **April 2001 workshop**
 - http://www.mitrecaasd.org/collab_wx_rerouting_workshop/index.html
 - **Collaborative operational concept being developed**
- **The list of collaboration participants includes:**
 - **Air Traffic Control System Command Center (ATCSCC)**
 - **Air Route Traffic Control Centers (ARTCCs)**
 - **Including Traffic Flow Managers and Air Traffic Control Area Supervisors**
 - **Airline Operation Centers (AOCs)**



Refining and Implementing the Plan

- **There are many cases where users will want to modify a plan before implementation**
 - Changes requested through collaboration
 - Plan tweaking
 - Alternate approaches
- **CRCT-AWPR is designed to allow quick what-if evaluations**
 - Plan processing requires less than one minute
 - Plans can be improved before final implementation
- **Once a plan is satisfactory, the user requests implementation of the plan**



Updating the Plan as Time Progresses

- **Even if the weather forecast is completely accurate, plans will have to be reexamined periodically**
 - New flight plans and flight plan amendments are continually entering the system
 - Each forecast update goes further out in time
- **When a forecast changes dramatically, plans will have to be modified**
 - CRCT-AWPR can retain the flight plans for reroutes that are clear of the weather while finding new reroutes for flights that are now predicted to enter weather



CRCT-AWPR Summary

- **CRCT-AWPR concepts offer capabilities that are not available today for example:**
 - **Reroutes can be limited to selected flights that are impacted by the weather**
 - **When weather improves, newly available capacity can be quickly utilized**
 - **The concept protects against unsafe sector workloads**
 - **Reroutes and ground delays are tailored for each flight**
 - **Automation allows reroute plans to be processed and assessed in seconds allowing more time for human collaboration and decision making**



Next Steps

- **Field evaluations to obtain user feedback**
- **Exploration of equitable allocation concepts**
- **Collaboration concept development and evaluation**
- **Further refinement of AWPR automation**
- **Integration with other ATC and TFM concepts and capabilities**

