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MITRE PRODUCT

Operational Evaluation Report (ZKC, ZID, ATCSCC)

September 2001

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Abstract

This report describes field evaluations of Traffic Flow Management (TFM) capabilities prototyped on the Collaborative Routing and Coordination Tools (CRCT) Concept Demonstration and Evaluation Prototype (CDEP). Evaluations were conducted during FY01 by FAA Traffic Management Coordinators (TMCs), facilitated by MITRE/CAASD. Three sites participated in the evaluations: the Air Traffic Control System Command Center (ATCSCC), and the Air Route Traffic Control Centers (ARTCCs) at Indianapolis (ZID) and Kansas City (ZKC). The evaluations helped identify which functions prototyped in CRCT were ready to incorporate in future releases of the Enhanced Traffic Management System (ETMS), which is the operational TFM decision support system (DSS). Following 10–14 hours of structured training, TMCs evaluated CRCT functions during lab exercises and by using the prototype functions to analyze live traffic on the operational floor. Data used in the evaluations included responses to structured interviews, freeform comments, and automatically-recorded interaction with the prototype. Certain capabilities and functions, including a core set of rerouting what-if capabilities, were deemed ready for prioritization by the FAA and subsequent Technology Transfer to the ETMS development team at Volpe National Transportation Systems Center (VNTSC). Some functions were considered ready for transfer as currently prototyped, while others may require slight functionality changes. An additional set of capabilities may require further research, using CRCT and/or other methods, regarding how they can best be implemented in ETMS or in the overall TFM environment. Slides 27 through 31 of this report summarize the functions recommended for Technology Transfer and for further research. Results supporting these recommendations are presented, followed by additional results about TMC perceptions of the functions prototyped in CRCT.

KEYWORDS: TFM (Traffic Flow Management), DSS (Decision Support System), CRCT (Collaborative Routing Coordination Tools), ETMS (Enhanced Traffic Management System), evaluation, rerouting, severe weather, training, structured interviews, Technology Transfer, collaboration

Acknowledgments

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The FAA members of the CRCT Core Team have provided very helpful guidance in the design and conduct of the FY01 evaluations, and have helped the evaluation activities to run smoothly by coordinating the logistics of our site visits and data collection activities. The Core Team members are Lorraine Vomacka, Tony Henry, Ed Wilken, Tom Wray, Steve Harting, Larry Leffew, Ed Corcoran, and Mark Libby.

Mark Huberdeau, Ken Thompson, Joe Hollenberg, and Jack Brennan (MITRE/CAASD) have been critical members of the training and evaluation efforts at ATCSCC and ZID. The evaluations would not have been possible without their contributions.

Claude Jackson, Alex Alshtein, and Tim Stewart of MITRE/CAASD have ensured the proper functioning of the CRCT systems during the evaluations. They and the software and infrastructure teams were especially essential during the initial release of the new CRCT version during the training and "Canned" evaluation period. Mr. Stewart was also the key "trainer of the trainers" during the initial development of the CRCT training package.

The following MITRE/CAASD personnel have made vital contributions to the evaluation analyses, by collecting and providing data on availability and "usage" of the CRCT systems at the evaluation sites: Ho Yi, Emily Beaton, and Alex Alshtein.

Executive Summary

Background

This report describes the methods and results of the FY01 field evaluations of Traffic Flow Management (TFM) capabilities. These evaluations used the Collaborative Routing and Coordination Tools (CRCT) Concept Demonstration and Evaluation Prototype (CDEP), referred to throughout this document as simply CRCT. The FY01 CRCT evaluations were the most recent in a series of TFM evaluations using the CRCT prototype and its precursors (see Carlson, Kapoor, and Rhodes, 1999; Carlson, 1999; Barlow, Carlson, Houde, and Watkins, 2000). Evaluations were conducted during FY01 by FAA Traffic Management Coordinators (TMCs), facilitated by MITRE/CAASD, at the Air Traffic Control System Command Center (ATCSCC), Indianapolis ARTCC (ZID), and Kansas City ARTCC (ZKC).

The purpose of the evaluations was to help assess the maturity of functions prototyped in CRCT, as input to the FAA decision of what functions were ready for Technology Transfer, i.e., ready to incorporate in future releases of the Enhanced Traffic Management System (ETMS). Maturity of a function includes several components; the first is its operational suitability, which in these evaluations was concluded based on field perception of the function and the function's usage for evaluation during the test period. Another aspect of maturity is technical maturity, i.e., how clearly the human-computer interface (HCI) and algorithmic requirements are defined, which can be determined by operational feedback about the prototype's HCI and data presentation methods. This report speaks to these two aspects of maturity, primarily the first. The other aspects of maturity, outside the scope of the report, are procedural (the extent to which the function's operational use is defined) and developmental (the extent to which the means for building it into the operational system are defined).

Method

Thirty-four TMCs underwent a two-day structured training protocol, facilitated by MITRE/CAASD and lasting 10-14 hours total, in order to gain proficiency at interacting with the CRCT system. Training consisted of a briefing on the background of CRCT, followed by hands-on, one-on-one training that demonstrated each component and function of the system and used recorded data to illustrate operational situations where the CRCT functions could be applied. Following training, the same TMCs evaluated CRCT functions during lab exercises in a canned evaluation (using pre-recorded data). Structured interviews were conducted after each exercise as well as at the end of the canned session, to determine the perceived usefulness of the prototyped functions for each exercise, the perceived importance of implementing the function in ETMS, and other data. Twenty-four of the original 34 TMCs participated in a real-time evaluation over the following weeks. Participants used

the CRCT CDEP to analyze live traffic on the operational floor. Their interactions with CRCT were automatically recorded, and when workload permitted, they completed brief log entries regarding their interaction with the prototype. At the conclusion of the real-time evaluation period, a longer structured interview was conducted to collect additional information from each participant about the perceived usefulness and implementation importance of the functions, how often the functions had been used for evaluation, and what types of operational situations had been evaluated with the functions. Another brief structured interview, the TFM Capabilities Acceptance Rating Scale (TCARS) was then administered. This scale assessed the expected overall effect on the TFM environment of the Technology Transfer of two functionality sets: FCA filters and reroute what-if functions. Data from the structured interviews and logs included numerical ratings on perception of each function and usage of that function during the evaluation period, as well as freeform comments about specific functions and how they could be improved.

Preliminary evaluation results and conclusions were presented at the CRCT Core Team (CCT) Meeting/Technical Interchange Meeting (TIM) during the week of July 30, 2001, by members of MITRE/CAASD's TFM Evaluation and Analysis group. The presentation led to discussion of the maturity and implementation priority of the evaluated functions, and several new recommendations regarding the functions' maturity and future research. This report includes the content of the briefing delivered at the CCT meeting, with additional supporting data added, as well as numerous annotations.

Recommendations

MITRE/CAASD's analysis of this quantitative and qualitative evaluation data led to the conclusion that certain core rerouting what-if capabilities were operationally and technically mature for transfer to the ETMS development team at Volpe National Transportation Systems Center (VNTSC).

Reroute what-if functions for Technology Transfer:

Methods for selecting flights for reroute what-if evaluation

- Selection of individual or all flights from the FCA List
- Crossing Segment

Methods for defining the reroute to be evaluated

- Text Edit
- Constructing the route with the mouse on the Traffic Display
- Altitude reroutes

Methods for evaluating the impact of potential reroutes

- Future Traffic Display*
- NAS Monitor*
- Sector Count Monitor*
- Time In Sector graph*
- Reroute List

*The Future Traffic Display, NAS Monitor, Sector Count Monitor, and Time In Sector graph were deemed important not only for evaluating potential reroutes, but also for assessment of sector volume and restriction issues.

The ten functions listed above, in addition to a Taskbar for window management, were recommended for Technology Transfer, some with minor refinements to the interface prototyped in CRCT. Additionally, more complex refinements were identified for some of the functions. It was concluded that these refinements would further improve the utility of these already-useful functions; however, detailed specification of the refinements' technical requirements requires further research. Some functions, such as the "reroute FCA" capability, were concluded to be not yet operationally mature, but the evaluation data helped to identify the research issues needed to move these capabilities toward maturity. Other functions, e.g. the "Progressive FCA" capability have not been fully prototyped, but were identified during the evaluation activities as important for further study.

Future research issues include:

- In Sector Count Monitor, enhancing the method of displaying changes in sector count due to potential reroutes, possibly to include displaying numerical difference in sector count, improved color coding, and alternate alert metrics.
- Combining FCA and reroute lists into one master list.
- Determining the appropriate logic for entering and modifying criteria and routes within the "reroute FCA" capability, which supports, among other applications, what-if analysis of National Playbook reroutes.
- Basing FCA lists and reroute evaluations on the assumption that a previously-evaluated reroute has already been assigned to the affected aircraft ("Progressive FCA" capability)
- Automatic communication of reroutes to areas, towers, and possibly airlines.

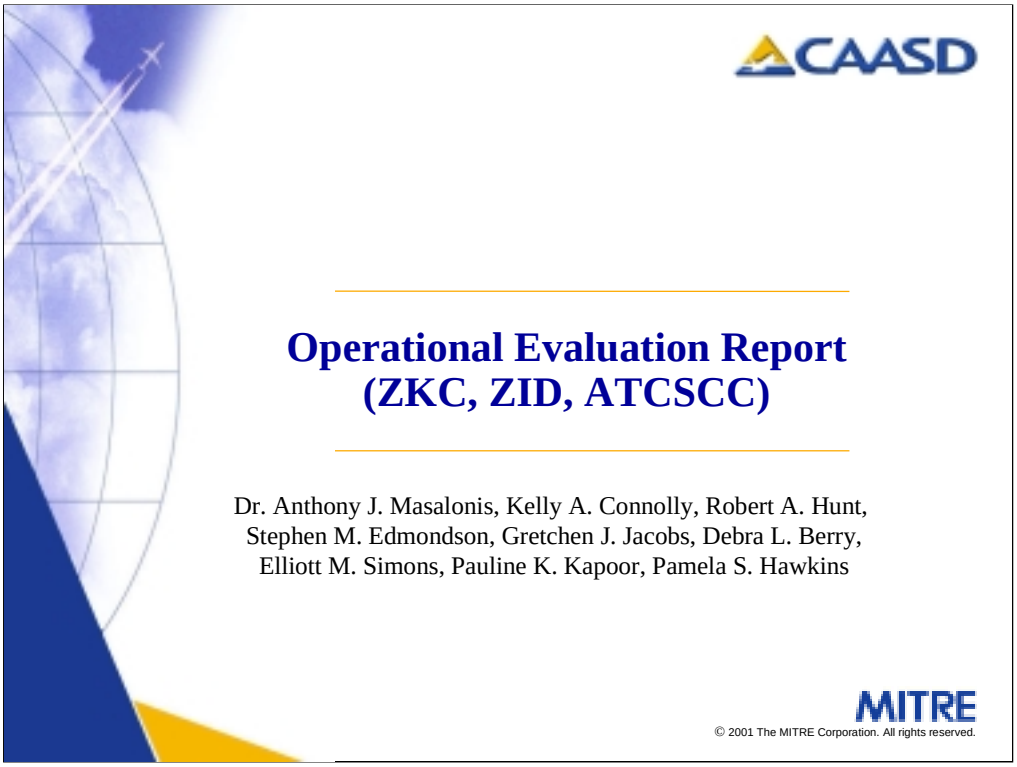
The above recommendations regarding function maturity and necessary research are supported by a variety of data. Perceived usefulness and importance for implementation of the evaluated functions, collected during the structured interviews, were used to infer operational maturity, as were reported and recorded frequency of use of the functions. Technical maturity was primarily determined based on TMC comments during structured interviews and the real-time evaluation period.

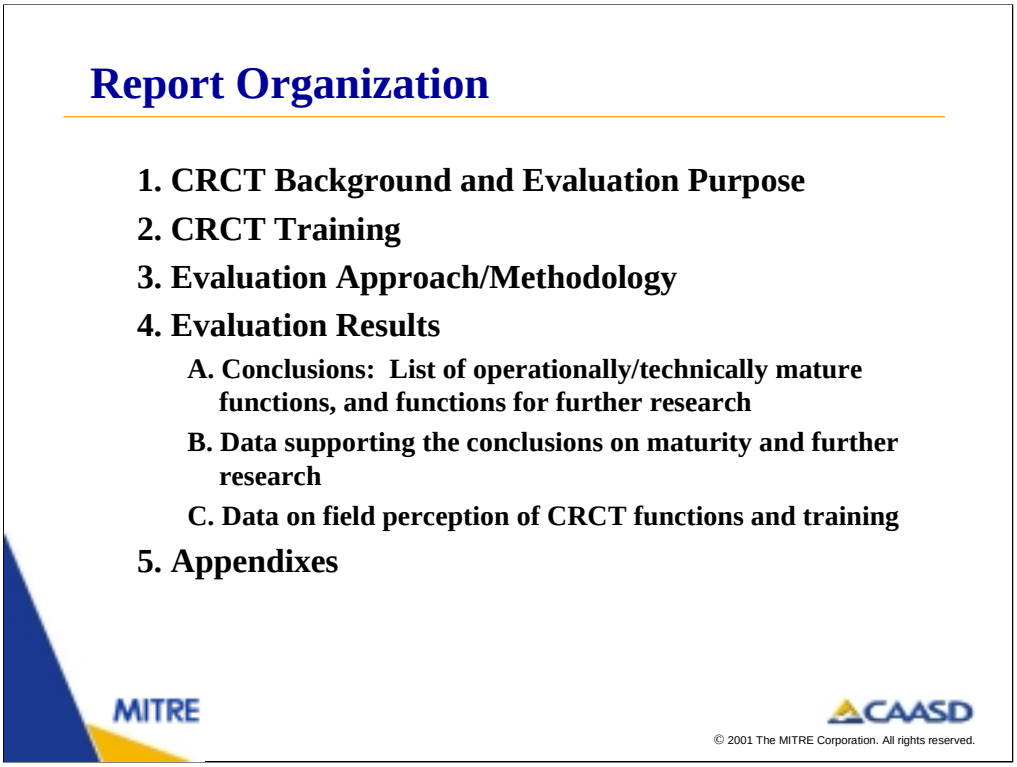
Other Results

Interview ratings were generally consistent across the three CRCT sites, though slight differences were found between the CRCT sites. For example, CRCT functions were considered more useful for sector volume issues at ZID and ZKC than at ATCSCC, reflecting the different roles of personnel at the ARTCCs and ATCSCC.

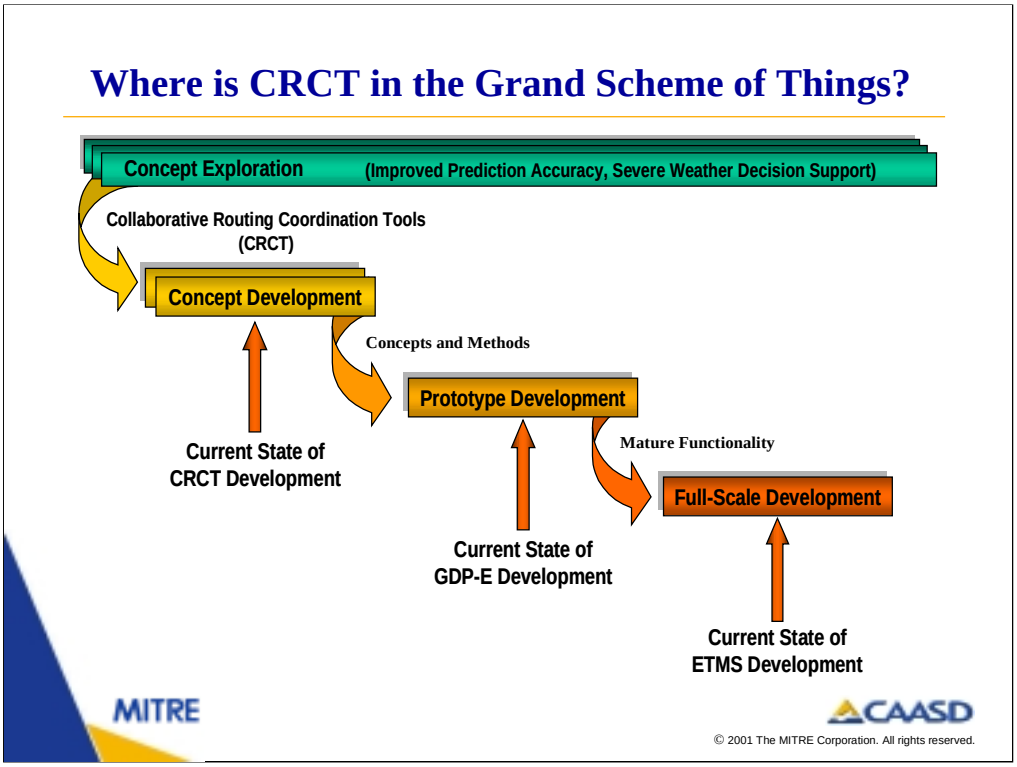
Additional data were collected regarding general perception of MITRE/CAASD's CRCT training protocol and the prediction accuracy of CRCT, as well as the perceived effects of implementing CRCT functions in ETMS. Ratings of the training received in preparation for the evaluations were generally high, as were ratings of confidence in CRCT's traffic predictions. TMCs believe that CRCT functions, if implemented, may or may not decrease the overall number of restrictions and other TFM initiatives, but would most likely improve the ability to make *appropriate* decisions regarding initiatives, including better decisions about the time frame in which to apply them. TMCs generally believe that the implementation of CRCT functions would benefit the airspace users. Responses varied regarding the effect of currently-prototyped CRCT functions on workload; interface improvements may be necessary to realize the full benefits, as well as additional capabilities

not yet prototyped, including the aforementioned automatic communication of reroutes to areas, towers, and possibly airlines. TCARS results support the planned Technology Transfer of FCA filters, and help to identify some of the interface issues surrounding implementation of the reroute what-if capabilities.



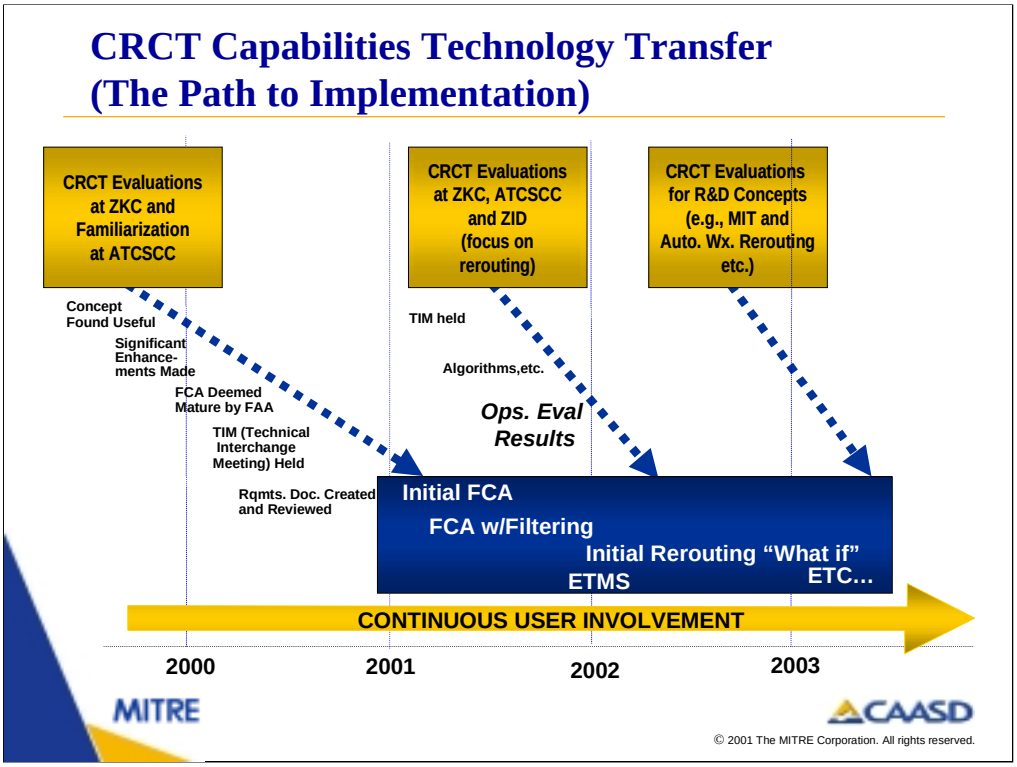


This report is primarily composed of the above sections. Its purpose is to present the results of the Collaborative Routing Coordination Tools (CRCT) evaluations conducted at Kansas City Air Route Traffic Control Center (ARTCC) (ZKC), Indianapolis ARTCC (ZID), and Air Traffic Control System Command Center (ATCSCC) in FY01. The evaluations were conducted to support decisions regarding which functions prototyped on the CRCT platform are ready for Technology Transfer to Volpe National Transportation Systems Center (VNTSC) for implementation in Enhanced Traffic Management System (ETMS).



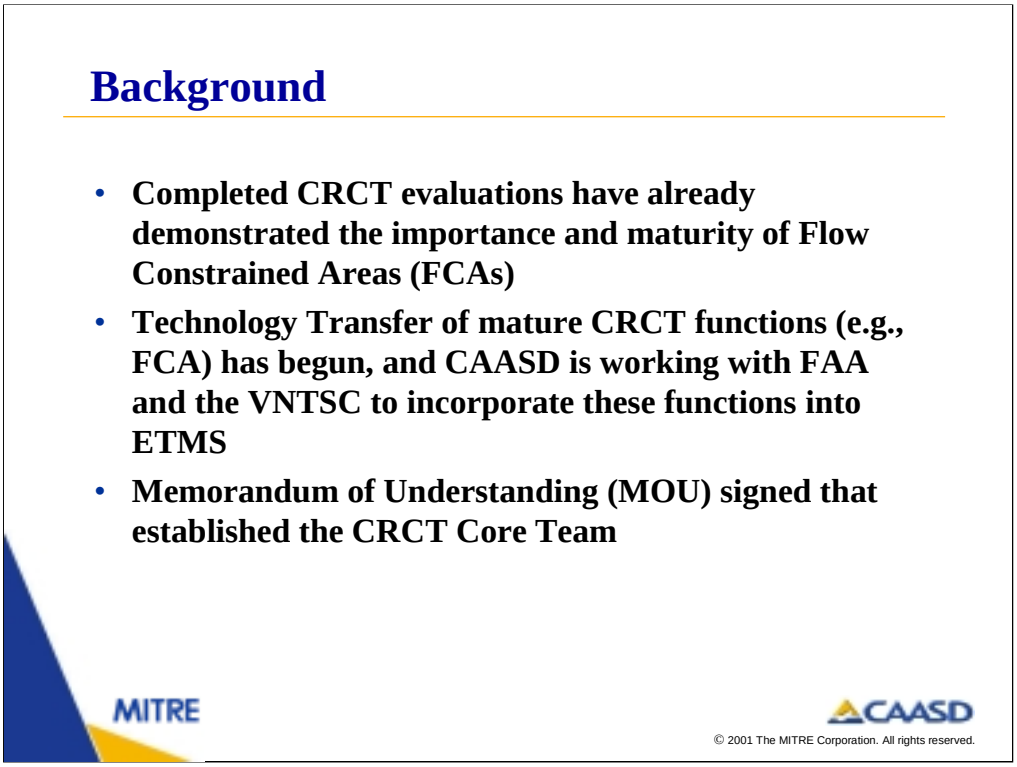
CRCT is a research platform developed by MITRE/CAASD to work with the Federal Aviation Administration (FAA) and VNTSC to study and prototype future capabilities and functions for Traffic Flow Management (TFM). This slide illustrates CRCT's place in the TFM Research and Development environment.

The four stages in the research and development process used by the FAA for TFM capabilities (Jordan, 1996) are Concept Exploration (CE), Concept Development (CD), Prototype Development (PD), and Full-Scale Development (FSD). The CRCT Concept Demonstration and Evaluation Prototype (CDEP) platform began with CE, where the needs for future TFM tools were defined, such as improved prediction accuracy and severe weather decision support. CRCT is now in the CD stage, where concepts are tested on the platform. Some of the CRCT functions were deemed mature by the FAA, such as Flow Constrained Areas (FCAs), and have moved to FSD by being implemented in ETMS. Others may do so in the future, such as the reroute what-if capabilities which were the main focus of the FY01 evaluations. The CRCT platform is utilized to prototype proposed capabilities, and as such, the capabilities may be considered to be in the PD phase, but the platform itself is not in the PD phase because it is not a full prototype for a system intended for fielding "as-is" in FSD.

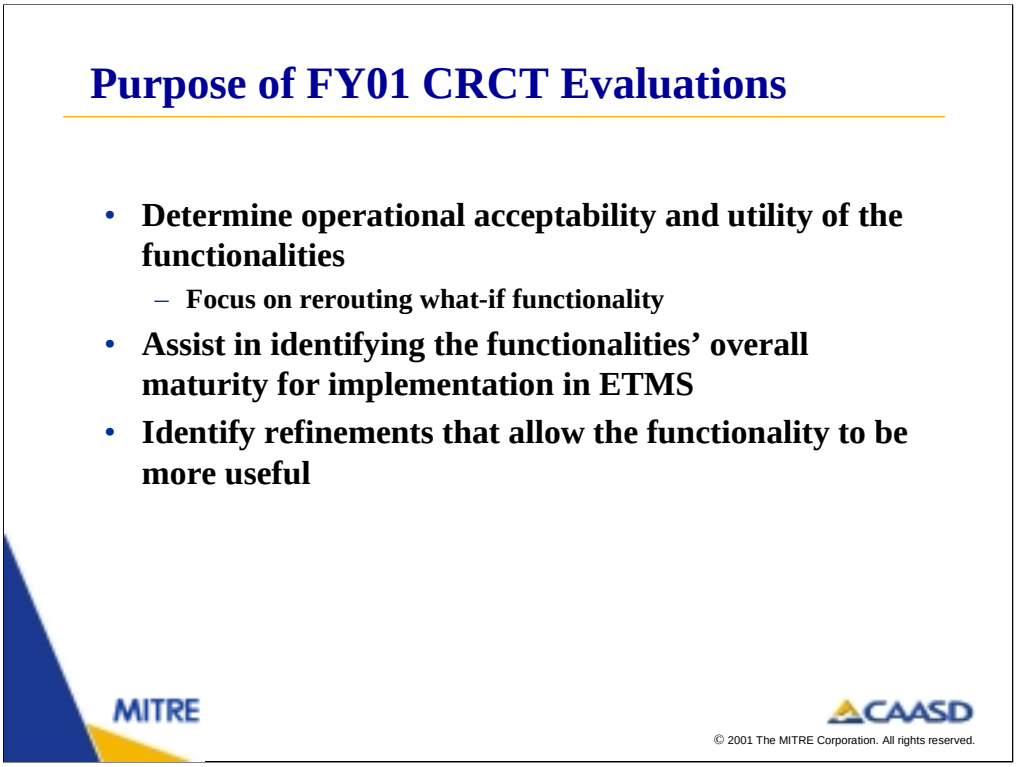


CRCT has been used to evaluate TFM capabilities over the past few years at ATCSCC, ZID, and ZKC. Users are directly involved in every evaluation. The results of evaluations have led to recommendations for Technology Transfer of mature functions into ETMS, including basic FCA capabilities (implemented in ETMS 7.2), and FCA filtering capabilities (to be implemented in ETMS 7.3). In addition, evaluation activities generally lead to recommendations about future TFM R&D that can be conducted on the CRCT platform, or via other methods. These activities may also lead to identification of refinements to CRCT that will support this future work. Detail regarding previous CRCT evaluations can be found in (Carlson, 1999a; Carlson et al., 1999b; Barlow et al., 2000; Yee, 2000).

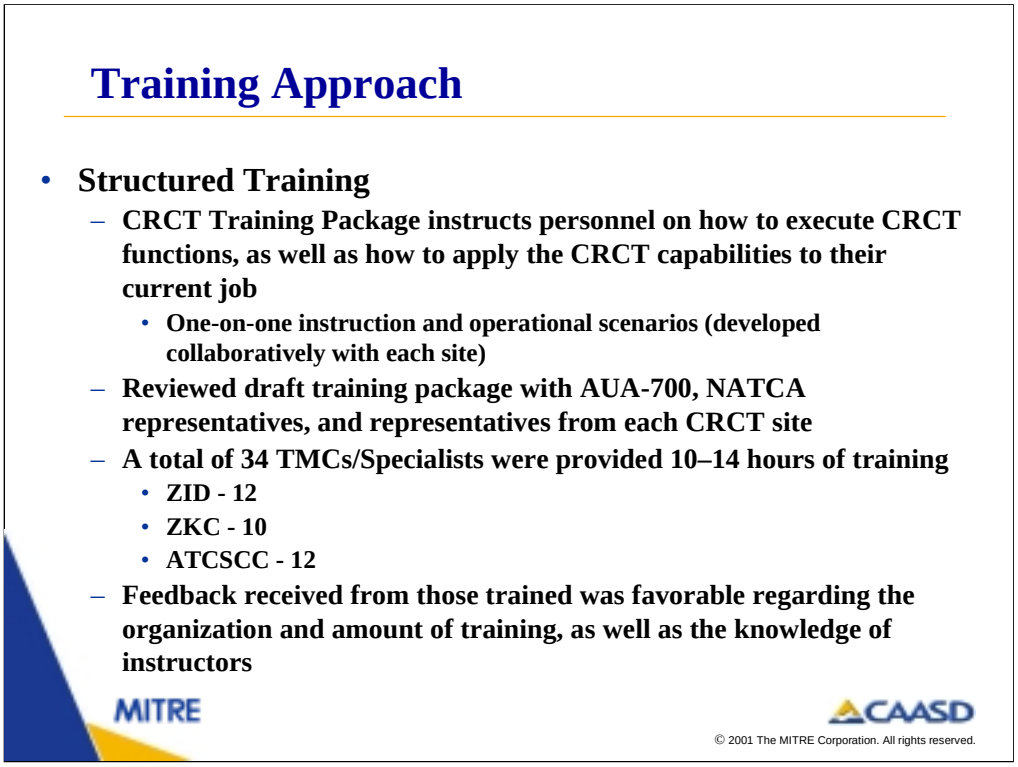
The evaluations presented in this report follow the plan outlined in the *FY01_CRCT Evaluation Plan* (Hollenberg et al., 2000). The evaluation activity focused on the reroute what-if capabilities and led to conclusions about which of these capabilities might be mature for implementation in ETMS 7.4 and 7.5. Future CRCT-based R&D is expected to include miles-in-trail (MIT) what-if functions, automatic construction of potential FCAs and reroutes for severe weather avoidance, and more.



As described on the preceding slide, a major result of previous CRCT work was the operational validation of the FCA concept. MITRE/CAASD works in collaboration with the FAA and the VNTSC to Technology Transfer mature CRCT functions into ETMS. On March 21, 2001, National Air Traffic Controllers Association (NATCA) and FAA management executed a Memorandum of Understanding (MOU) to create the CRCT Core Team (CCT). The CCT is composed of NATCA and management representatives from each of the three evaluation sites as well as national leads. The CCT is the governing body of the CRCT evaluation activities. The MOU also specified that the CRCT platform was not to be used as the sole source for decision making in live operations.



As previously stated, the evaluations conducted in 2001 at ATCSCC, ZKC, and ZID were designed to help assess the maturity of the CRCT rerouting what-if functionality for implementation in ETMS. The evaluations also investigated the maturity of other functions for assessing projected demand on an airspace sector or center, volume of airspace, or other NAS elements. In addition to determining the operational suitability of the evaluated functionality, refinements to the functions were identified.



Structured training was conducted in May 2001 at each of the three CRCT sites to prepare TMCs to evaluate CRCT functions. The CRCT Training Package (TFM Evaluation and Analysis Group, 2001) was developed by MITRE/CAASD with extensive field input from each site as well as AUA-700 representatives, the CCT members, and other NATCA and FAA management personnel. The package provided a brief history and background of CRCT, instructed personnel how to execute CRCT functions, and concluded with a series of operational scenarios illustrating how to apply the CRCT capabilities in current TFM operations. Instruction was administered by MITRE/CAASD personnel in a lab area at each TMC's normal work location (ATCSCC, ZID, or ZKC). The training was delivered on a one-on-one basis in front of the CRCT system, using replayed data (recorded on July 14, 2000). The TMC performed the functions and scenarios specified in the training package in order to gain hands-on experience. The exception to this approach was the history and background portion of the training, which was delivered in briefing format. TMCs received this portion either one-on-one or in pairs.

The Training Package was given to each TMC to keep, as were two other instructional items: the *CRCT Reference Manual* (Kapoor et al., 2001b), which is a detailed user manual describing the CRCT functions; and the *Quick Reference Guide* (Kapoor et al., 2001a), containing reminders on how to activate the basic functions and the meaning of various color coding and symbology on the displays.

A total of 34 TMCs/Specialists were provided 10–14 hours of training, depending on the length of time required to complete the package. The number trained at each site was:

ZID - 12

ZKC - 10

ATCSCC - 12

As indicated on slides 73 through 75 later in this report, feedback received from those trained was favorable.

CRCT Training at ATCSCC

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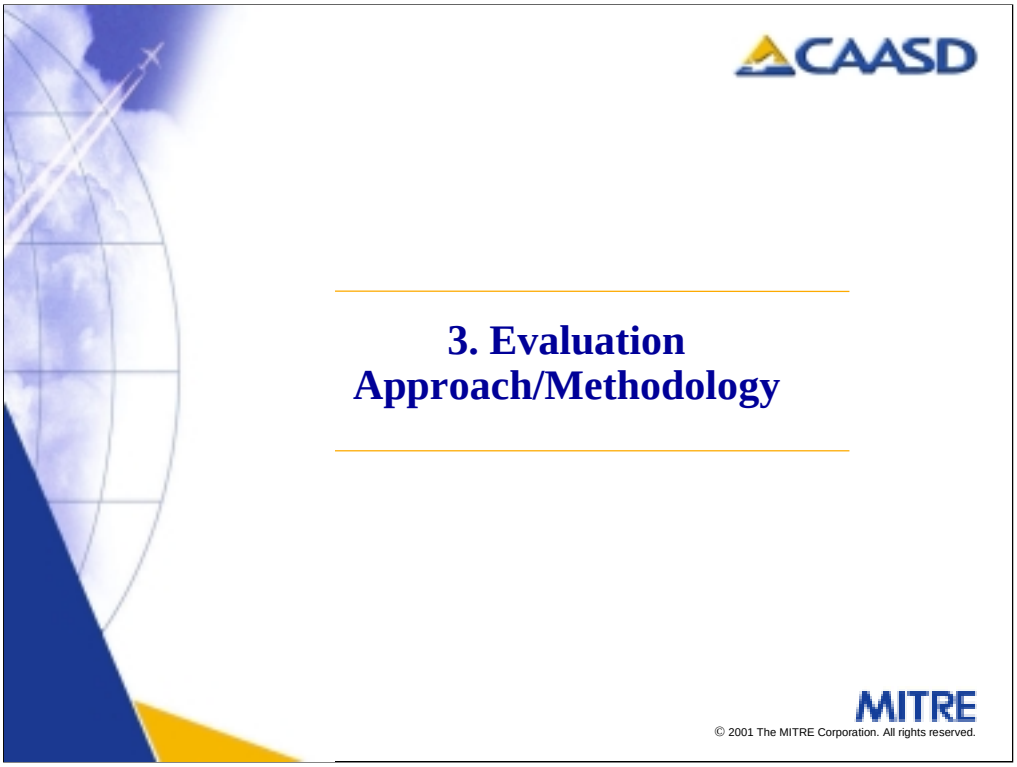
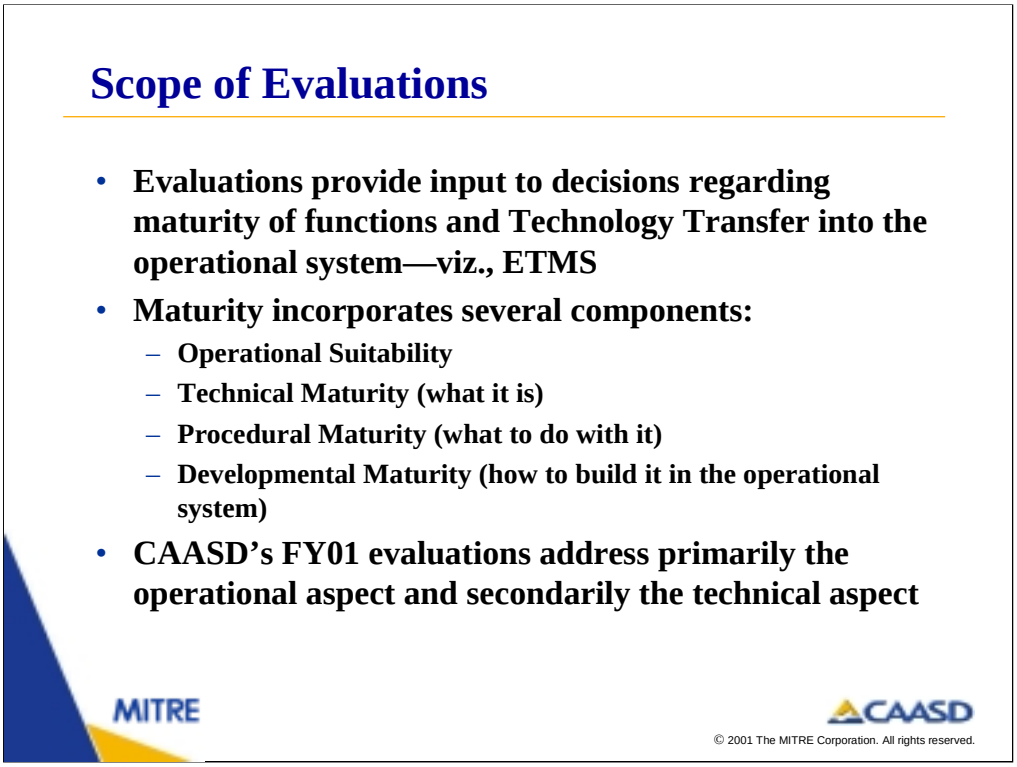
This slide illustrates a TMC being trained on CRCT at ATCSCC by a MITRE/CAASD trainer. Another MITRE/CAASD analyst records trainee comments and any system performance notes, and helps to answer questions.

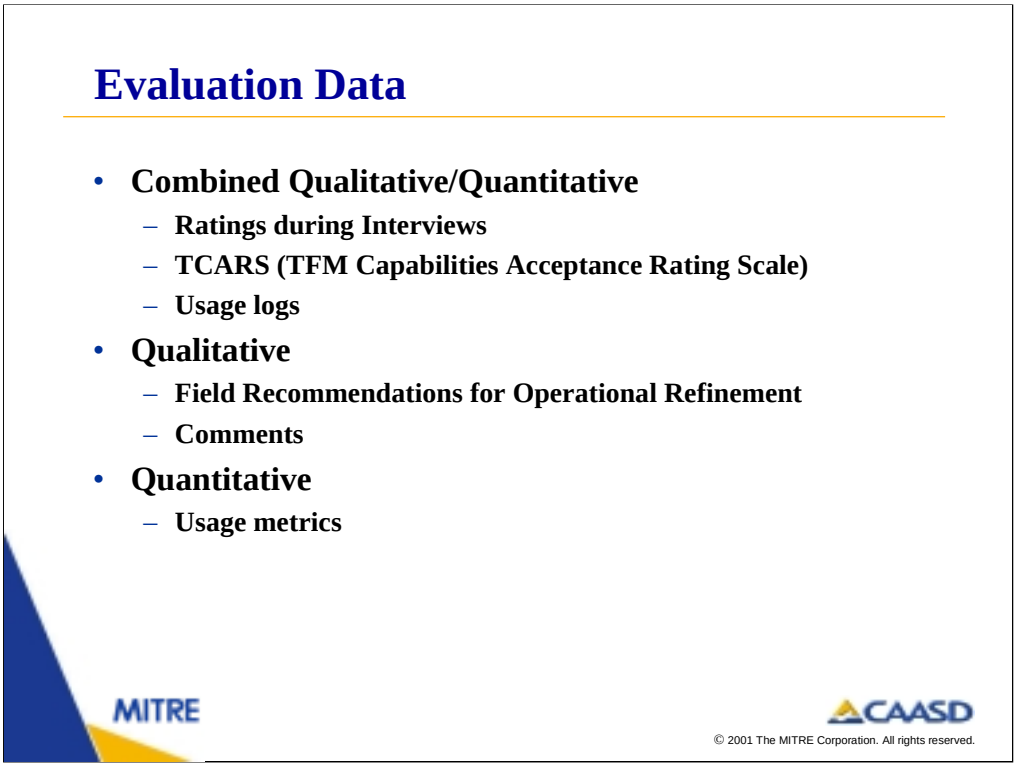




The evaluations' purpose was to determine the maturity of the reroute what-if functions prototyped in CRCT, so that decisions could be made by the FAA as to which of these functions should be incorporated into future releases of ETMS. Maturity of a function includes its operational suitability (based on field perception of the function and usage for evaluation during the test period), and its technical maturity (i.e., how clearly are HCI and algorithmic requirements defined). This report addresses these two aspects of maturity, especially the first.

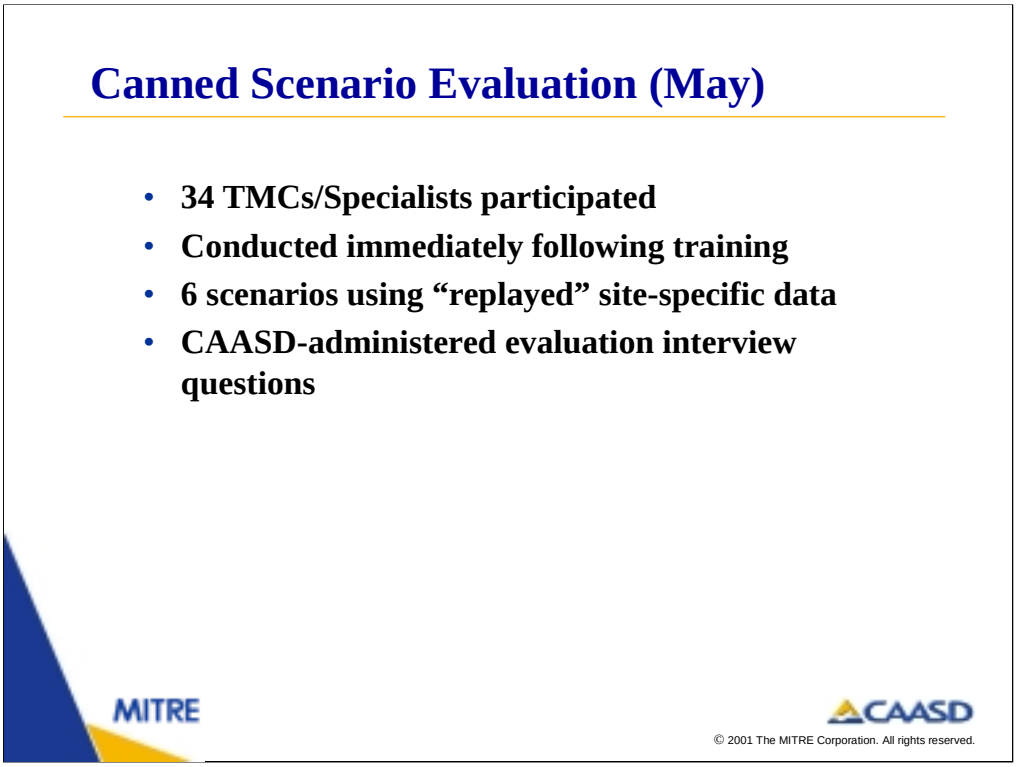
The other aspects of maturity, outside the scope of the evaluation and of this report, are procedural (the extent to which the function's operational use is defined) and developmental (the extent to which the means for building it into the operational system are defined).

Conclusions from this evaluation must be considered in light of the fact that the CRCT system could not be used as the sole source for operational decision making during the real-time evaluation period. However, fairly extensive usage of CRCT, for evaluating live traffic situations on the Traffic Management Unit (TMU) floor, was observed and reported during the real-time evaluation period (see, for example, slides 21 through 24, and 51). Therefore, the conclusions regarding maturity and effects of CRCT functions, based on TMC ratings, comments, and observed usage, especially during the real-time evaluation and follow-up interviews, can be considered fairly reflective of what would occur if the capabilities were implemented in the ETMS system.



The evaluation approach entailed a combination of qualitative and quantitative data. In agreements between MITRE/CAASD and the CCT, time was allocated specifically for each TMC's interviews. Therefore, the interview data were collected and analyzed in a more systematic, controlled way than other data sources. Therefore, TMCs' ratings given during the interviews, and their recommendations for refinement of the functions prototyped in CRCT, are the focus of this report. Supporting data in this report include the TFM Capabilities Acceptance Rating Scale (TCARS; slide 17), usage logs (slide 20), general comments, and automatically-collected usage metrics (slide 19).

Future reports are planned to provide further detail on other data collected, particularly the TCARS results and usage metrics.

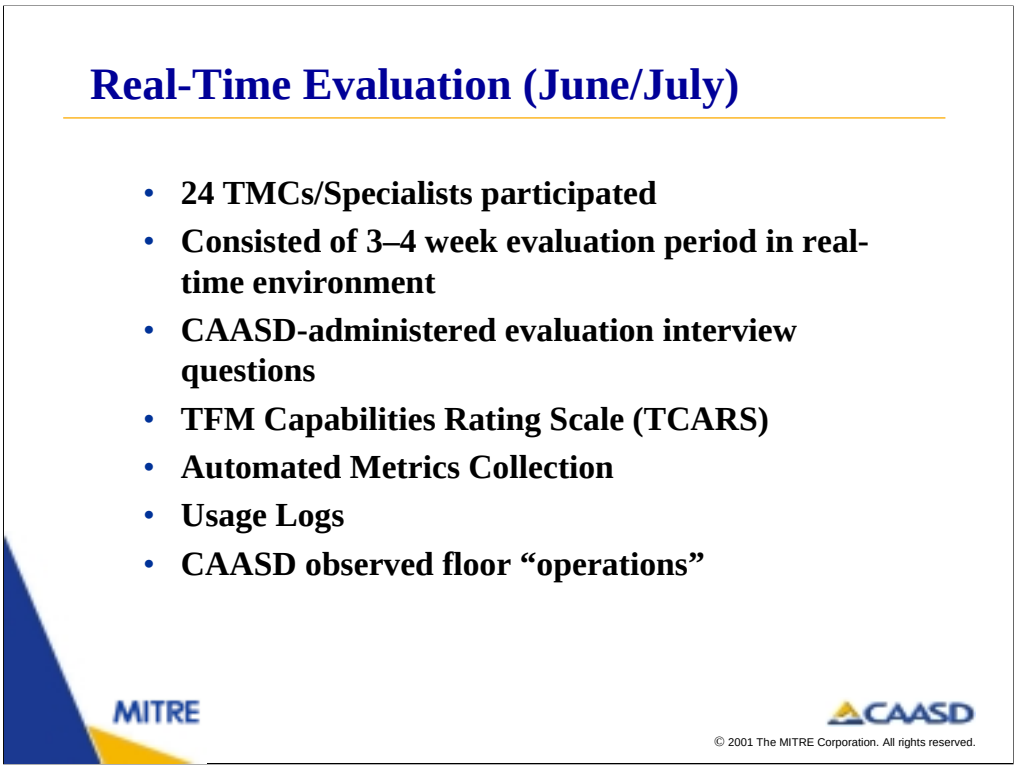


The approach for the FY01 CRCT evaluations was developed by MITRE/CAASD with feedback from the CCT and other field personnel. The evaluations described in this report consisted of a canned evaluation conducted at the three CRCT sites in May 2001 immediately following CRCT training, and a real-time evaluation in June and July.

The canned evaluation consisted of six scenarios based on situations where the MITRE/CAASD evaluation team, and field personnel, believed that CRCT functions might be useful. These included the situations validated as applicable for CRCT capabilities in earlier evaluations (Carlson, 1999b) such as severe weather and sector congestion, as well as additional situations identified in (Carlson, 199b) as possibly applicable. A complete list of scenario instructions can be found in Appendix A.

The evaluation was conducted on a one-on-one basis. In each scenario, the TMC received written instructions for a realistic operational task similar to one or more of the training scenarios, and was asked to complete the task on CRCT using replayed data. TMCs were not told how to perform the tasks on CRCT, but instead were encouraged to use whatever CRCT functions they believed would best support the goals of the scenario. A MITRE/CAASD facilitator was available to assist with system problems or to answer questions if the TMC was not clear on how to perform a specific task. Following each scenario, a brief interview was conducted with the TMC regarding several issues, including which CRCT functions were used, what decision would have been made were this a real operation, and whether information would have to be shared with, or requested from, others. These interview questions can be found in Appendix B.

Following the completion of all six scenarios and interviews, a slightly longer interview (Appendix C) was conducted to ascertain general perceptions about the usefulness of CRCT functions and the effects on the TFM environment if CRCT functions were implemented in ETMS.



The real-time evaluation took place between the first week of June and the first week of July, 2001. During this period, a new release of CRCT was installed in the TMU at ZID and ZKC, and at the ATCSCC Severe Weather Desk. The TMCs who had participated in the May training and evaluation were assigned to an additional TMU position on specific days. While assigned to this position, TMCs analyzed live traffic situations using the functions prototyped on the CRCT system. Overtime funds were provided by the FAA to support the additional TMU position.

MITRE/CAASD system administrator support was available 70 hours per week at ZKC, 154 hours per week at ZID, and between 40 and 70 hours per week (schedule varied) at ATCSCC. Throughout the real-time evaluation period, the CRCT systems were scheduled to be available to TMCs 23 hours per day; one hour in the early morning was reserved for system reboot. Due to infrequent system and data outages, CRCT was available 150.5 hours per week on average between June 4 and June 30, a total of 93.5 percent of the scheduled time.

During the real-time evaluation period, an automated utility program collected metrics on the activation of specified CRCT functions (more detail on slide 19). In addition, TMCs completed a usage log on a workload-permitting basis (slide 20).

During the week of July 9, 2001, structured interviews (Appendix D) were conducted individually with each participant regarding the perception of CRCT functions. Slide 16 provides an example of the type of rating scale used in the May and July interviews, and slide 17 shows the TCARS rating scale, used in the July interviews. Interview topics included the importance and usefulness of each set of functions, as well as how each function could be improved when implemented in ETMS (the database of suggested improvements or refinements is described on slide 18).

Twenty-four of the original 34 TMCs participated in the real-time evaluation. Some of the original participants did not perform Traffic Management Coordinator duties as part of their regular job description, and others were not able to use CRCT for evaluation purposes during the June-July test period, due to scheduling constraints. Therefore, these ten were excluded from the real-time evaluation.

Sample Interview Rating Scale

In this scenario, how useful was each of the listed CRCT functions for your decision making (i.e., how much did the function, as implemented in CRCT, assist you in making a decision)?

1 Not at All Useful	2 Slightly Useful	3 Moderately Useful	4 Quite Useful	5 Very Useful

Function	Usefulness: 1-5	Comments
Current traffic display Future traffic display FCA definition Moving FCA Crossing segment Reroute definition FCA list NAS Monitor Sector Count Time in Sector charts FCA Demand Graph Playbook Other_ Other_		

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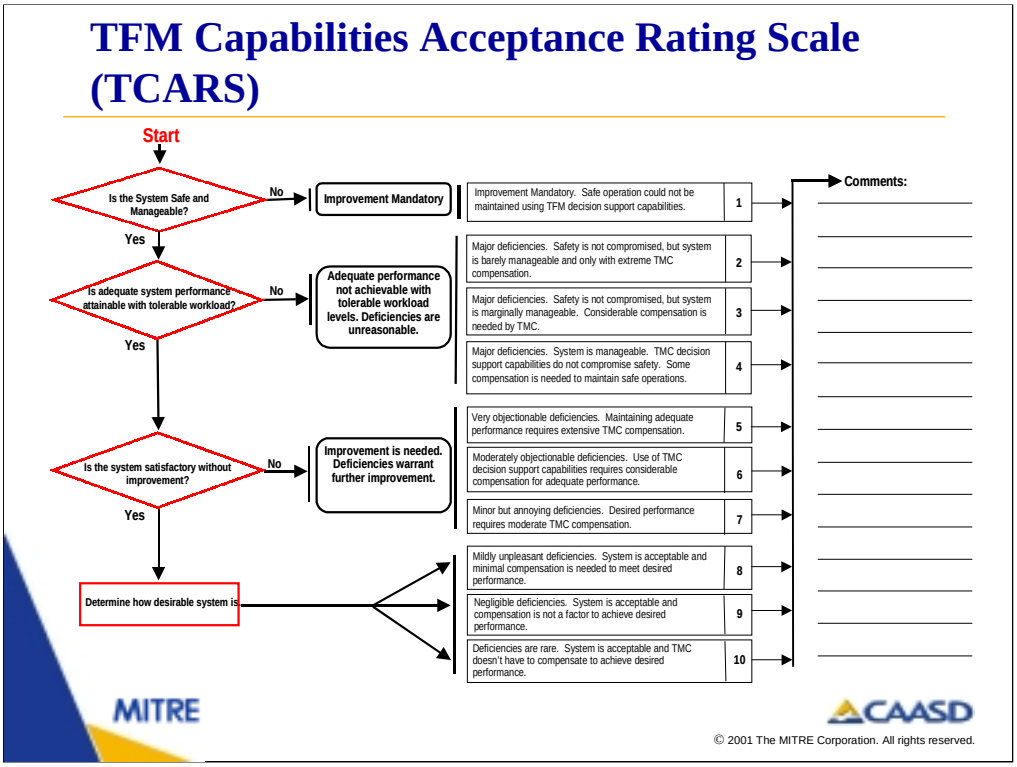
Many of the interview questions in both the canned and real-time evaluations employed rating scales such as this one, taken from the interview administered after each scenario in the canned evaluation.

Open-ended questions were employed as well, and the questions containing rating scales included space for comments, enabling the collection of many TMC opinions about specific CRCT functions or about the CRCT functionality in general.

Interview responses were recorded by a CAASD facilitator.

The complete text of the interview forms employed during the evaluations are found in Appendixes B through D.



During the interviews conducted in July at the end of the real-time evaluation period, TMCs completed the TFM Capabilities Acceptance Rating Scale (TCARS). TCARS was developed at MITRE/CAASD for this evaluation and is based on the Controller Acceptance Rating Scale (CARS) (Kerns et al., 1998; Lee and Davis, 1995). CARS, in turn was derived from the Cooper-Harper Scale, which has been used in transportation research and development, particularly in the aviation domain, by the National Aeronautics and Space Administration (NASA) and others (see, for example, U.S. Navy [undated]).

The TCARS ratings were collected following the real-time evaluation interviews. The protocol involves following the flowchart illustrated above and arriving at a single numerical rating, which is always an integer between 1 and 10 inclusive. Comments supporting the rating are encouraged during administration. Both the number rating and the comments were recorded by a CAASD facilitator.

TCARS was administered three times to each TMC: one rating was given with regard to the present-day TFM system, one for the system as it would be if the remaining FCA capabilities were implemented in the ETMS system (i.e., those capabilities prototyped in CRCT but not yet included in ETMS), and one for the the system if all FCA and rerouting capabilities prototyped in CRCT were implemented in ETMS. The exact text describing the three TCARS ratings, as well as the full instructions for TCARS, as it was administered during the evaluation, can be found in Appendix E.

Sample of Refinements Database for Recommendations and Comments

#	Operational Refinement Suggestion	Concept Category	Functional Category
26	When a route is deselected in the Prefs Box, it should make a corresponding change in the filter group. For example, if you deselect DCA from the Prefs box, all references that correspond in the filters should automatically update.	Windows Management	Reroute FCA
61 65	Have the appropriate Pref routes automatically retrieved when filter groups and 'routed through' are applied.	General CHI	Reroute FCA
27	Cannot see the need for both a Clear and Delete function in the Rerouting window.	General CHI	Rerouting
54 198 129	Have one reroute set named the same as the original FCA, but retain the option of establishing new (independent reroute sets).	Windows Management	Rerouting
7	Display on the Traffic Display only those reroute sets that are checked. Do not automatically display the active set.	Windows Management	Rerouting
97	Once finished with the Rerouting Windows, should default back to Reroutes being unselected	Windows Management	Rerouting
23	Be able to activate a reroute set by checking the box on the TD, and the Sector Count Monitor should switch to 'evaluate' mode for the selected set	Windows Management	Rerouting
31	Combine the Reroute Set and Rerouting windows	Windows Management	Rerouting
41 137	Be able to toggle off/on portions: ability to easily modify "arrive at". Yes/No for airports in FCA definition window: groups can be called up individually and destination airport individually selected in the Pref route definition window, etc.	General CHI	Reroute FCA
44 11	Be able to: • Reroute/connect other routes • Compare a revision of the play against the original play • Pick up the Pref route at any existing point without changing the whole thing.	General CHI	Reroute FCA

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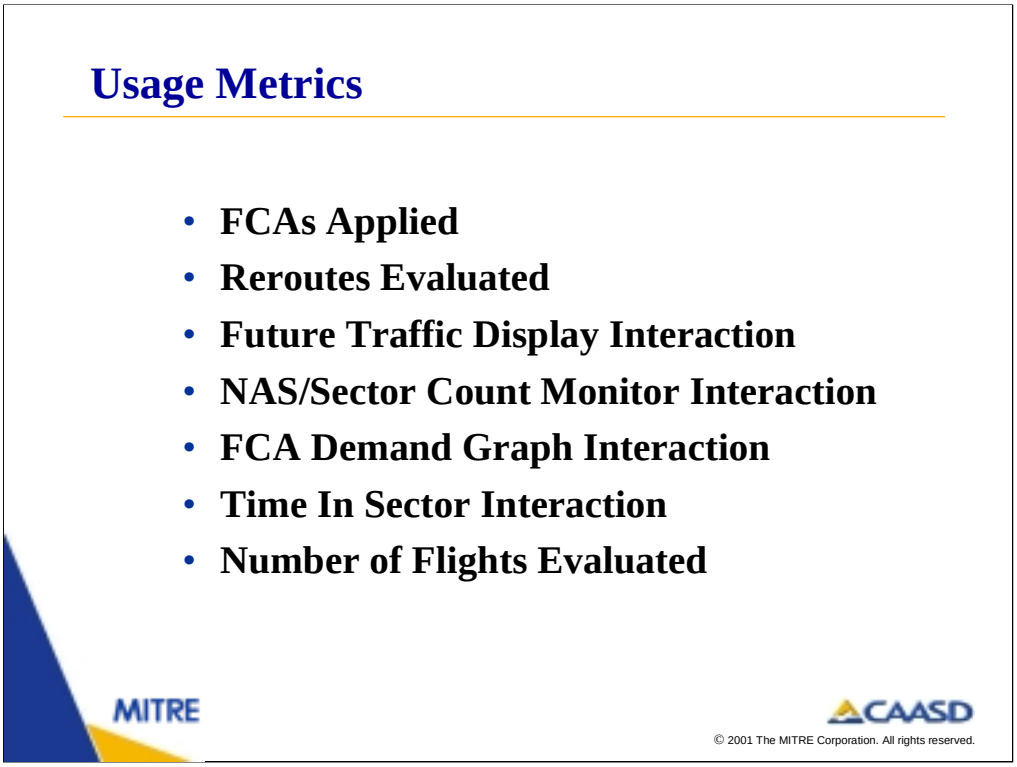
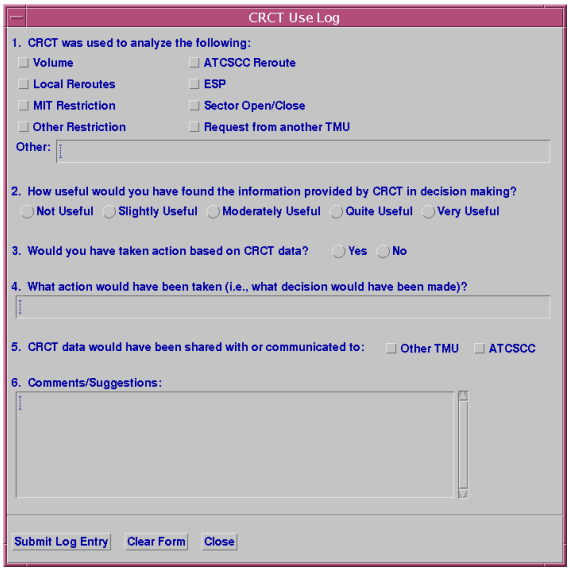
Many of the TMCs' comments collected on the interview forms (as well as during training and during the real-time evaluation period) involved specific recommendations for refining the prototyped CRCT functionalities for implementation in ETMS, and/or refining the CRCT system itself for further research and evaluation. A database was constructed to facilitate the analysis of these new suggestions and of the refinements defined in prior evaluations (Barlow et al., 1999; Carlson, et al., 1999b). This slide shows a sample of the database. The suggestions and comments were examined along with the numerical rating data to support conclusions regarding which functions were operationally suitable, which ones required further research, and what refinements, if any, were needed to a given function to ensure its technical maturity (refer to maturity definitions in Executive Summary).



A utility program running in the background on each CRCT workstation captured the frequency of interaction with each of the major functions of the system, such as FCAs, reroute what-if, sector volume analysis and future traffic analysis. To support these data, the interview conducted at the end of the real-time evaluation period contained a question regarding the number of problems the TMC had analyzed per week on the CRCT system in the TMU.

CRCT Usage Log



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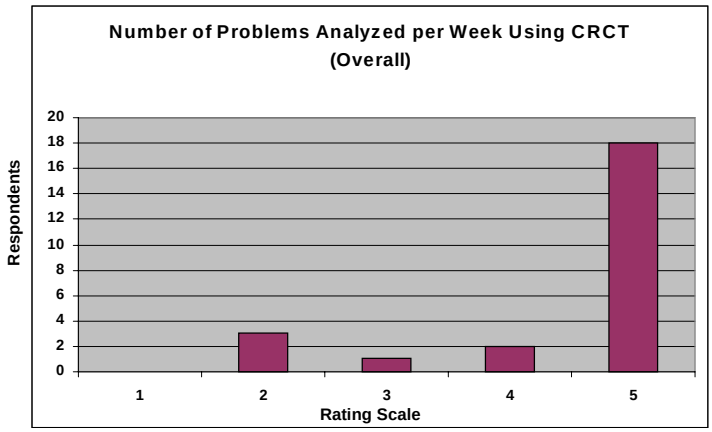
The usage log was available to the TMCs during the real-time evaluation period to submit comments on how CRCT functions would have been used if decisions were being made based on the output of the CRCT capabilities. The log was accessed though a button on the CRCT Traffic Display, and evaluation participants were encouraged to submit a log entry after analyzing a problem on the CRCT platform. The purpose of the log was to capture data immediately following each CRCT activation to capture the "why and how" of the operation just completed, to supplement and explain the "what and when" information collected via the usage metrics utility (see previous slide). This information would provide input about the types of operational situations for which the CRCT capabilities could be useful, and what types of decisions they might support if implemented in ETMS.

The log was used on an "as-possible" basis and was not submitted every time CRCT was used to examine a situation. Additionally, log usage varied greatly across sites. Therefore the results from this source of data may not be representative of CRCT capability use during the real-time evaluation, and the results are not covered in detail in this report.

Number of Problems Analyzed per Week Using CRCT, All Sites

Throughout the test period, how many problems did you analyze per week using the CRCT prototype during daily operations? Use the following scale: 1 = none, 2 = 1–3 per week, 3 = 4–6 per week, 4 = 6–10 per week, 5 = more than 10 per week



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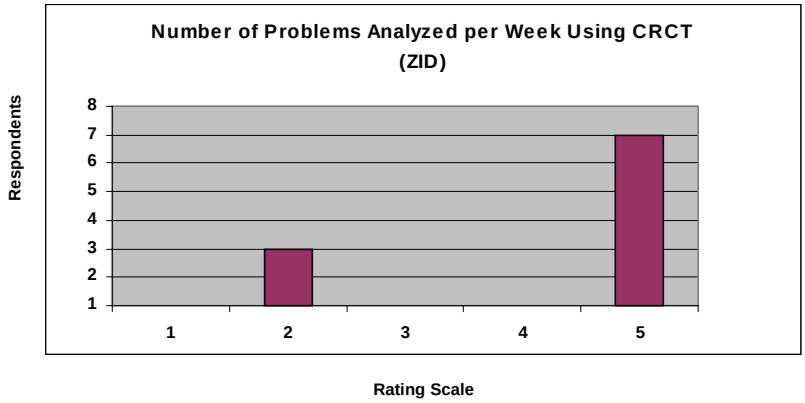
As can be seen above, during the real-time evaluation period, the majority of participants analyzed more than ten problems per week using the CRCT prototype. As shown on the following three slides, the number of problems analyzed during the real-time evaluation was consistent across all three CRCT facilities.

Number of Problems Analyzed per Week Using CRCT, ZID

Throughout the test period, how many problems did you analyze per week using the CRCT prototype during daily operations? Use the following scale: 1 = none, 2 = 1–3 per week, 3 = 4–6 per week, 4 = 6–10 per week, 5 = more than 10 per week



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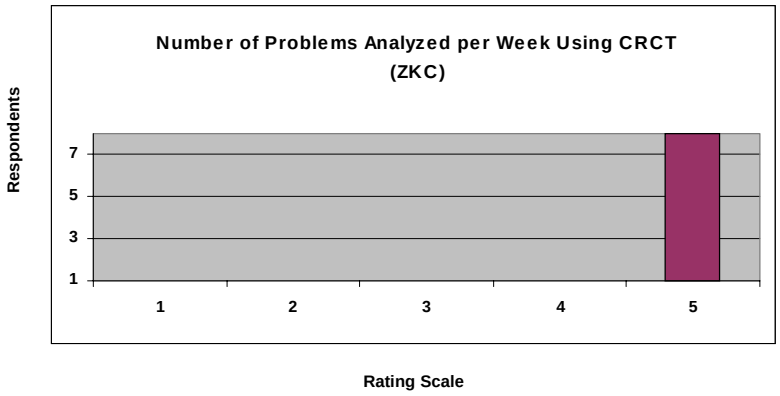
Number of Problems Analyzed per Week Using CRCT, ZKC

Throughout the test period, how many problems did you analyze per week using the CRCT prototype during daily operations? Use the following scale: 1 = none, 2 = 1–3 per week, 3 = 4–6 per week, 4 = 6–10 per week, 5 = more than 10 per week



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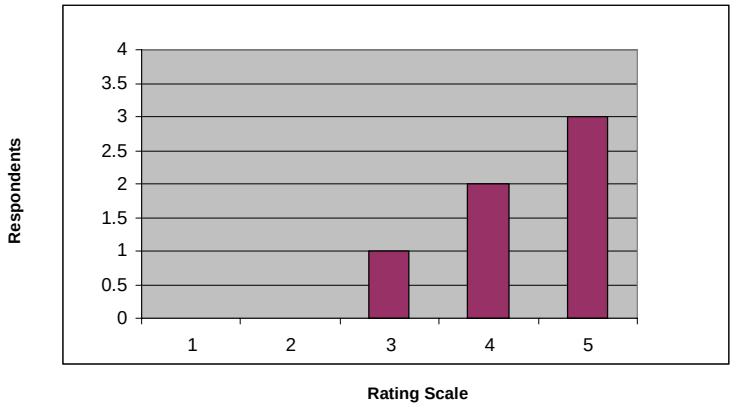
Number of Problems Analyzed per Week Using CRCT, ATCSCC

Throughout the test period, how many problems did you analyze per week using the CRCT prototype during daily operations? Use the following scale: 1 = none, 2 = 1–3 per week, 3 = 4–6 per week, 4 = 6–10 per week, 5 = more than 10 per week



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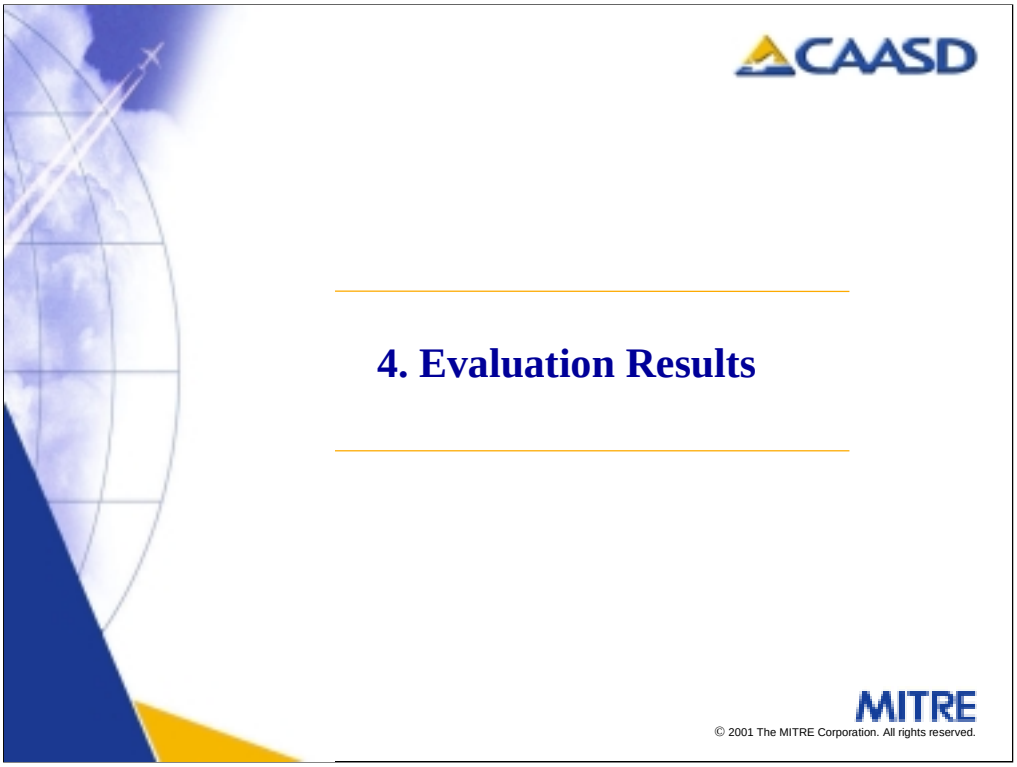


The remainder of this report provides detail on the results of the FY01 CRCT evaluations. The results are organized as follows:

A. Conclusions

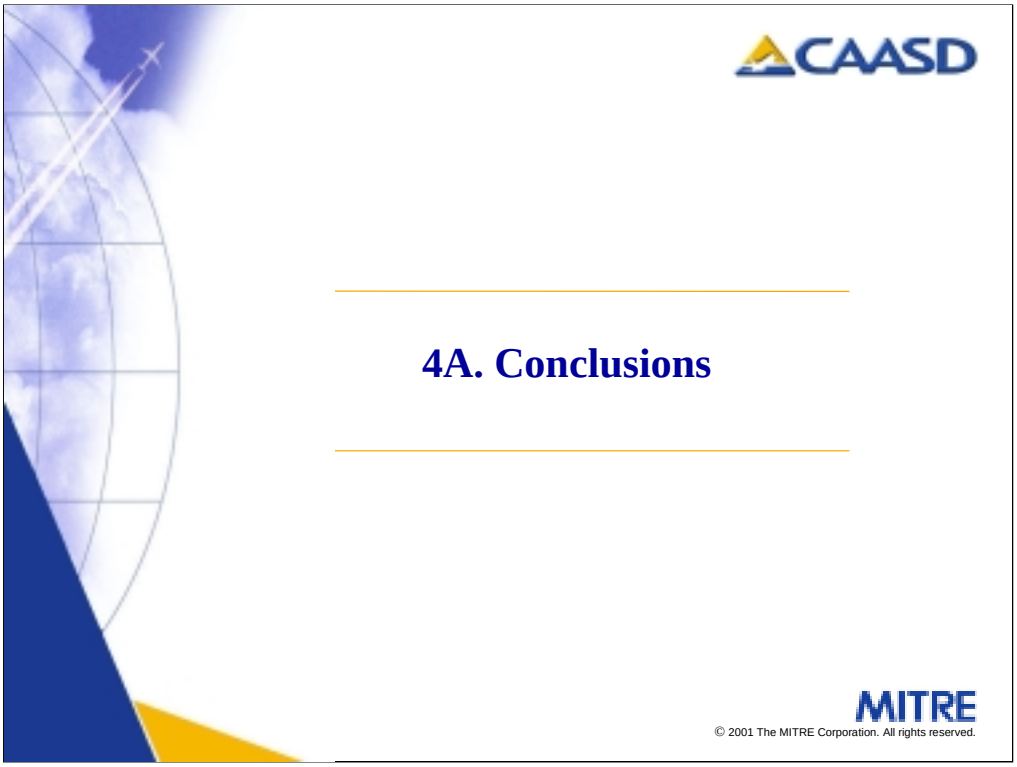
- Operationally/technically Mature Functions
- Functions for Further Research

B. Data supporting the conclusions on maturity and further research

- Importance and Evaluation Usage of specific Rerouting What-If Functions
- Operational Applications
- Importance and Evaluation Usage of all CRCT Functions

C. Data on field perception of CRCT functions and training

- Perception of Training
- Confidence in Predictive Information
- Expected Effects of using CRCT Functions
- Communication and Collaboration



The slides in this section detail the primary conclusions of the evaluations, and are divided into two sections. First, the functions deemed operationally mature are listed on slides 27 through 29, with the refinements deemed necessary for technical maturity. These were presented at the CCT meeting/TIM in July and August 2001 for further prioritization by the FAA, pending estimation of implementation difficulty by VNTSC. Functions requiring further research are shown on slides 30 and 31; these were also presented at the CCT meeting/TIM for FAA prioritization.

Operationally Mature Functions

Selecting Traffic for Rerouting "What-if"
Load from List
Crossing Segment
FCA List
Defining the Reroute
Text Edit
Traffic Display (point and click)
Altitude
Evaluating Reroutes
Sector Count Monitor (SCM)
National Airspace System (NAS) Monitor
Future Traffic Display (FTD)
Time in Sector Graph
Reroute List with +time/mileage

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This slide shows the functions related to the reroute what-if capability that are recommended for implementation in either ETMS 7.4 or 7.5, depending on the procedural and developmental maturity (see maturity definitions in Executive Summary). For ease of reading, the functions are classified into which stage of the reroute what-if process they support (i.e., selecting flights, defining reroutes, or evaluating reroutes.)

Operationally Mature Functions, with Recommended Refinements for ETMS Implementation

Function	Recommendation
Selecting Traffic for Rerouting "What-if"	
Load from List	Add more descriptive labeling on "load from list" button.
Crossing Segment	
FCA List	Add ability to select one, several, or a block of flights to reroute.
Defining the Reroute	
Text Edit	• Selecting "Insert" Button inserts the route text and then closes the window. • Text Edit window comes up with existing text (if any) highlighted and ready for typing into without need to delete existing text. • Pull down menu of the last **n** text routes.
Traffic Display (point and click)	Add ability to turn SIDS and STARS on and off for rerouted flights.
Altitude	Select "At or Above" (AOA) and "At or Below" (AOB) as criteria for altitude selection.

Can be implemented as is

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This slide and the one following show the functions on the previous page, with refinements, if any, that CAASD and/or field personnel deem necessary for technical maturity. Shading denotes functions which should be implemented in ETMS as-is, without any changes to the functionality as implemented on the CRCT prototype.

Operationally Mature Functions, with Recommended Refinements for ETMS Implementation (Concluded)

Function	Recommendation
Evaluating Reroutes	
Sector Count Monitor (SCM)	"Grouping" or "Sorting" sectors by area.
National Airspace System (NAS) Monitor	
Future Traffic Display (FTD)	
Time in Sector Graph	
Reroute List with added (or subtracted) time and mileage (NOTE: CCT deems that this function, or at least the added time/mileage information, may be unnecessary.)	• Put reroute set Create, Delete, Merge, etc. as part of the Reroute Window. • Implement only Delete, not Clear. • Make reroute set activation "global." Select the reroute set in any window (SCM, Traffic Display, NAS, etc.) and that reroute set becomes the one displayed in all windows, or select "current" and the current status is displayed in all appropriate windows, with no reroute sets selected in other windows. • Use ETMS sorting functions and apply them to the reroute list. • Allow user to edit a reroute string in RR window, and re-evaluate. • Automatically assign the reroute set with the same name as the FCA it is associated with. When that FCA is selected in the FCA definition window, let the associated reroute set come up as the default.
Other	
Taskbar for Window Management	Microsoft style taskbar

Can be implemented as is

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This slide presents the remaining operationally mature functions, continued from the previous slide.

Note: The final item in this list, the taskbar, is not currently part of either the CRCT or the ETMS platform. Therefore, it was not explicitly evaluated in this study. However, due to the large number of windows on both systems and the difficulty of managing those windows, the taskbar was repeatedly requested by field personnel.

Note: Three other ETMS refinements, not covered in the CRCT evaluation, were deemed operationally and technically mature by the FAA during the July CCT meeting. Because the meeting represented the first step in applying and using the evaluation results, these refinements are presented here, as follows. The first additional refinement involves the need for a remarks field when creating an FCA. The capability to enter remarks should be modeled after Flight Schedule Monitor (FSM). A somewhat related capability involves the sorting of an FCA List based on the contents of the Remarks field in the flight plan. The primary application of this capability would be to identify flights that have already agreed to avoid an existing FCA (according to the planned procedure, these flights would have the FCA name in the Remarks field of their flight plan), and avoid rerouting them further. A third capability is automatic updating of the FCA and reroute lists whenever new flight plan information is received or a trajectory is recalculated. This automatic updating allows the system to constantly display the latest data without requiring the user to manually re-query ETMS.

Functions for Additional Research

Function	Description of Additional Research
Selecting Traffic for Rerouting	
Rerouting in FCA Using Multiple Filters	Needs additional research on logic and procedure for use
Defining the Reroute	
Playbook	Needs additional research on how to best use and how to make modifications easier
Evaluating Reroutes	
Sector Count Monitor (SCM)	Needs additional research on how to handle open/closed sectors, and indication of increase or decrease of sector traffic by specific number, color coding and alternate alert metrics
NAS Monitor	Needs additional research on indication of increase or decrease in Center traffic by specific number
Future Traffic Display (FTD)	Needs additional research on HCI and ability to type in time directly
Reroute List with +time/mileage	Needs additional research on combining FCA List and Reroute List into a "Super List"
Managing Reroutes	
"Delete" vs. "Cancel" (reroute window)	Needs additional research on the best method for implementing these two functions
Active Reroute Set Selection	Needs additional research on alternate methods to select/display the active reroute set

Research in progress

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This slide lists the reroute what-if functions that require further research in order to improve the usability of the given function prior to implementation in ETMS. As on slides 27 through 29, they are classified by the stage of the reroute what-if process that they support.

Some of these functions are also found on slides 27 through 29, such as Sector Count Monitor and Future Traffic Display. Functions such as these, that fall in both the "operationally mature" and "further research" categories, are recommended for implementation as-is or with the minor refinements listed on the preceding slides. However, further improvements to these functions have also been identified in the evaluations, and the best method for implementing these improvements is not technically mature. In other words, more detailed requirements are needed regarding the HCI and/or how the data are processed and presented, and the exact nature of the improvement cannot be specified without further study.

As denoted by the shading, many of the functions in this category are already under research at MITRE/CAASD via the CRCT platform and/or lower-fidelity prototyping methods. Others may be appropriate for future CRCT or prototyping work, or might be best studied by other methods.

Other functions for additional research, not relating to reroute what-if evaluation, are listed on the following slide.

Functions for Additional Research (Concluded)

Windows Management	
FCA/Reroute Select Boxes on Traffic Display	Needs additional research on alternatives for implementation.
Other	
Sector Count Monitor	Needs additional research on how to handle open/closed sectors, and indication of increase or decrease of sector traffic by specific number.
Future Traffic Display (FTD)	Needs additional research on HCI and ability to type in time directly.
Future	
Miles in Trail (MIT) what-if	
Flight Management List	
Progressive FCA/RR	
"Go" Button	
"Undo" Button	

Research in progress

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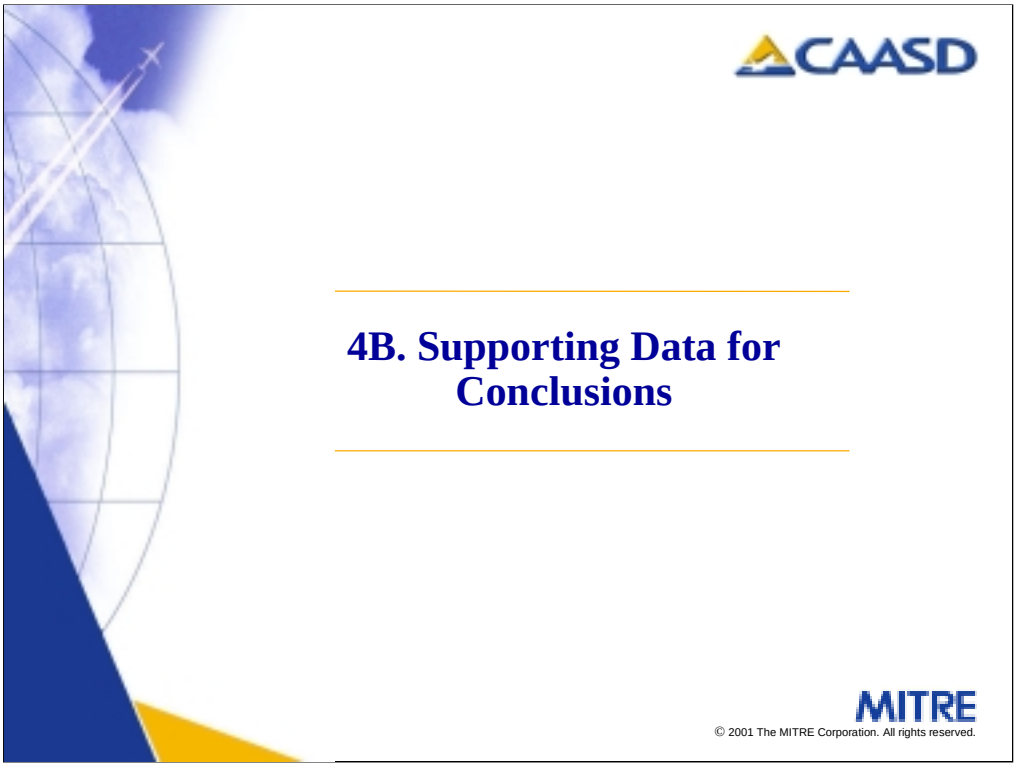
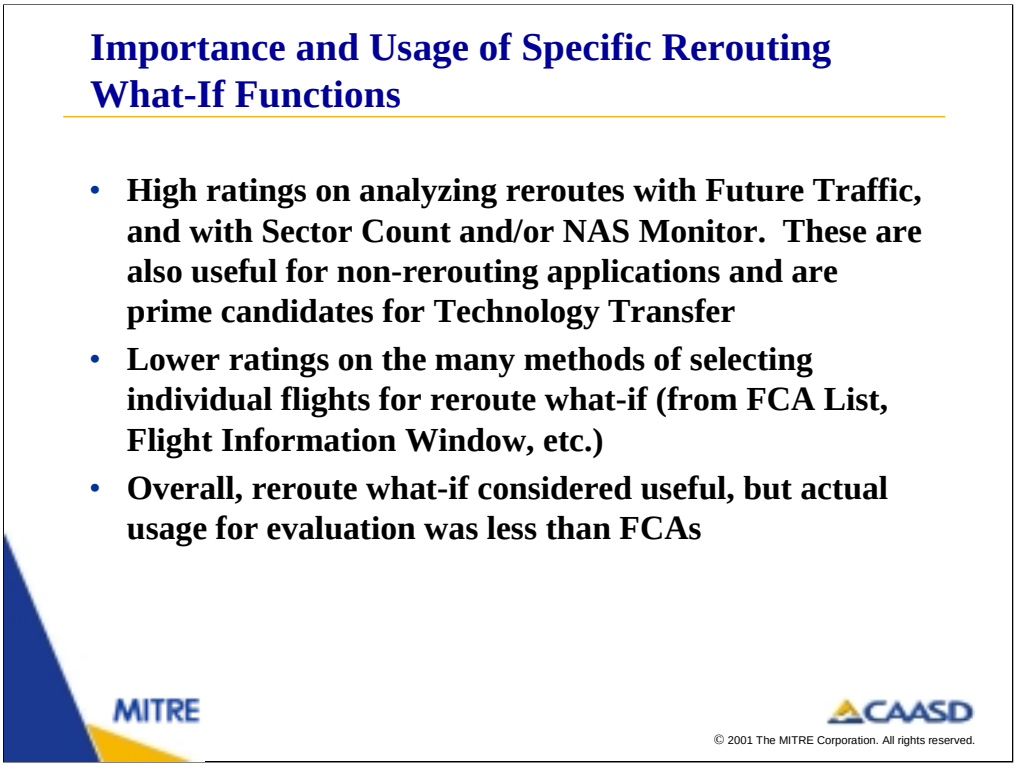
This slide presents the functions, in addition to the reroute what-if tools, that are deemed important but are not yet operationally and/or technically mature enough to recommend further consideration for implementation as-is. The items under the heading “Future” indicate more fundamental changes to methods for rerouting what-if analysis, displaying data, and disseminating reroutes, which are mostly in the basic research stage.

One additional function for further research did not surface in the evaluations but was raised at the CRCT Core Team Meeting: a compliance monitor to determine whether an assigned reroute is being adhered to. It is intuitive that this function would be operationally important, but further evaluation is needed to determine the appropriate algorithms for computing compliance, and the best way to present the information to the user.



This section provides the data that support the conclusions presented in the previous section. First, rated and recorded data on the operational importance, usefulness, and usage of the reroute what-if functions (the main focus of the evaluation) are presented. The next subsection shows results regarding the operational situations for which the functions prototyped on CRCT are most useful. Third, a separate subsection presents importance and usefulness data on CRCT functions not used for reroute what-if analysis. For the most part, the data are self-explanatory and plots are provided without annotation. Summary slides with annotations precede each section of plots.

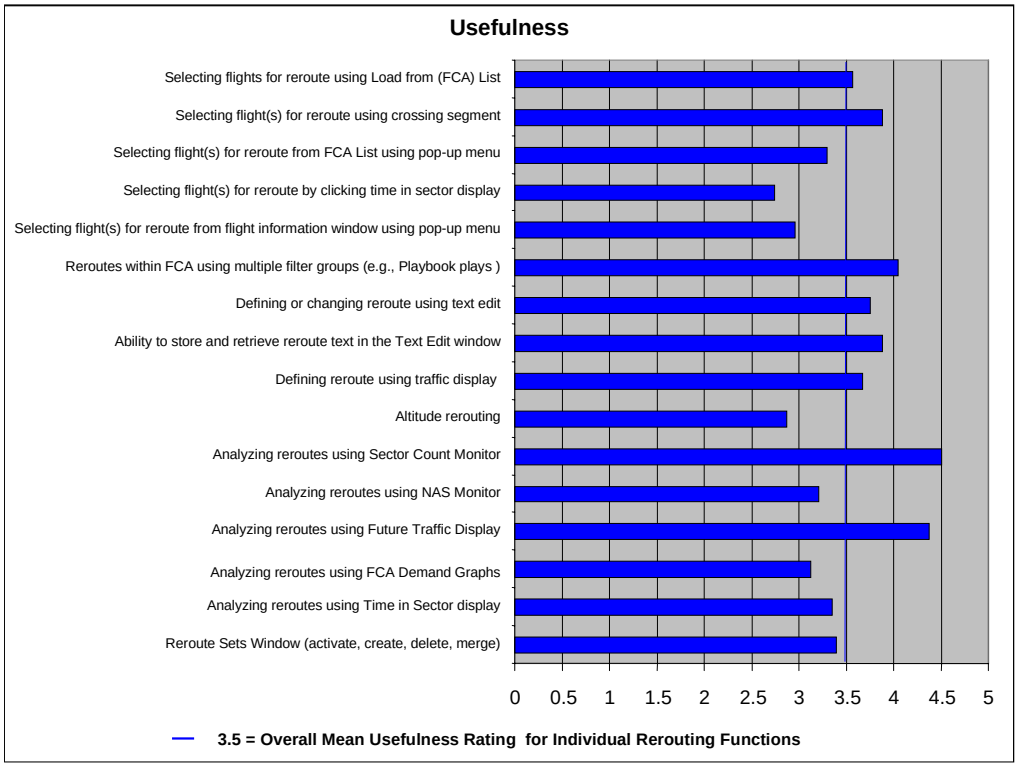


The Future Traffic Display and Sector Count and/or NAS Monitor are deemed useful for both rerouting applications (see slides 34 through 37) and non-rerouting applications (see the subsection "Operational Applications," beginning on slide 41). Usefulness ratings on these functions are uniformly high across sites and respondents.

Lower usefulness ratings were given on some of the individual flight selection methods for rerouting (from FCA List, Flight Info Window, etc.). It was concluded at the CRCT Core Team Meeting that there should be at least one way of selecting individual flights for reroute what-if, and at least one method for selecting flights as a group.

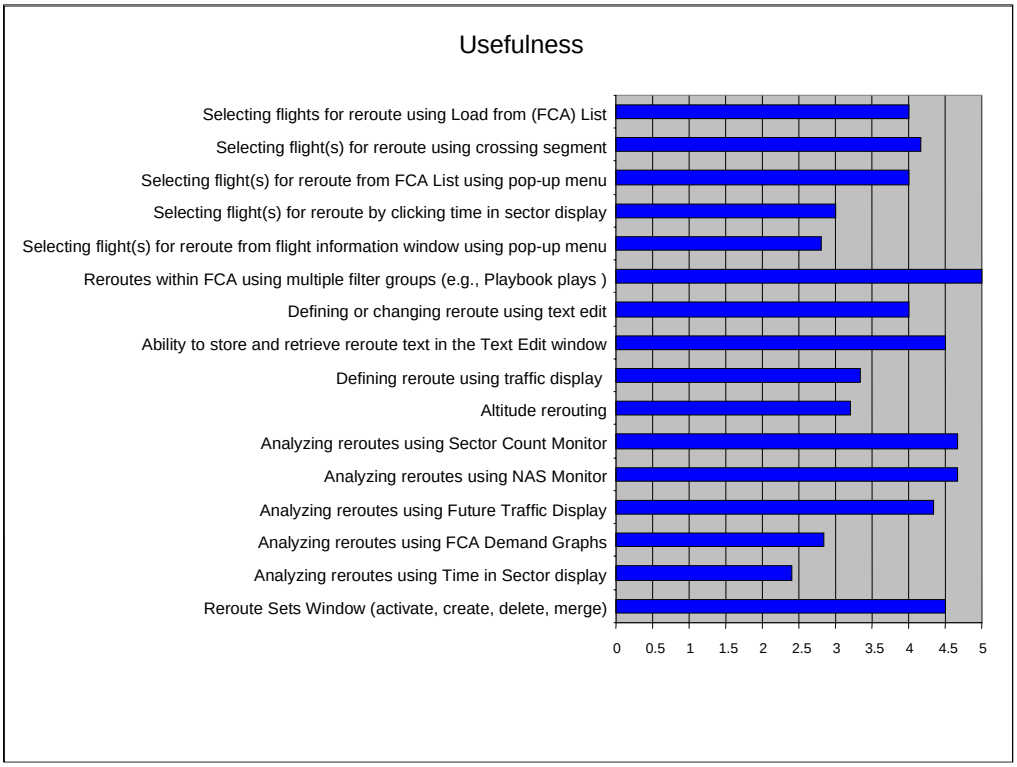
As seen on slide 38, CRCT's reroute what-if functions on average are considered useful, and their usefulness ratings (on the question regarding the "overall" rerouting definition and analysis) approach those of the FCA functions, which previous evaluations determined were mature for ETMS implementation. However, slide 39 illustrates that rated frequency of usage for evaluation was often quite low, and was less than that for FCA functions, and slide 40 shows that rerouting functions were used on the evaluation systems less than FCA's. The TCARS results presented later in this report (slide 86) provide further evidence that CRCT's full suite of reroute what-if functions are not completely operationally mature.

Comments from the evaluations indicate that the reroute what-if functions, as currently prototyped, can be difficult to use. Additionally, the algorithms currently used in evaluating reroutes may not be technically mature, as instances were found during the evaluation period where reroute plans being analyzed were not modeled as expected or as specified by the TMC. The combination of rating data, evaluation usage metrics, and comments lead to the recommendation to implement reroute what-if capabilities on a gradual, "evolutionary" basis.

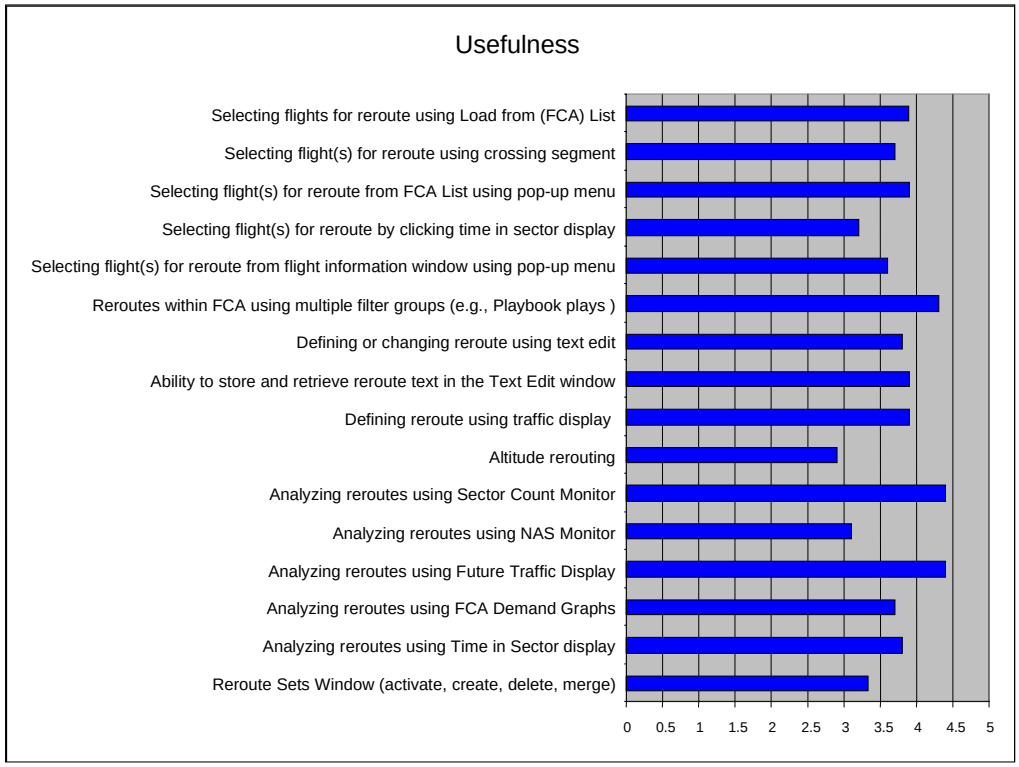


Usefulness of Individual Rerouting What-If Functions, All Sites

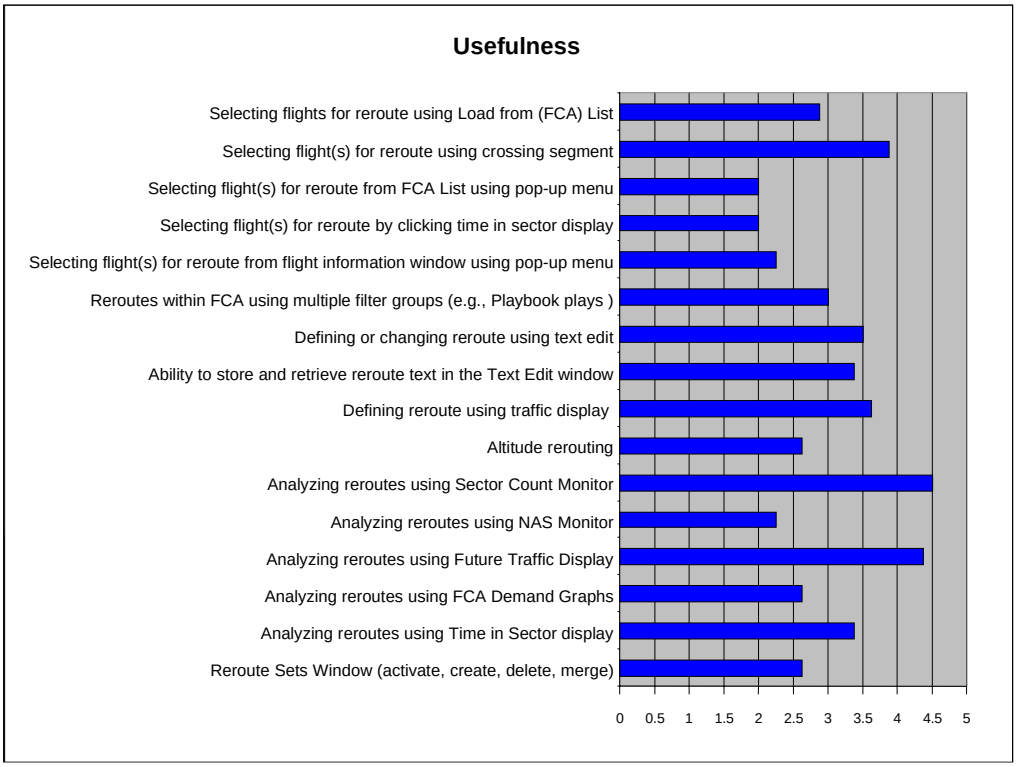
How useful was each of the listed CRCT functions (i.e., how much did the function, as implemented in CRCT, assist you in your analysis and/or decision making)? 1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful



ATCSCC Usefulness of Individual Rerouting What-If Functions



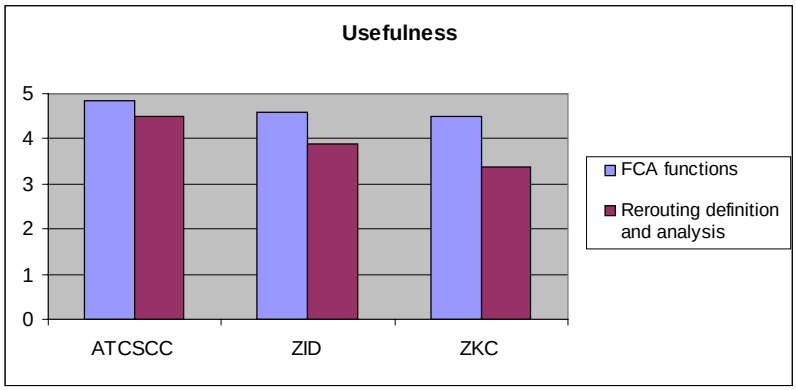
ZID Usefulness of Individual Rerouting What-If Functions



ZKC Usefulness of Individual Rerouting What-If Functions

Rated Usefulness of FCA and Reroute What-If Functions Following Real-Time Evaluation

How useful was each of the listed CRCT functions (i.e., how much did the function, as implemented in CRCT, assist you in your analysis and/or decision making)? 1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful



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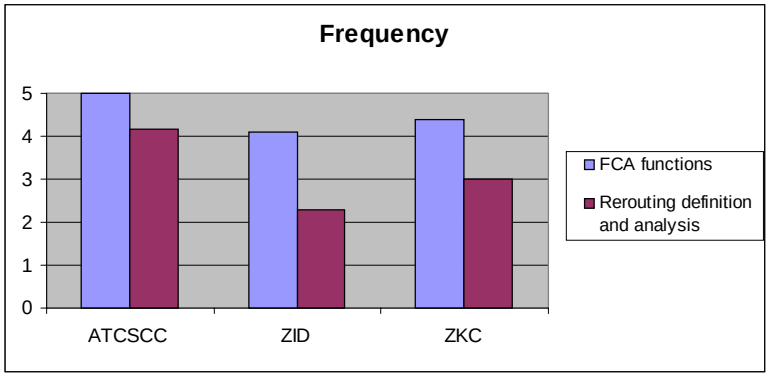
Rated Frequency of FCA and Reroute What-If Functions Following Real-Time Evaluation

How frequently did you use the listed CRCT functions? 1 = not at all, 2 = seldom, 3 = occasionally, 4 = somewhat often, 5 = very often



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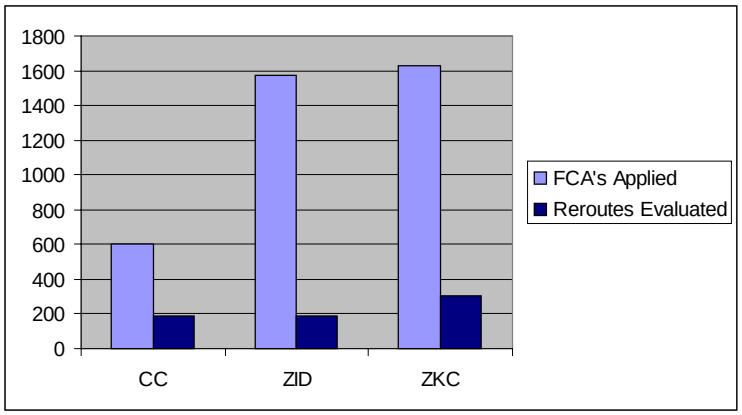
Recorded Frequency of FCA and Reroute What-If Functions During Real-Time Evaluation



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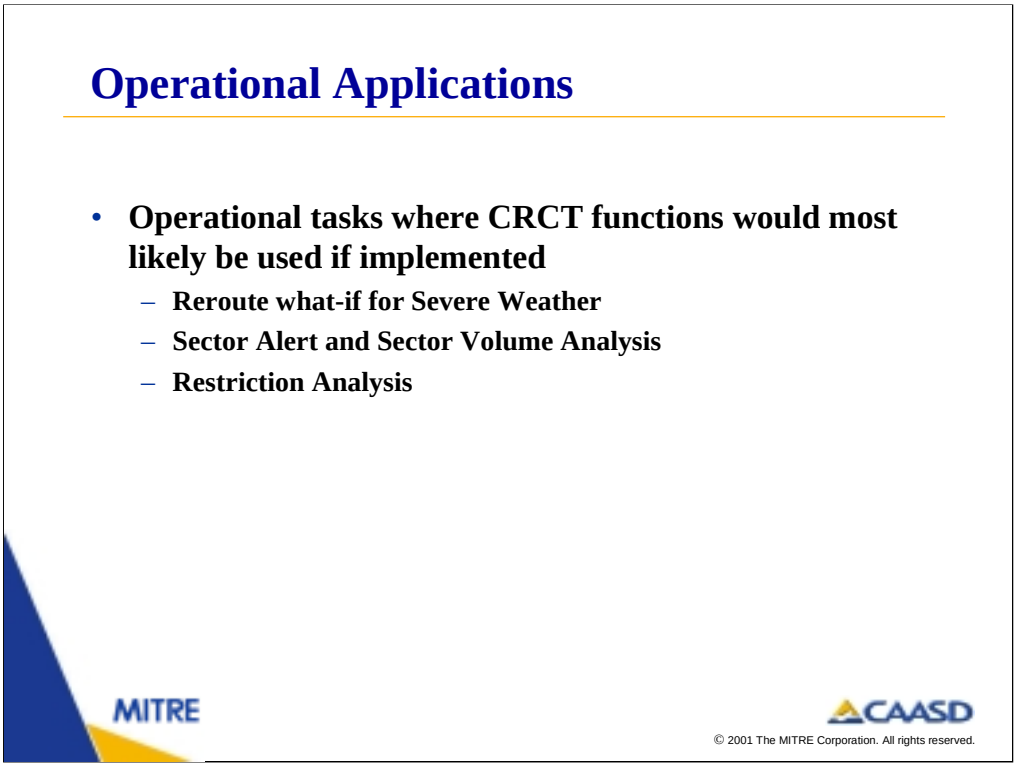
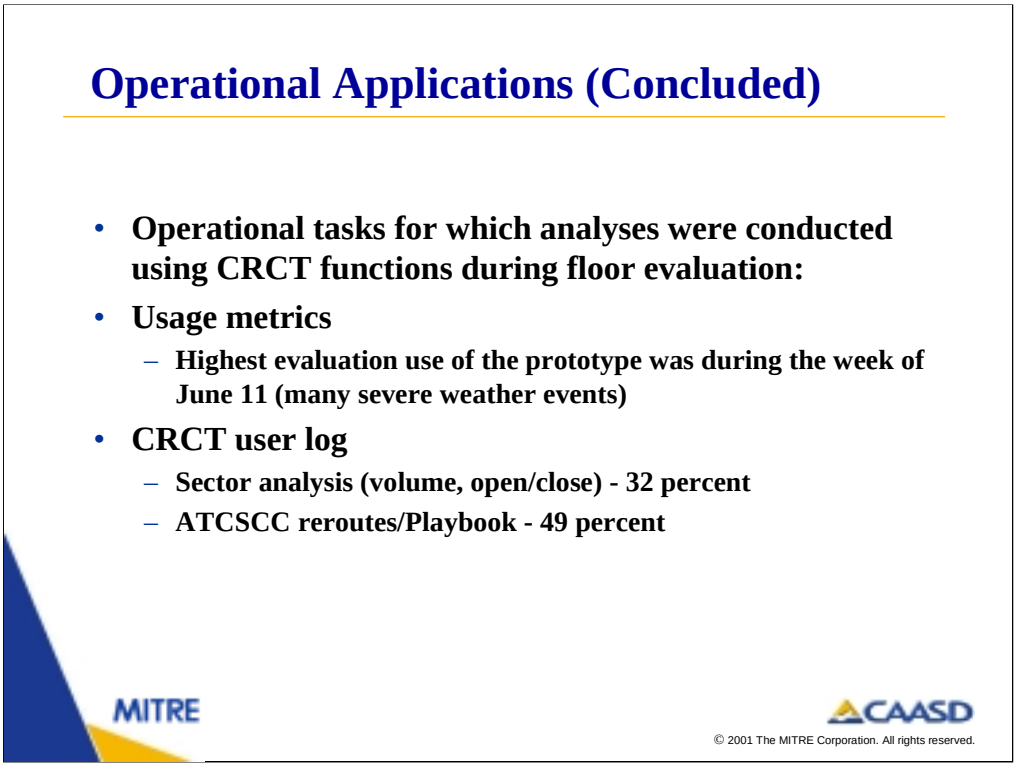


One issue surrounding the prioritization of functions to implement in ETMS is to determine which tasks and operational situations could best be supported by the prototyped functions. As shown on slides 43 through 46, evaluation of potential reroutes in severe weather situations (scenarios 1 and 6), and sector volume analysis (scenario 3) were the scenarios where it was determined, via the May interviews during the canned evaluation, that CRCT functions would be used most frequently. This finding is in agreement with (Carlson, 1999b), who found that TMCs deemed CRCT functions to be most applicable in these two types of situations. Results are fairly consistent across sites, though ATCSCC personnel rated anticipated usage slightly lower in the standard reroute (Playbook) scenario (scenario 1); comments from ATCSCC users during the real-time evaluation period suggest that certain changes to the methods for using the Playbook functionality (e.g., modifying the standard plays) are required to make this functionality useful to the Command Center. Slightly lower ratings were also observed in the airport arrival demand scenario (scenario 2). This scenario was deemed one that would be more of a local (ARTCC) concern.

The post-real-time (July) interviews bore out the conclusions regarding operational applications: as can be seen in slides 47 through 50, at all sites the tasks in which CRCT functions were most examined during the real-time evaluation included those involving severe weather (planning/assessing severe weather strategies; SWAP) and sector alerts/sector demand. In addition, the same slides show that "evaluating need for proposed restriction," one of the "new uses" of CRCT capabilities named by (Carlson, 1999b) was among the highest-rated tasks in terms of frequency of use of CRCT capabilities. These situations received the highest frequency ratings at all sites, though at ATCSCC, the weather situations were the highest of all, while at ZID and ZKC the sector issues were the highest. These slight differences reflect the different roles at the ARTCCs and ATCSCC.

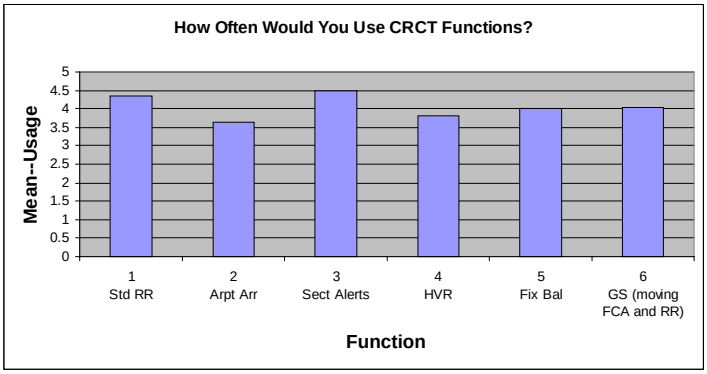
The high frequency ratings for restriction evaluation do not correspond to the lower ratings in the canned evaluation for the Historically Validated Restriction (HVR) scenario (scenario 4) but it is concluded that it was only after gaining experience with the CRCT functions that TMCs recognized the functions' full utility for restriction analysis.



Additional information regarding operational applications came from the reported and measured use of the system for evaluation during the real-time period. Sample analyses of these data sources, shown on slides 51 and 52, support the notion that the tasks most supported by the functions evaluated in CRCT, are sector volume issues and response to severe weather using Playbook plays and other reroutes. More detailed analysis of these data will be reported in future papers.

CRCT Functions, Anticipated Frequency of Use, All Sites

When encountering a situation like this in the future, how often do you expect you will use CRCT functions?
1 = not at all, 2 = seldom, 3 = occasionally, 4 = somewhat often, 5 = very often



Overall Mean Frequency Rating

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Legend (slides 43 through 46):

1-Standardized Reroutes from Playbook

2-Airport Arrival Demand

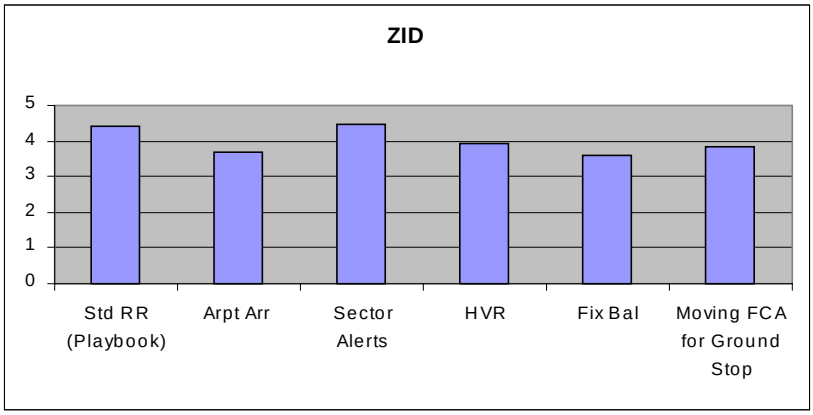
3-Sector Alerts

4-Assessing need for HVR (Historically Validated Restriction)

5-Arrival Fix Balancing

6- Assessing need for Ground Stop with Moving FCA and Rerouting

CRCT Functions, Anticipated Frequency of Use, ZID



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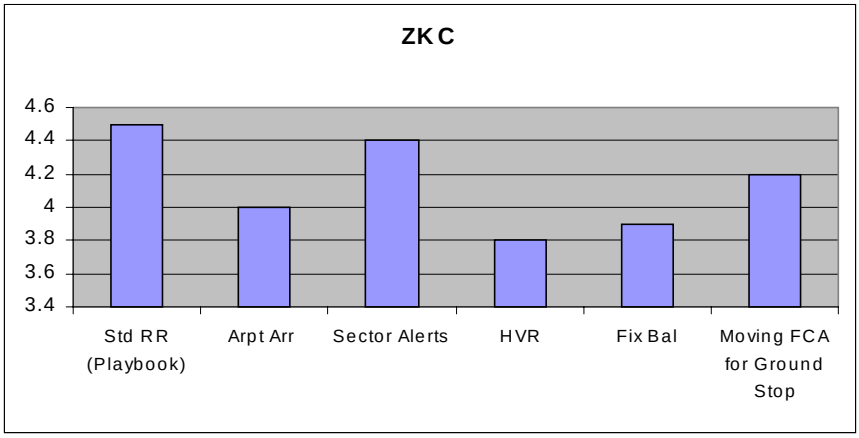
CRCT Functions, Anticipated Frequency of Use, ZKC



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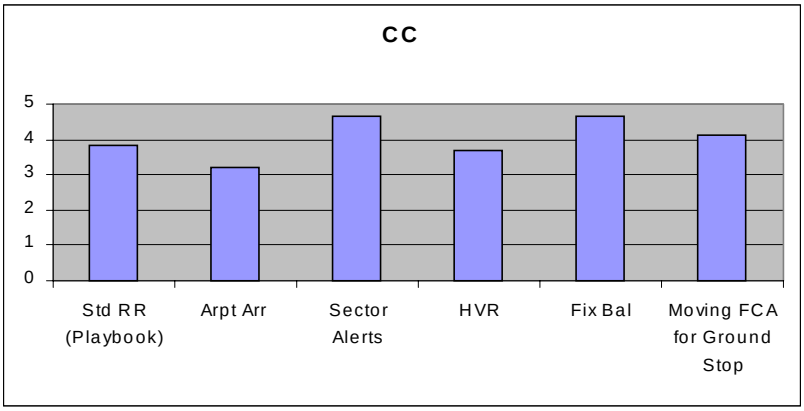
CRCT Functions, Anticipated Frequency of Use, ATCSCC



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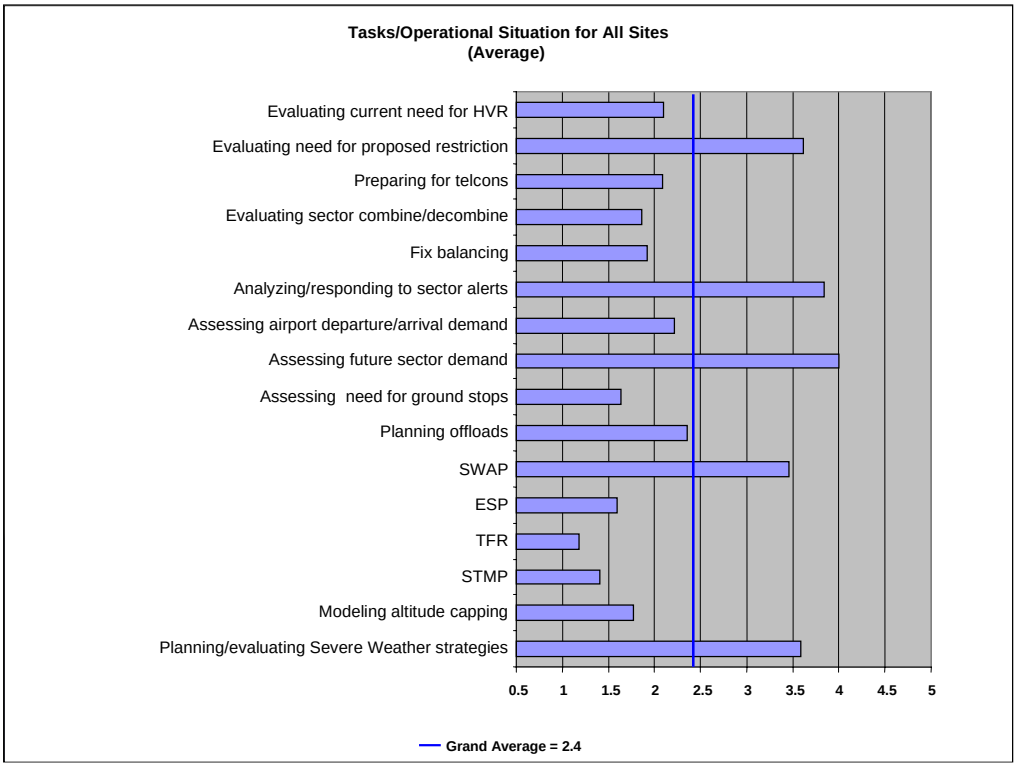
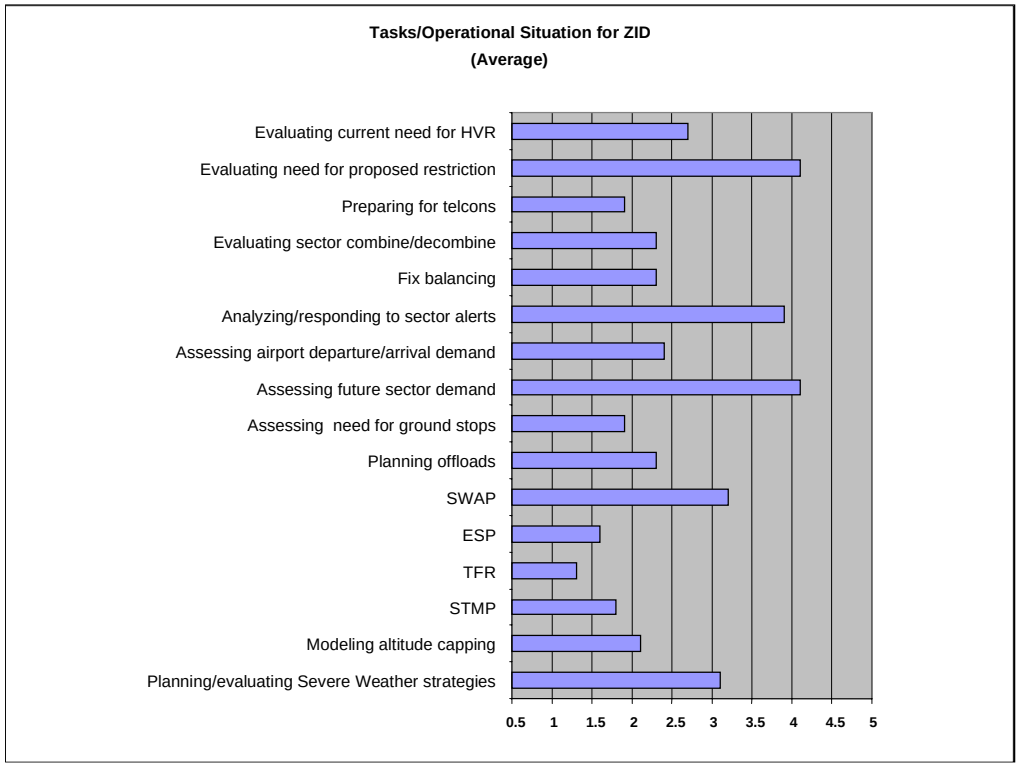


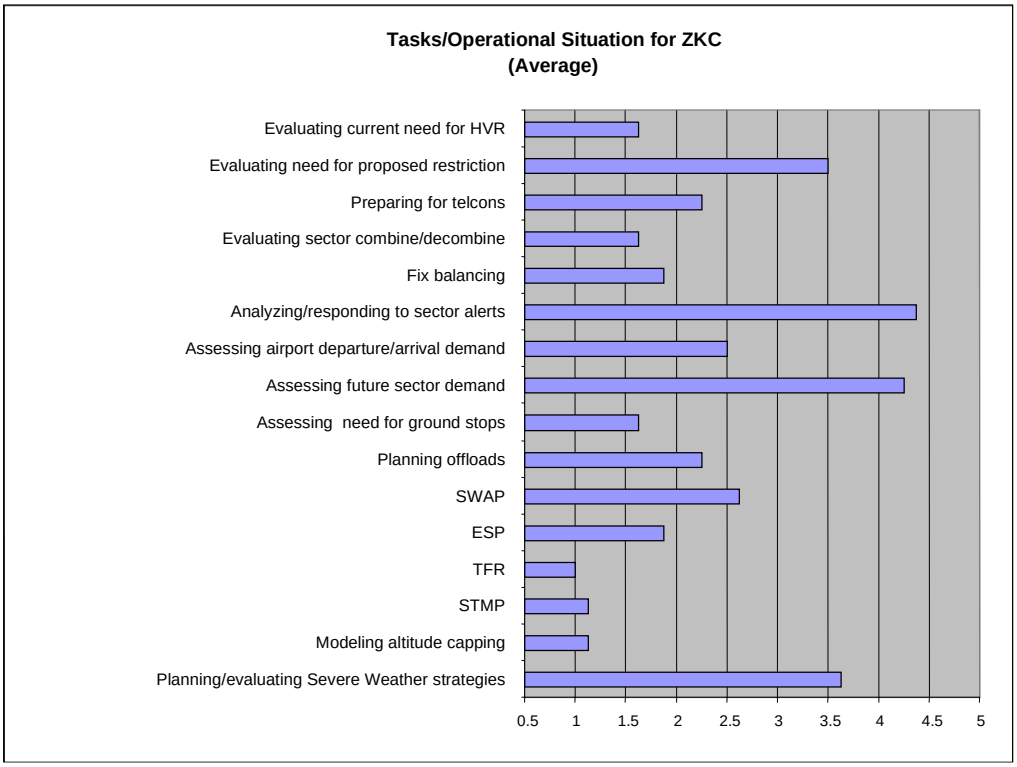
Tasks/Operational Situation, All Sites

For which tasks or operational situations did you use the CRCT functions? How frequently?

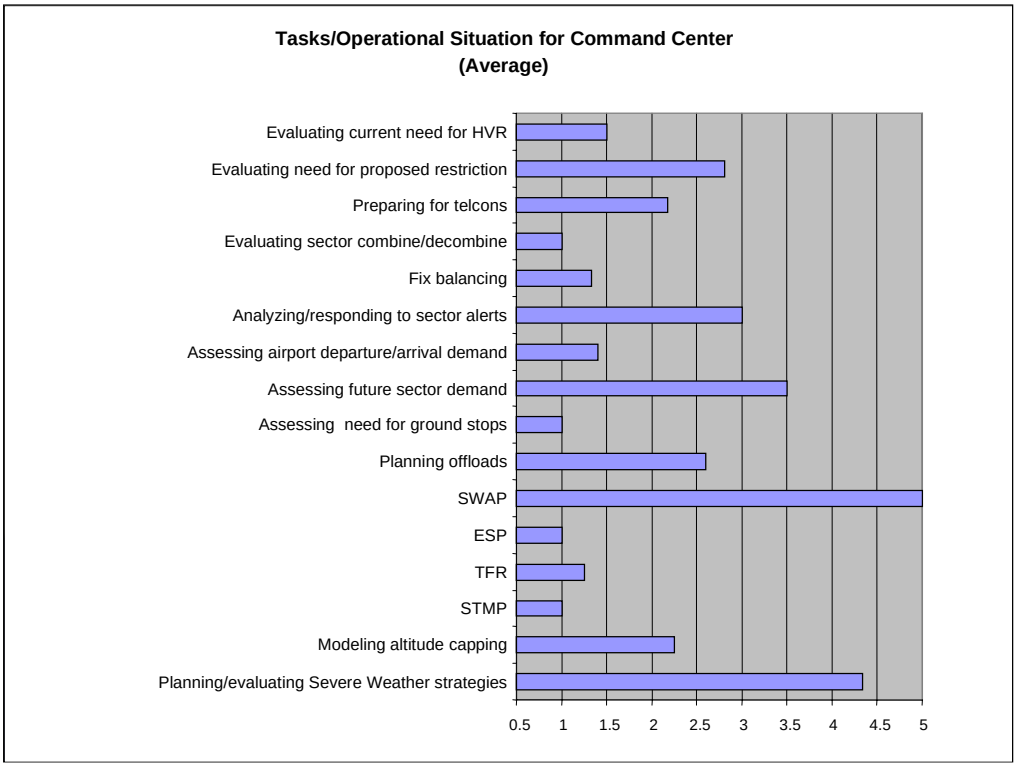
1 = not at all, 2 = seldom, 3 = occasionally, 4 = somewhat often, 5 = very often



Tasks/Operational Situation, ZID

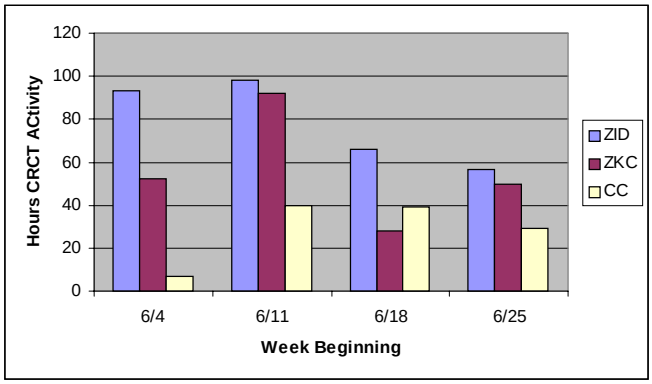


Tasks/Operational Situation, ZKC



Tasks/Operational Situation, ATCSCC

Usage of CRCT Functions for Evaluation, by Week



Notes:

•"CRCT Activity" = workstation interacted within TMU at least every 30 minutes during the hour

•ATCSCC results not comparable to ARTCCs (one system available at ATCSCC and two at ARTCCs; different job functions). Data are to illustrate general usage levels.

•Week of June 11 contained many severe weather events

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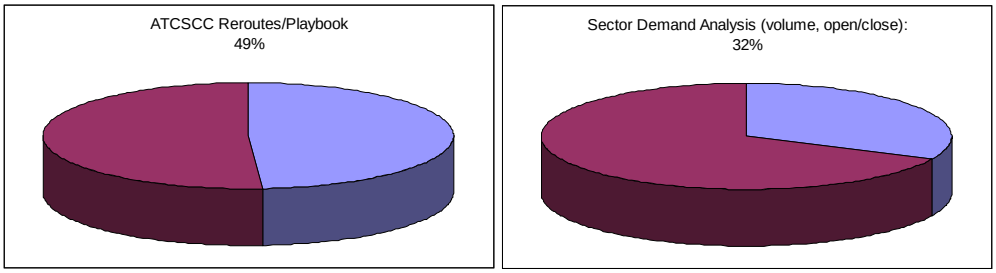
Events Analyzed with CRCT Functions



Notes:

•Data source is On-screen Log

•Majority of data come from ZID

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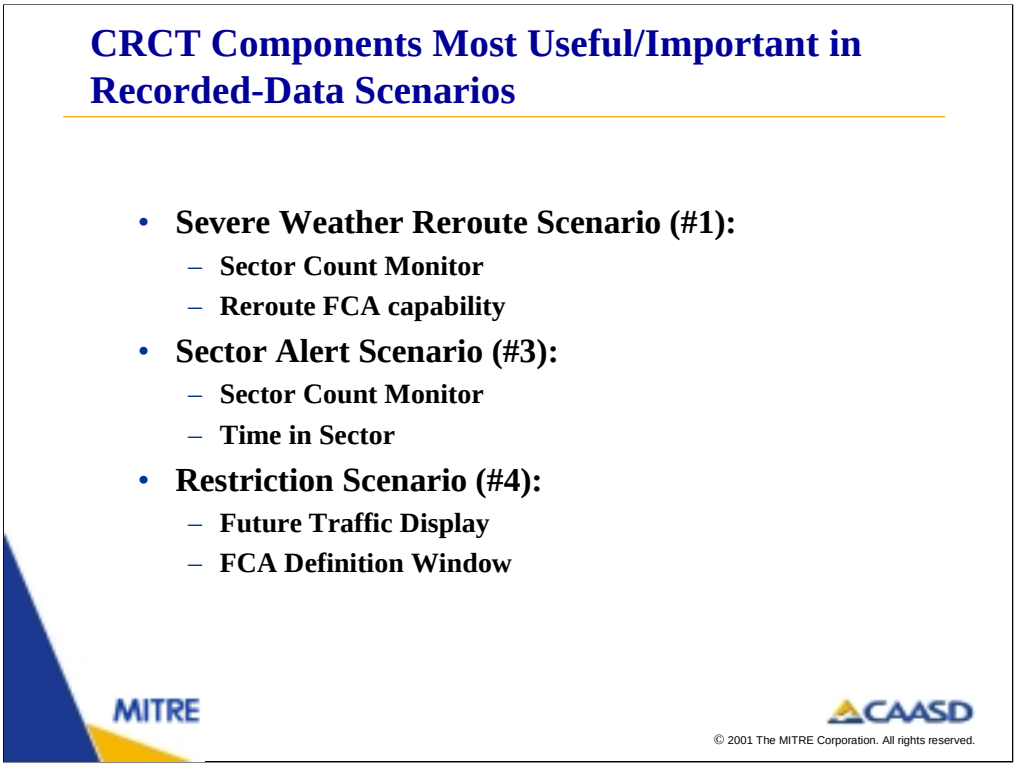
Illustrated above are the events most commonly analyzed with CRCT functions, according the the CRCT on-screen Log. The following Log comments from ZID are illustrative of the types of situations for which CRCT capabilities could be used:

•TMC modeled NO-J6-1 Playbook play and found that "If we implement this playbook, with some modifications, ZID sectors 81 and 91 will have an increase in traffic and other TMU initiatives will have to be imposed due to volume. I would have told the ATCSCC that we could not accommodate both SWAPs."

•"I used the playbook function and reroute set merge to evaluate the use of two Playbook SWAPs used simultaneously. This situation actually occurred recently and I wanted to see how it looked on CRCT. I used the FL-NE3 and the NO_J42-2 Playbook SWAPS and then merged them to evaluate. No amount of MIT could save this situation from being a huge mess!"

•The CRCT Sector Count Monitor indicated that the high altitude sectors ZID88 and ZID89 "were alerted red for approximately ten minutes. Several inactive a/c (aircraft) were proposed into these sectors during the alert times. I would have advised the area supervisor in charge (ASIC) to have their low altitude sectors cap their departure traffic during this time." (This would keep the departing traffic in a lower sector, thus decreasing sector volume in ZID88 and ZID89).

•"CRCT data supported (the need for an) MIT restriction from ZOB on PHL LTFC (traffic landing at PHL). The data did not support (the need for) passing anything back to ZAU or ZKC. I was able to determine this in about a minute…very quick."

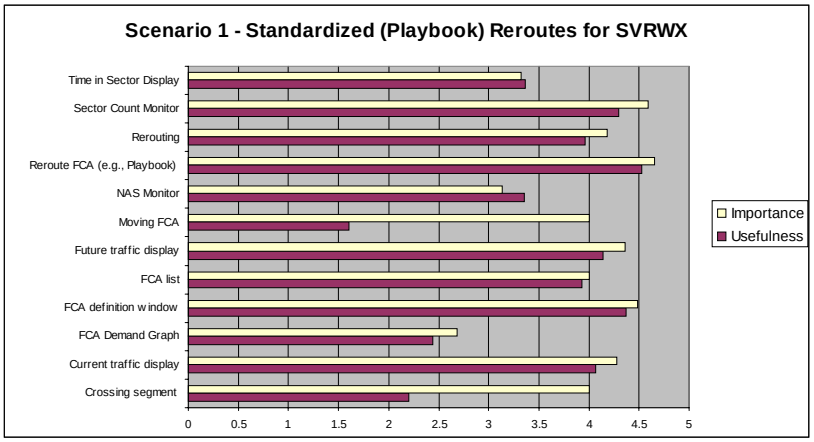


Using the preceding information about what the primary applications (i.e., tasks) for CRCT functions would be, the canned scenarios corresponding to each of these tasks were examined to determine which CRCT functions were deemed the most useful and important for each of these scenarios. Both scenarios 1 and 6 involve rerouting for severe weather. Scenario 1 was chosen for this part of the analysis, because it was rated higher on the anticipated use of CRCT functions. Also, in real operations the events depicted in this scenario would have more impact on the NAS, being a larger-scale reroute (national Playbook instead of departures from a single airport as in scenario 6). The highest-rated functions are listed above and illustrated graphically along with all functions, on the next three slides.

CRCT Component Usefulness/Importance Standardized Reroute Severe Weather Scenario, All Sites

In this scenario, how useful was each of the listed CRCT functions for your decision making (i.e., how much did the function, as implemented in CRCT, assist you in making a decision)?
1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful

And, how important was each of the listed CRCT functions (i.e., how important is it that this function be implemented)? 1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = quite important, 5 = very important



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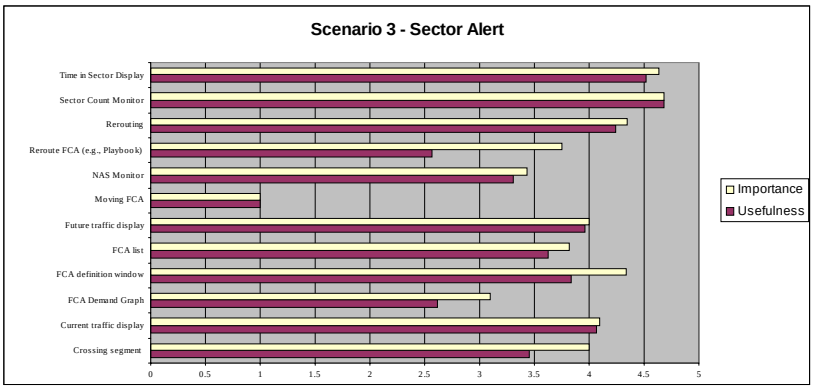
CRCT Component Usefulness/Importance Sector Alert Scenario, All Sites

In this scenario, how useful was each of the listed CRCT functions for your decision making (i.e., how much did the function, as implemented in CRCT, assist you in making a decision)?
1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful

And, how important was each of the listed CRCT functions (i.e., how important is it that this function be implemented)? 1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = quite important, 5 = very important



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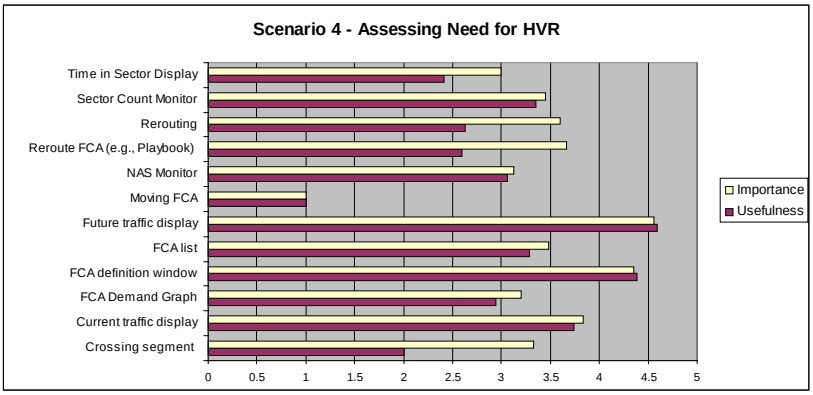
CRCT Component Usefulness/Importance
Historically Validated Restriction Scenario, All Sites

In this scenario, how useful was each of the listed CRCT functions for your decision making (i.e., how much did the function, as implemented in CRCT, assist you in making a decision)?
1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful

And, how important was each of the listed CRCT functions (i.e. how important is it that this function be implemented)? 1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = quite important, 5 = very important



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Importance and Usage of All CRCT Functions

- **Future Traffic Display is rated highly on all three factors at all three sites, but especially ARTCCs**
- **FCA functions, and Playbook functions, are useful and frequently used at all sites (Playbook frequency is especially high at ATCSCC)**
- **Sector Count Monitor is rated highly at ARTCCs on all three factors, and receives some high usefulness ratings at ATCSCC despite lower usage**

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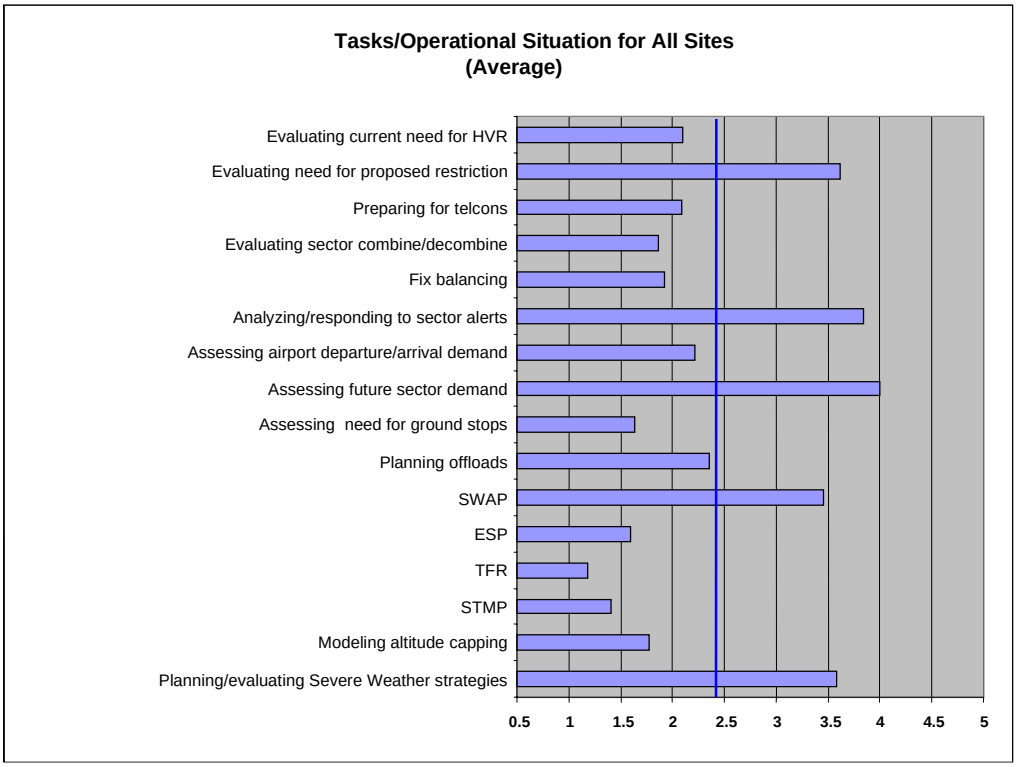
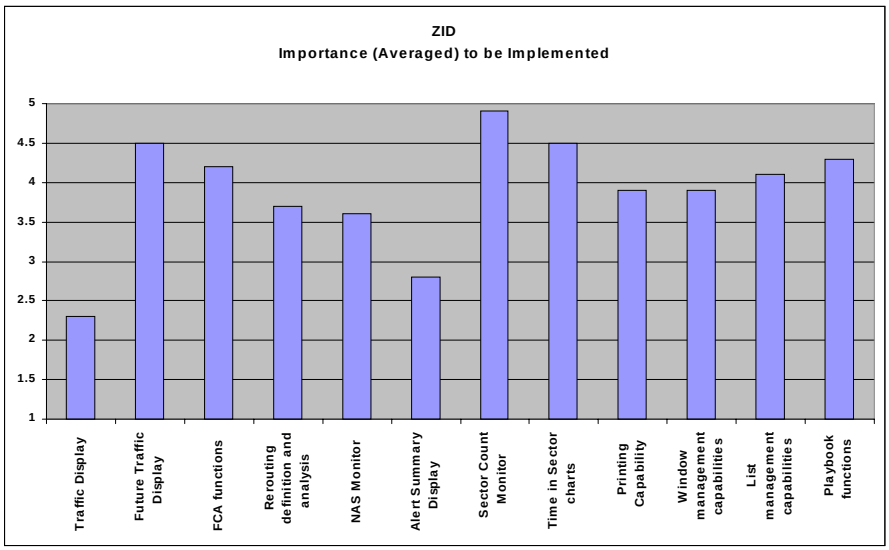
Although this evaluation focused on the reroute what-if functions, additional data were collected on other functions, such as the sector volume analysis tools, and refinements to the FCA capability. The following slides, 58 through 70, illustrate the results regarding reported or recorded usage of the capabilities prototyped on the CRCT platform; a summary of the findings is shown above.



Average Function Importance Rankings, All Sites

In your opinion, how important is it that the CRCT functions listed below be implemented in ETMS (i.e, priority for implementation)?: 1 = not at all, 2 = slightly important, 3 = moderately important, 4 = quite important, 5 = very important

Function Importance Rankings, ZID



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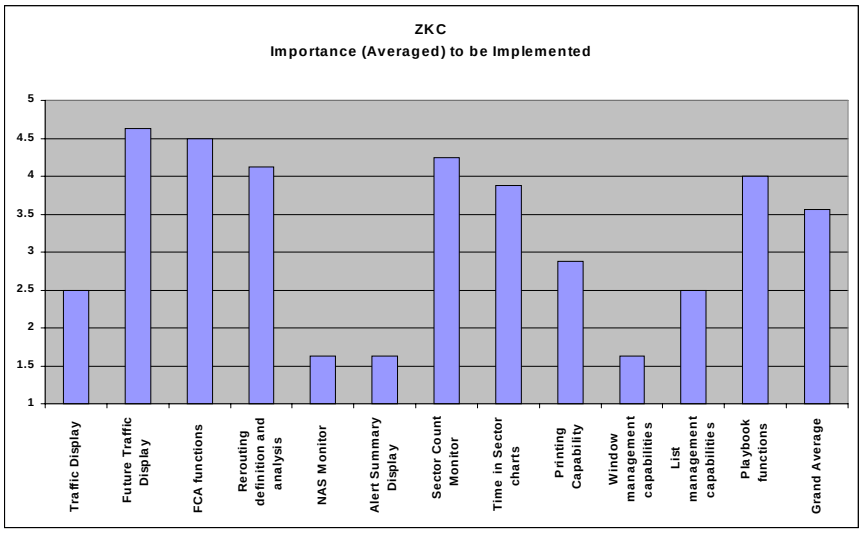
Function Importance Rankings, ZKC



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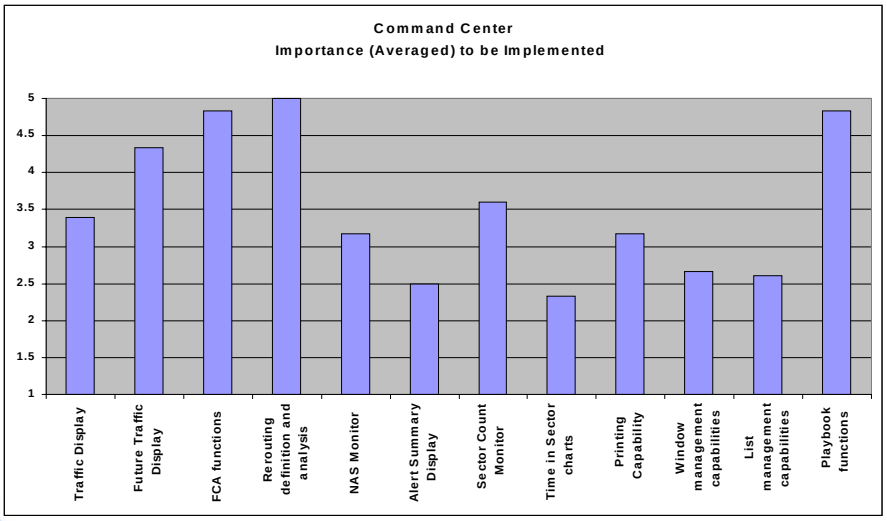
Function Importance Rankings, ATCSCC



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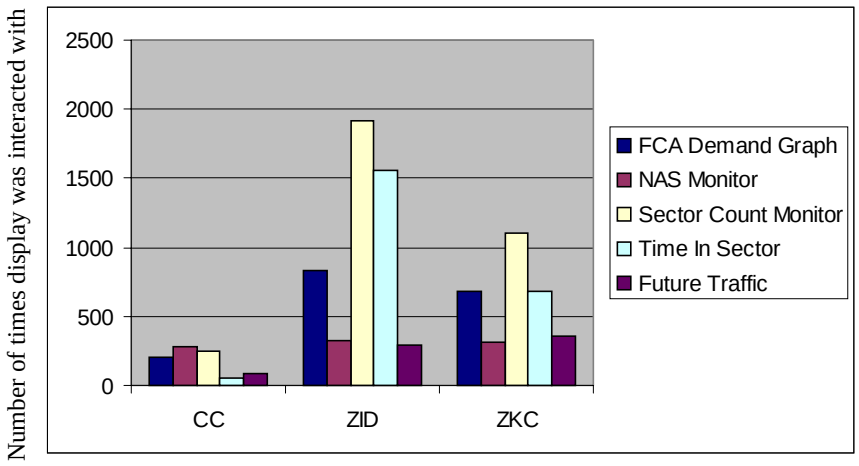
Recorded Frequency (From Usage Metrics Utility), June–July 2001



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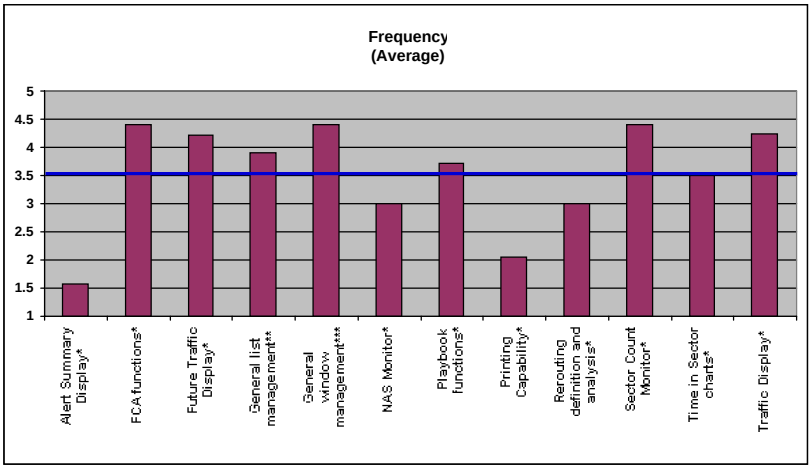
Average Rating of Frequency, All Sites

How frequently did you use the listed CRCT functions? 1 = not at all, 2 = seldom, 3 = occasionally, 4 = somewhat often, 5 = very often



* Overall
** (e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)
— Overall Mean Frequency Rating = 3.5

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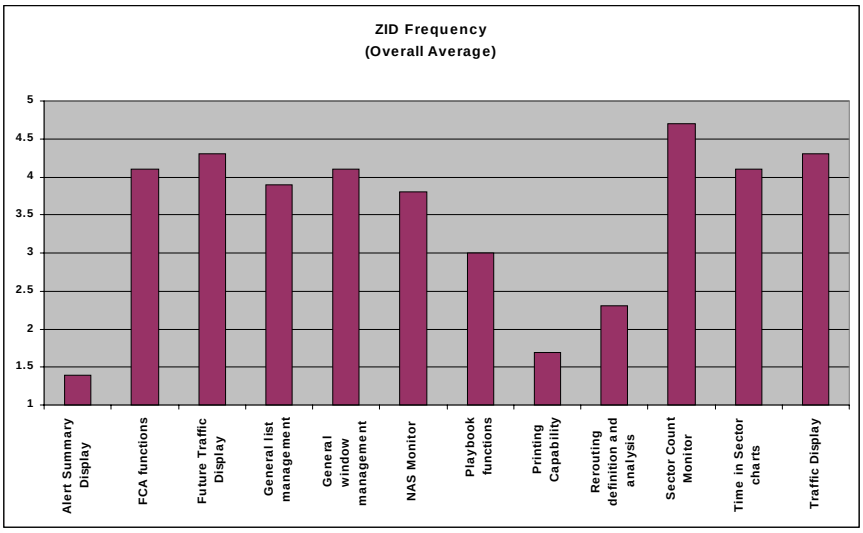
Rating of Frequency, ZID



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

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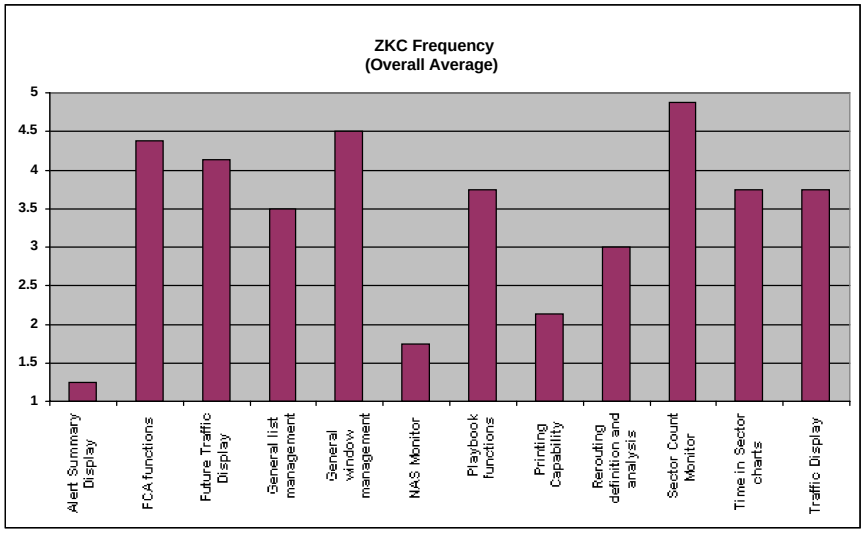
Rating of Frequency, ZKC



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

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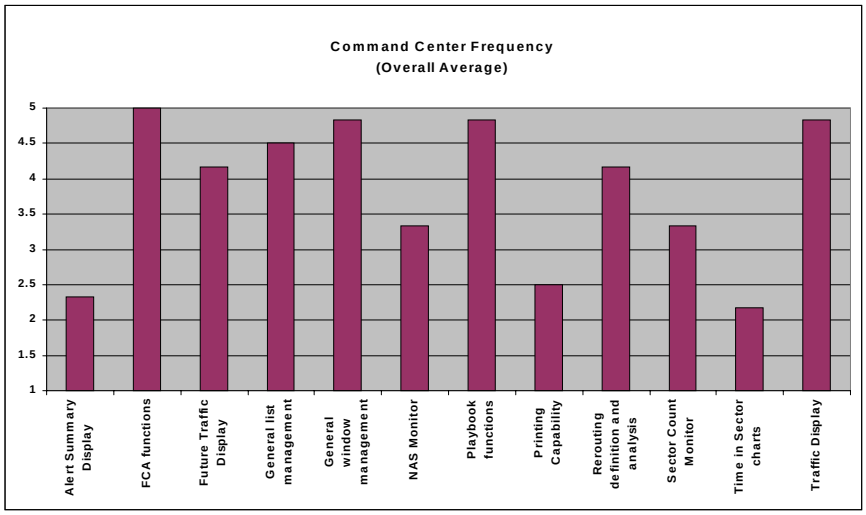
Rating of Frequency, ATCSCC



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

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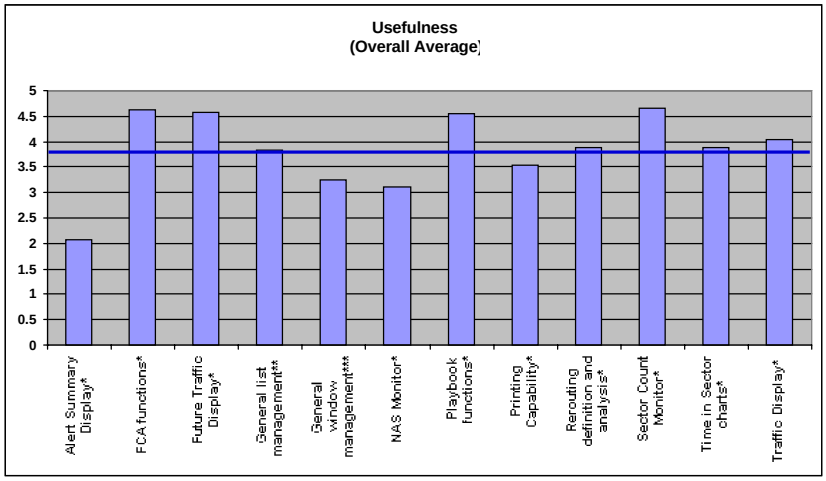
Average Rating of Usefulness, All Sites

How useful was each of the listed CRCT functions (i.e., how much did the function, as implemented in CRCT, assist you in your analysis and/or decision making)? 1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = quite useful, 5 = very useful



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)
Overall Mean Usefulness Rating = 3.8

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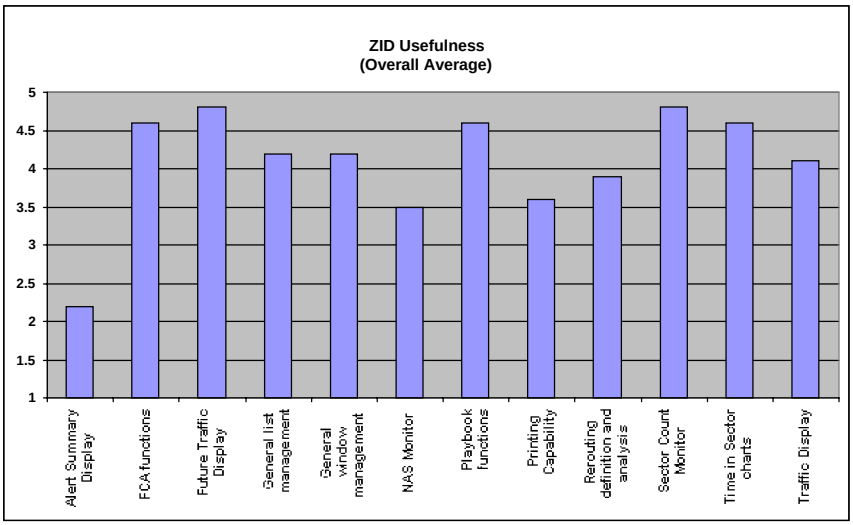
Rating of Usefulness, ZID



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

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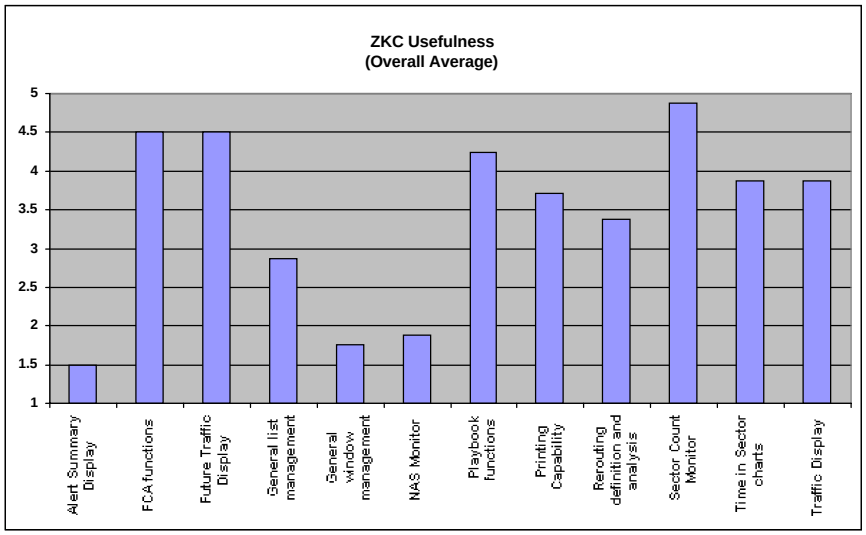
Rating of Usefulness, ZKC



*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

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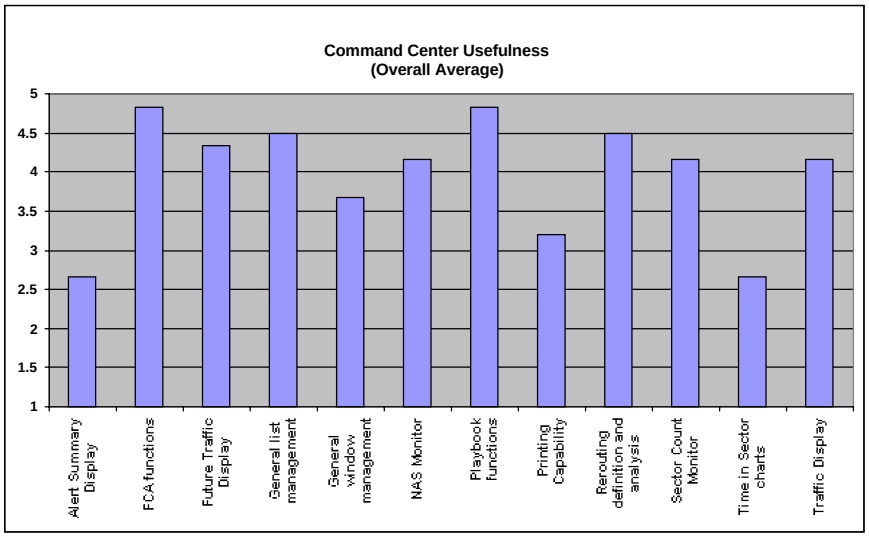
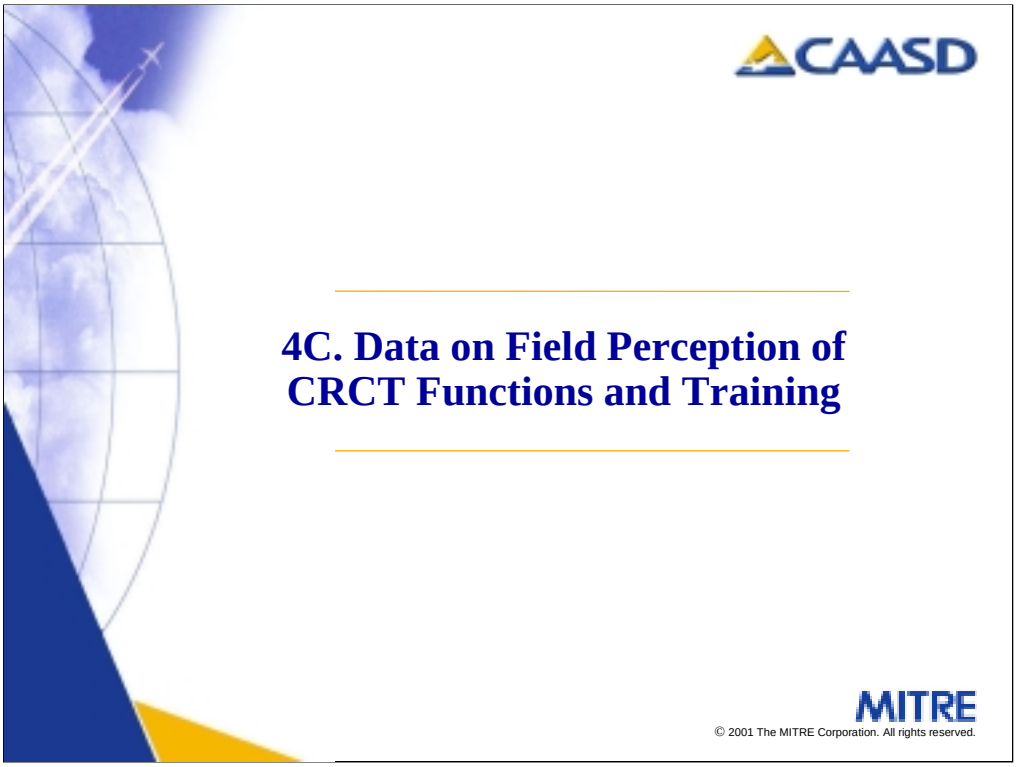
Rating of Usefulness, ATCSCC

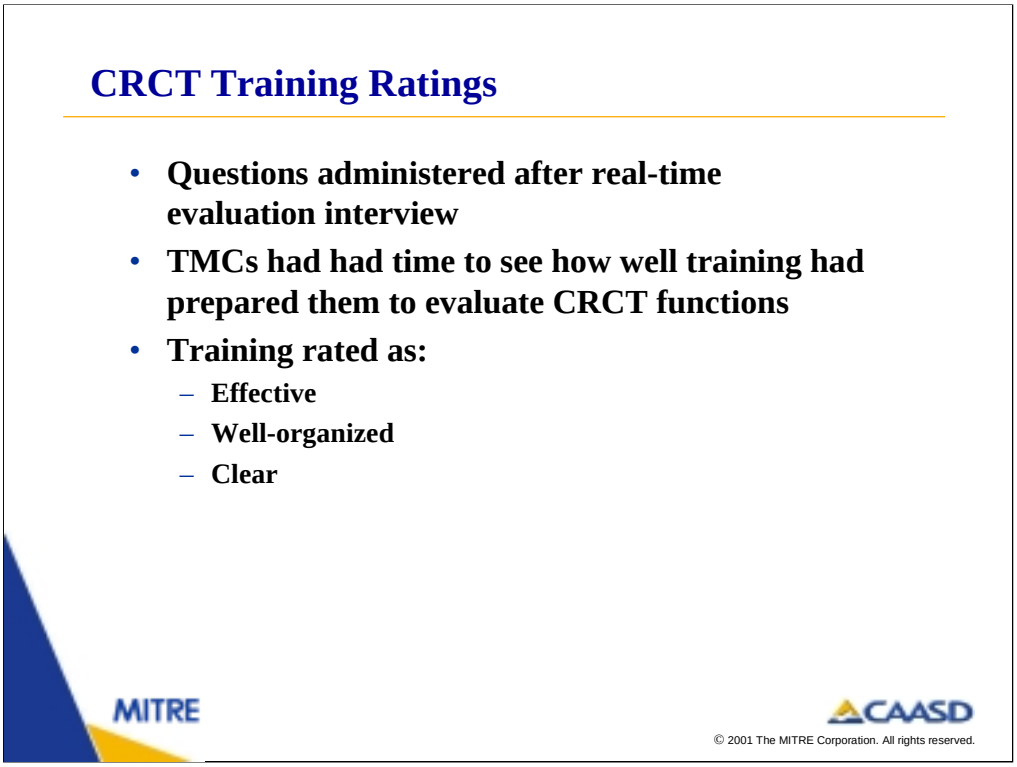


*Overall
**(e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)
*** (e.g., switching between windows, bringing desired window into view)

MITRE CAASD

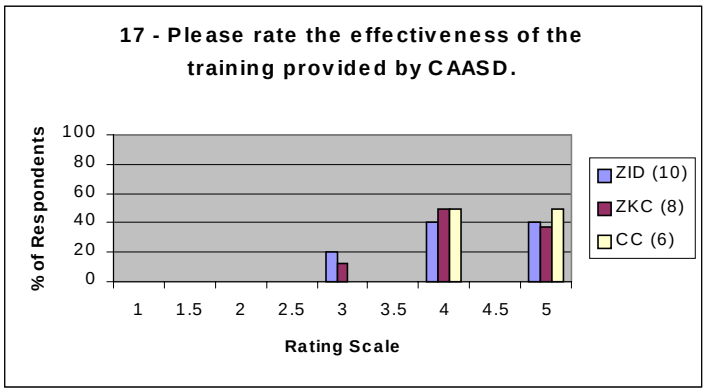


This section details findings from the evaluation interviews regarding the more general perceptions of the effects that CRCT functions could have on the TMC job and the TFM environment if implemented. The section begins with TMCs' perception regarding the training they received for using CRCT during the evaluations, continues with coverage of the confidence invested in CRCT's predictive information, followed by the general perceived effects on TFM of the capabilities prototyped in CRCT, and finally, the effects of the capabilities on communication and collaboration.



The following three slides illustrate the results of the evaluation questions administered at the end of the real-time evaluation period. The questions were administered at this time instead of immediately following training because by then, participants had had the opportunity to use CRCT for the real-time evaluations, and would have a more realistic picture of how the training had prepared them to operate CRCT. The training was generally rated as effective, well-organized, and clear.

CRCT Training Ratings (Continued)



1 = very ineffective, ..., 3 = moderately effective, ..., 5 = very effective

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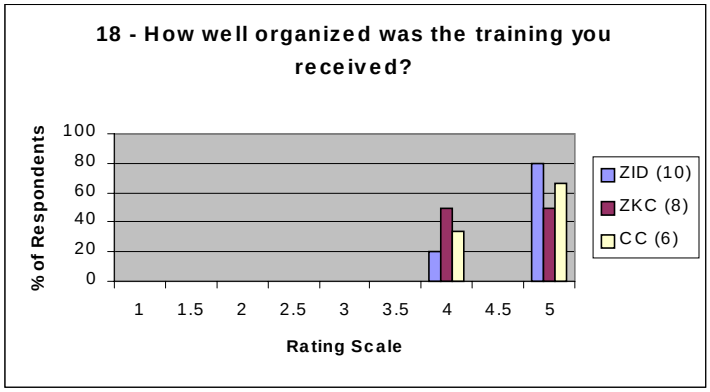
CRCT Training Ratings (Continued)



1 = very disorganized, ..., 3 = moderately organized, ..., 5 = very organized

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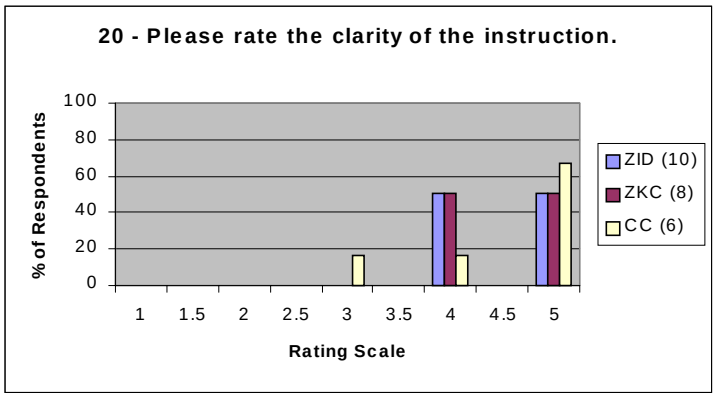
CRCT Training Ratings (Concluded)



1 = very unclear, ..., 3 = moderately clear, ..., 5 = very clear

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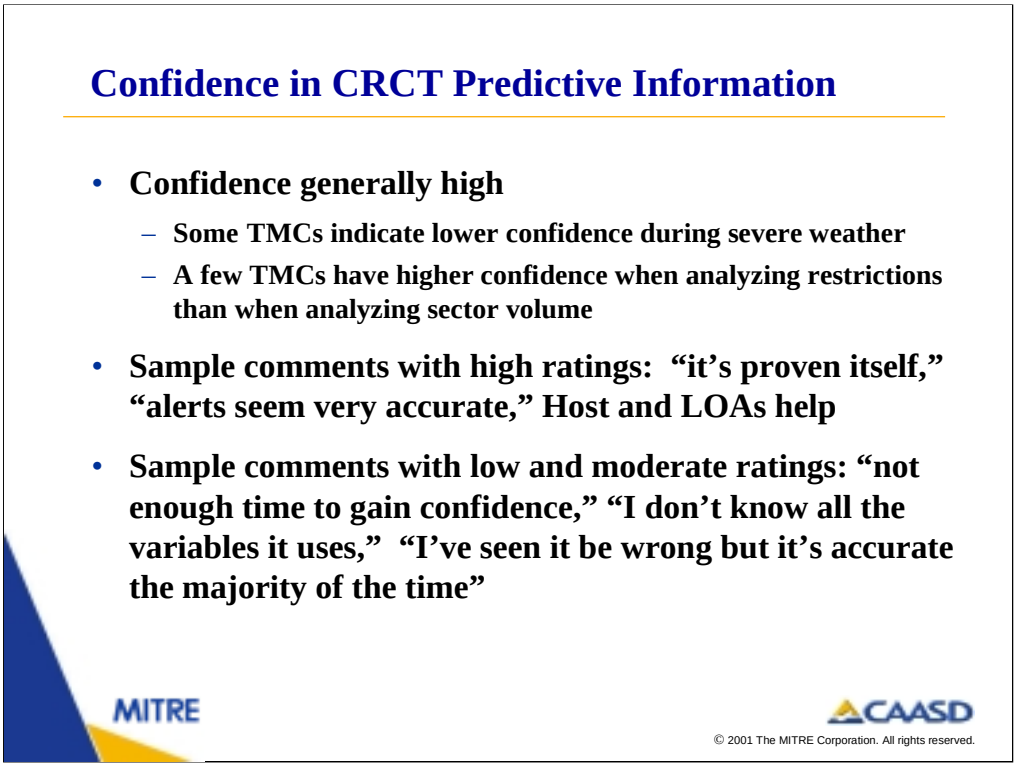


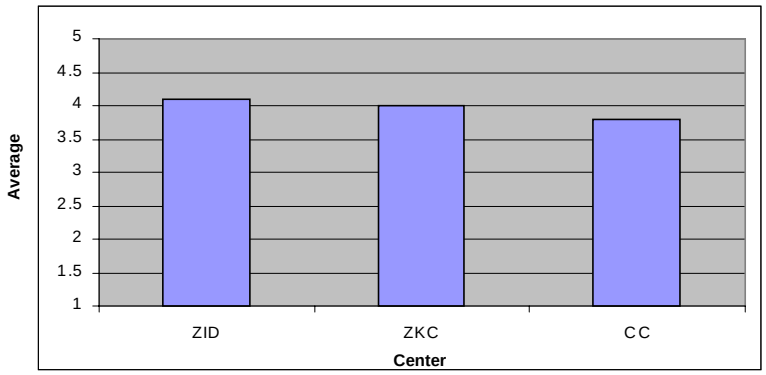
Confidence in the predictive information provided by CRCT is generally high, as seen on the next slide.

Additional questions were asked regarding whether the operational situation or the task being done affected confidence. Ten of the 24 participating TMC's indicated that confidence was lower during severe weather and/or the resulting ground stops and ground delay programs. However, some of them pointed out that this decreased confidence was not necessarily due to problems with the prediction engine, but rather resulted from the inherent unpredictability of the NAS in these situations. A few TMC's reported higher confidence when analyzing restrictions than when analyzing sector volume, because of the inherently more predictable nature of whether a flight will cross a given facility boundary or arrive at a specific airport, whereas with sector volume issues, more variables are required to know which flights will traverse which sectors, and when.

A sample of general comments regarding perceived CRCT prediction performance are shown above.

Confidence in CRCT Predictive Information (July Follow-Up Evaluation)

In general, how much confidence do you have in the predictive information provided by CRCT? 1 = very little, 2 = slight, 3 = moderate, 4 = quite a lot, 5 = very much



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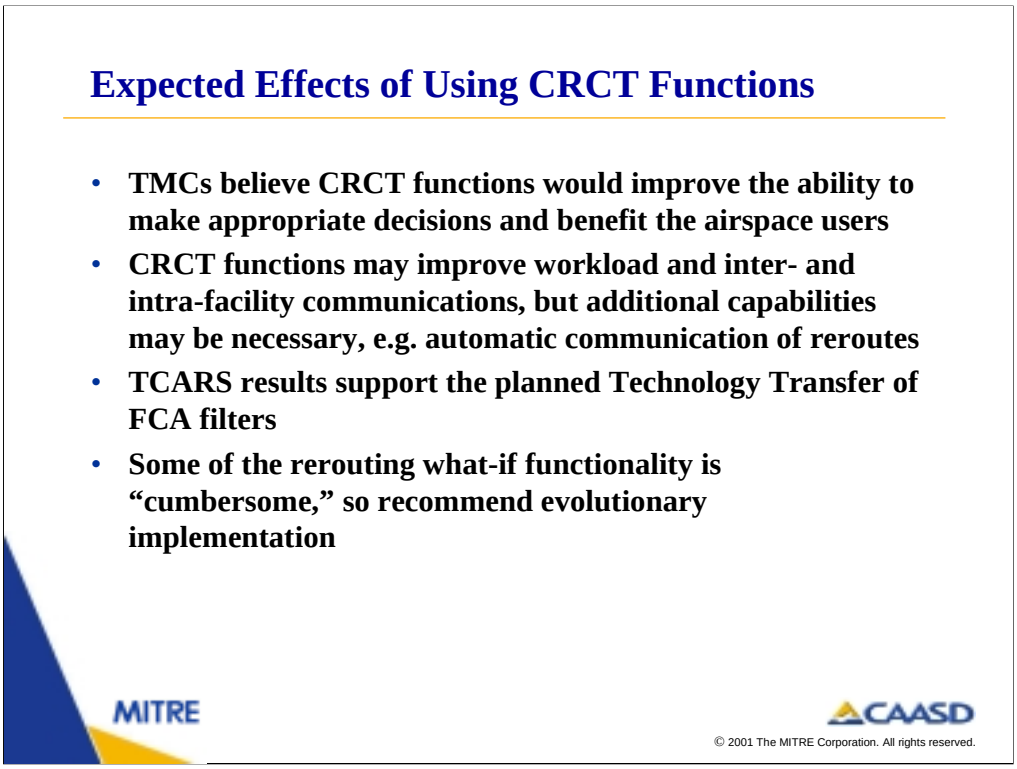


According to the interviews, TMCs believe that CRCT functions, if implemented, would improve the ability to make appropriate decisions (slide 79) and would benefit the airspace users (slide 80).

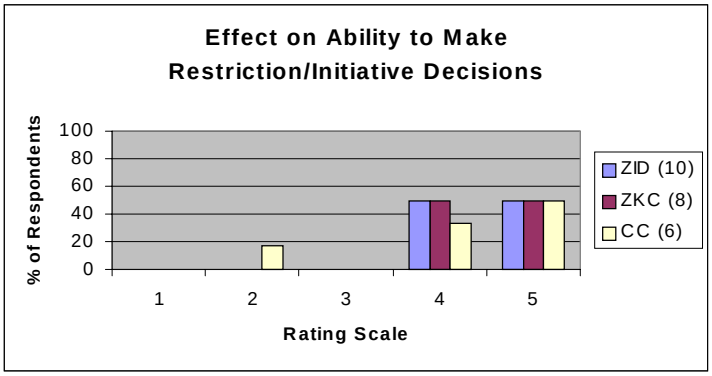
Responses varied as to whether currently-prototyped CRCT functions would improve the relationships within and between facilities (slide 81), the associated collaboration workload (slide 82), and other workload issues (slides 83 through 85). Though TMCs acknowledge some possibility of benefits on these dimensions, capabilities beyond what is currently prototyped in CRCT may be required to realize the full benefits. For instance, it may be necessary to enable automatic communication of reroutes to areas, towers, and possibly airlines—a suite of capabilities sometimes referred to as the "Go" Button. It should be noted that although the consensus appears to be that the number of restrictions and other initiatives would remain unaffected by the implementation of CRCT functions (slide 85), comments in the interviews and logs indicated that the effectiveness or appropriateness of initiatives could be improved.

TCARS results are seen on slide 86 and lead to two primary conclusions. First, prior evaluations (Barlow, 2000; Carlson, 1999b) led to the recommendation to Technology Transfer FCAs, and TCARS ratings support the planned Technology Transfer of FCA filters. Second, the rerouting what-if functionality as implemented in CRCT does not necessarily increase the acceptability of the overall TFM system. This is partly because some of the functionality is "cumbersome," a descriptor used repeatedly during the TCARS evaluation and the structured interviews. A number of comments in the main structured interview shed further light on what makes the reroute what-if capabilities "cumbersome." For example, TMCs commented on the excessive display clutter in showing aircraft involved in reroute evaluations and their original and potential new routes. Also noted were the need to make "a lot of entries" to obtain the desired information, and the difficulty of keeping track of multiple reroute sets and FCA lists and which lists were associated with each other. However, some participants acknowledged that the CRCT reroute what-if functionality could be useful given sufficient time for extensive training and practice.

In addition to the cumbersome nature of the reroute what-if functions, comments from TCARS and from the structured interview indicate that the benefit of implementing these function might be limited due to the current unavailability of capabilities (such as the aforementioned "Go" Button) that some participants deemed necessary to realize the benefits of reroute what-if analysis. These findings regarding rerouting capabilities provide additional support for the previously-stated recommendation for gradual, evolutionary implementation of rerouting capabilities.

Effect on Ability to Make Appropriate Decisions

How do you believe the use of CRCT functions would affect flow management's ability to make appropriate decisions regarding restrictions/initiatives (e.g., whether to apply initiatives and what the initiatives should be)? 1 = very much degraded, 2 = somewhat degraded, 3 = no change, 4 = somewhat improved, 5 = very much improved



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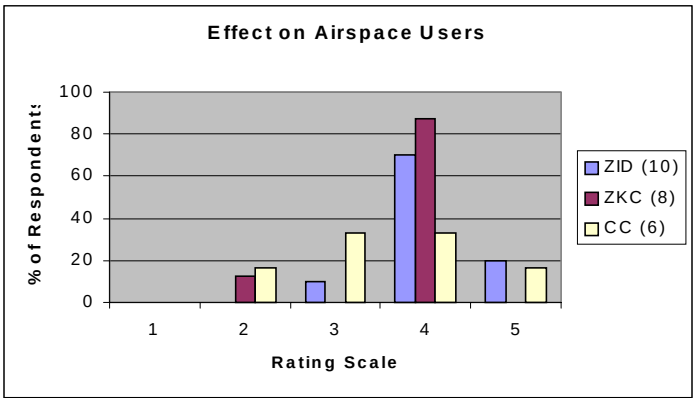
Benefit of CRCT Functions to Airspace Users

How do you believe the use of CRCT functions would affect the airspace users? 1 = very much burden, 2 = moderate burden, 3 = no change, 4 = moderate benefit, 5 = very much benefit



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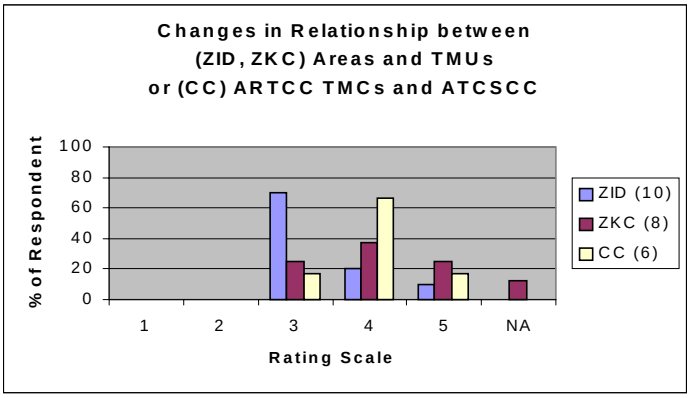
Effect on Relationships within/between FAA Facilities

If CRCT functions were implemented, what changes would occur in the relationship between Areas and TMUs (for example, would Areas' acceptance of TMU initiatives be improved)? (CC: substitute "ATCSCC" and "ARTCC TMUs" for "TMUs" and "Areas," respectively) 1 = very much degraded, 2 = somewhat degraded, 3 = no change, 4 = somewhat improved, 5 = very much improved



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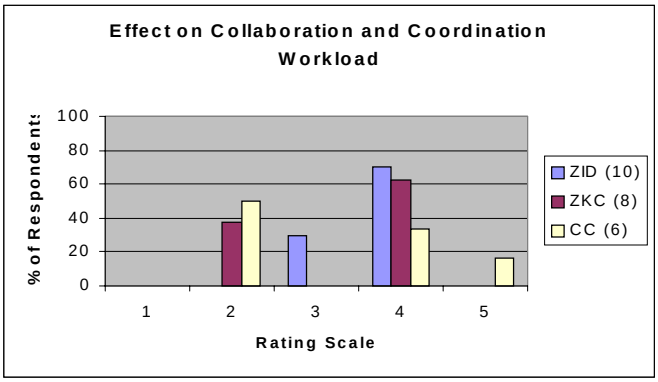
Effect on Collaboration and Coordination Workload

How would the use of CRCT functions affect your collaboration and coordination workload? 1 = much higher workload, 2 = somewhat higher workload, 3 = no change, 4 = somewhat less workload, 5 = much less workload

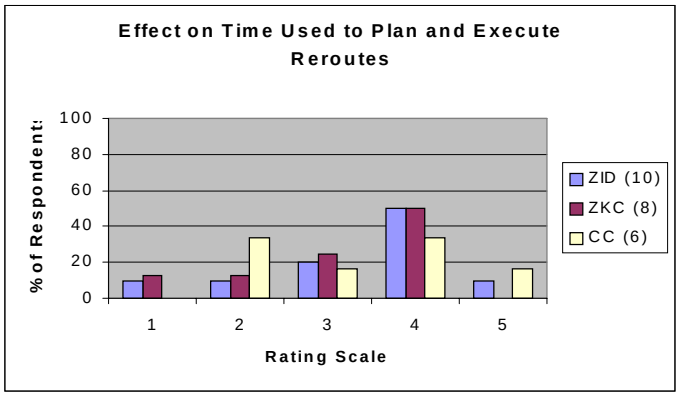


MITRE

CAASD

Effect on Time to Plan and Execute Reroutes

How would the use of CRCT functions affect the time it took to plan and execute reroutes?
1 = much more time, 2 = somewhat more time, 3 = no change, 4 = somewhat less time,
5 = much less time

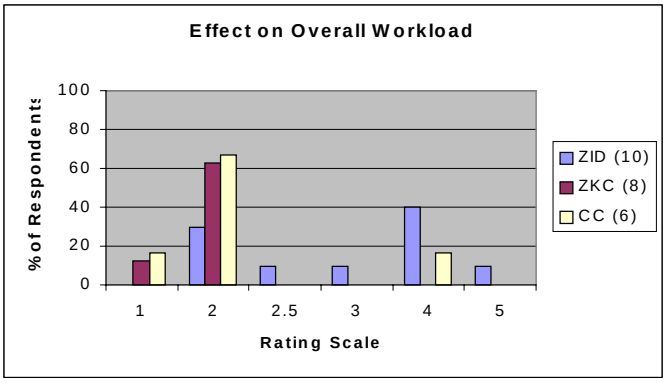


MITRE

CAASD

Effect on Overall Workload

How would the use of CRCT functions (in particular, interacting with the workstation) affect your overall workload? 1 = much higher workload, 2 = somewhat higher workload, 3 = no change, 4 = somewhat less workload, 5 = much less workload

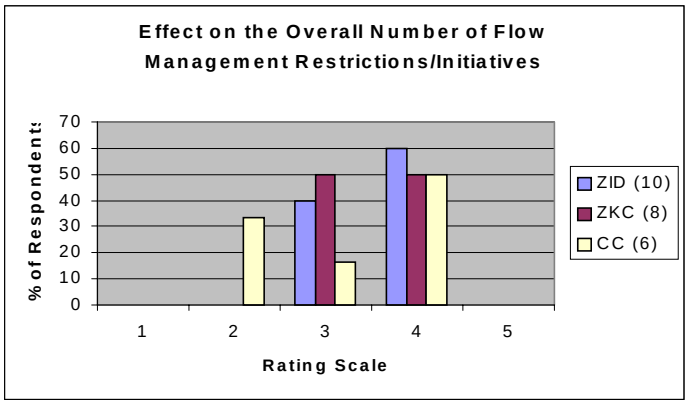


MITRE

CAASD

Effect on the Overall Number of Flow Management Restrictions/Initiatives

How do you believe the use of CRCT functions would affect the overall number of flow management restrictions/initiatives? 1 = many more, 2 = somewhat more, 3 = no change, 4 = somewhat fewer, 5 = much fewer



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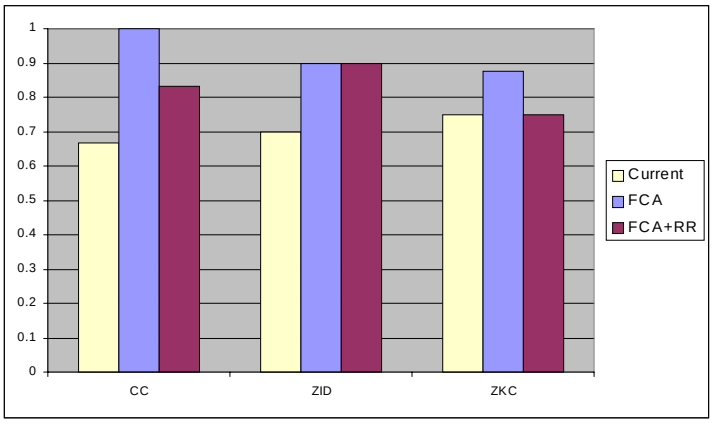
TCARS



Percent responding higher than 6 (i.e., system is satisfactory/acceptable or only moderate compensation is required for desired performance)

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This slide illustrates the percentage of respondents assigning a TCARS rating of greater than six at each of the sites for each of the three TCARS ratings (see TCARS scale and instructions, Appendix E). Ratings greater than six indicate that the overall TFM system composed of TMU personnel, their decision support tools, and other personnel and tools affecting TFM, is generally considered satisfactory/acceptable, or that only moderate compensation is required for desired performance.

The participating TMCs generally find the current TFM system acceptable, although compensation is needed according to some of the respondents. Implementing the remainder of the FCA filtering capabilities is judged to improve the acceptability of the TFM system, which provides some validation for the current plan for implementing these capabilities in ETMS 7.3.

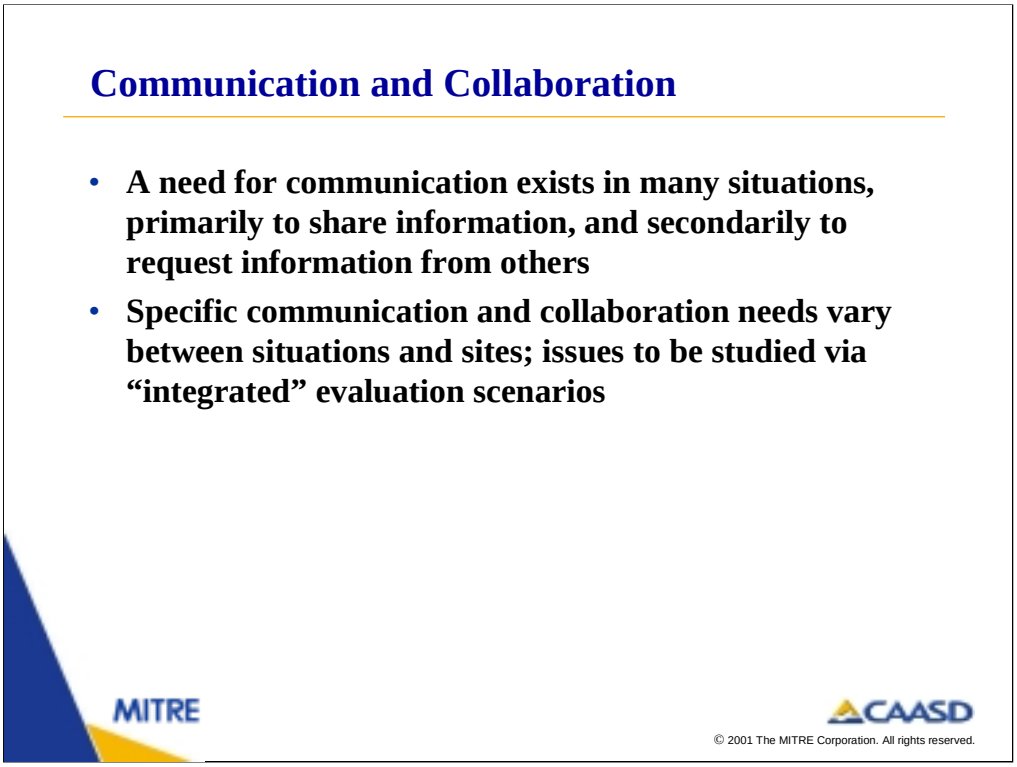
Implementing the CRCT rerouting capabilities generates mixed results regarding system acceptability. Although some participants believe the rerouting capabilities as prototyped in CRCT would increase the acceptability of the overall TFM environment, others indicate that the acceptability of the system would actually be lower than the "current + FCA" situation, if the rerouting capabilities were implemented. The comments provided during the TCARS ratings cast some light on these mixed results.

Sample favorable comments (from TMCs whose TCARS went up from "Current" to "FCA," and from "FCA" to "FCA+Rerouting") include:

> "(currently) to make a properly informed decision would take a lot of counting and adding and still wouldn't be very accurate…rerouting functions would take *most* of guesswork out." "rerouting functions would help to validate decisions and implement actions."

Sample unfavorable comments (from TMCs whose FCA+Rerouting rating was lower than their FCA rating):

> "Need the whole rerouting package in ETMS - including Sector Count Monitor for impact assessment."…"Rerouting is too cumbersome. Way too many lines on the traffic display. Need better way to manage reroute sets."…"need ability to rearrange filter groups."

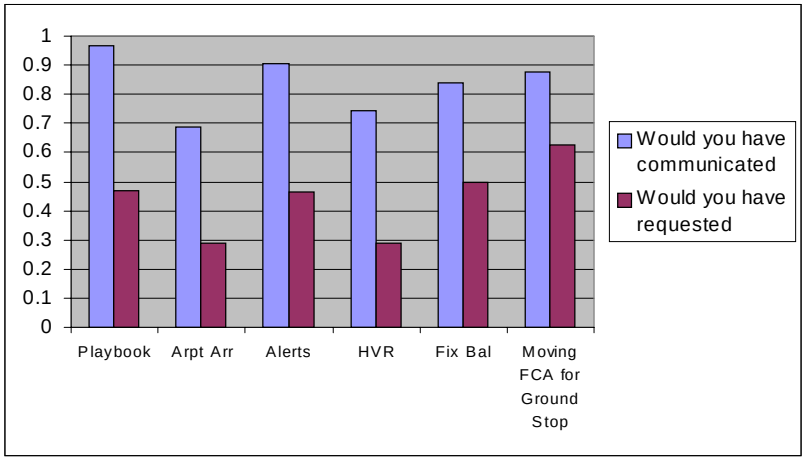


In the canned evaluation, after each pre-recorded scenario, TMCs were asked about needs for sharing/requesting information in this type of scenario. As seen in slides 88 through 91, the need for communication exists in many of the scenarios studied, especially to share information, and to a lesser but notable extent, to request information from others (as might be expected given their role, ATCSCC personnel are more likely than ARTCC personnel to report that they would request information). It can be seen on the following slides that specific communication and collaboration needs vary between situations and sites; these differences are being used to inform the design of collaborative or "integrated" evaluation scenarios to explore protocols for sharing information between FAA facilities and between the FAA and airspace users, under different conditions. The outcome of these collaboration studies will be reported in future papers.

Information Sharing, All Sites

In this scenario, would you have communicated CRCT information to others at your facility, and/or another facility?

In making a decision during this scenario, would you have requested information from other facilities?



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Legend (slides 88 through 91)

1-Standardized Reroutes from Playbook

2-Airport Arrival Demand

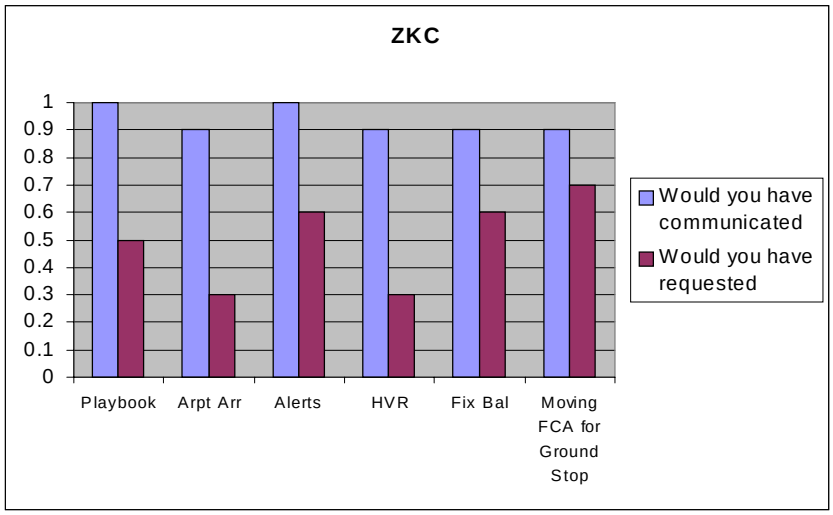
3-Sector Alerts

4-Assessing need for HVR

5-Arrival Fix Balancing

6-Assessing need for Ground Stop with Moving FCA and Rerouting

Information Sharing, ZKC



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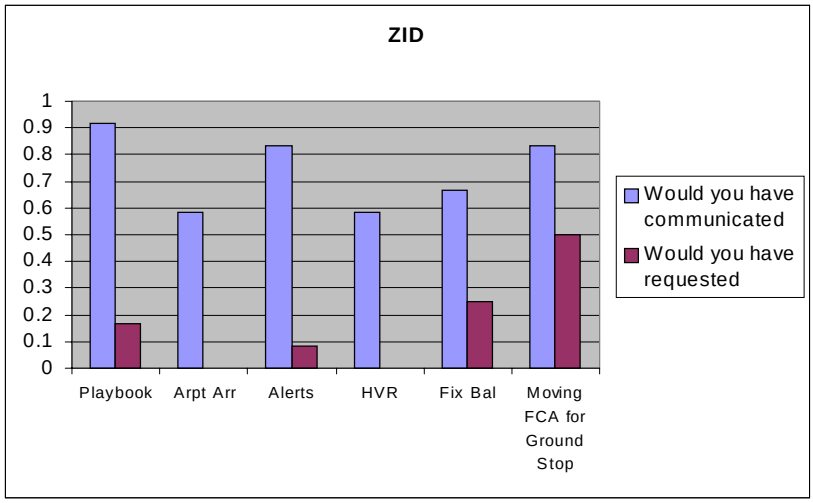
Information Sharing, ZID



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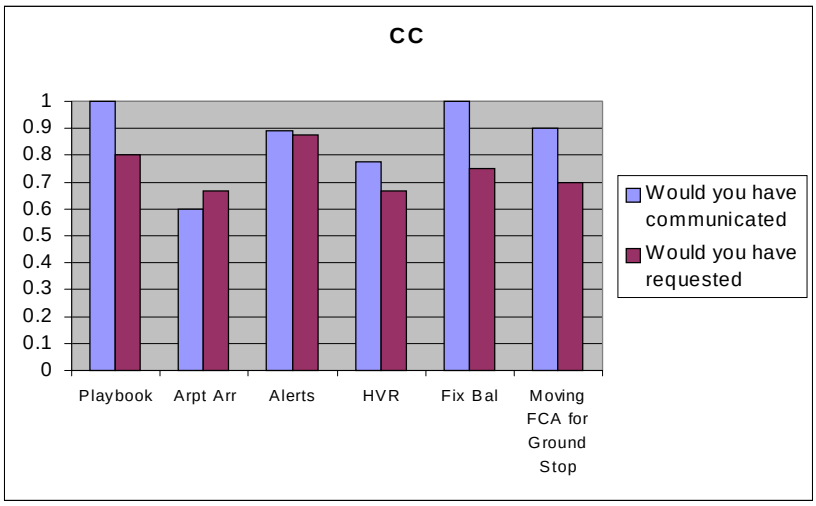
Information Sharing, ATCSCC



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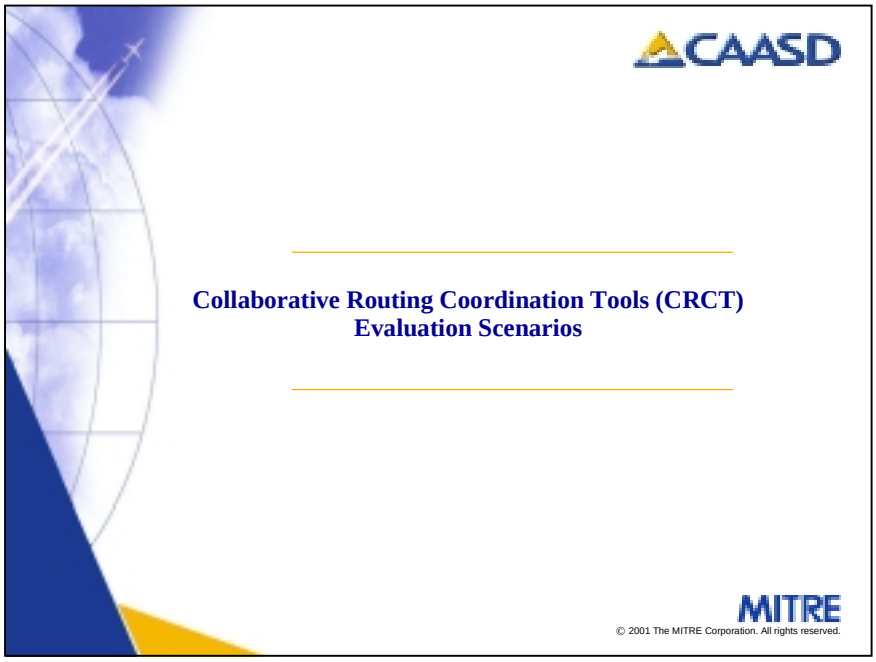
Appendix A

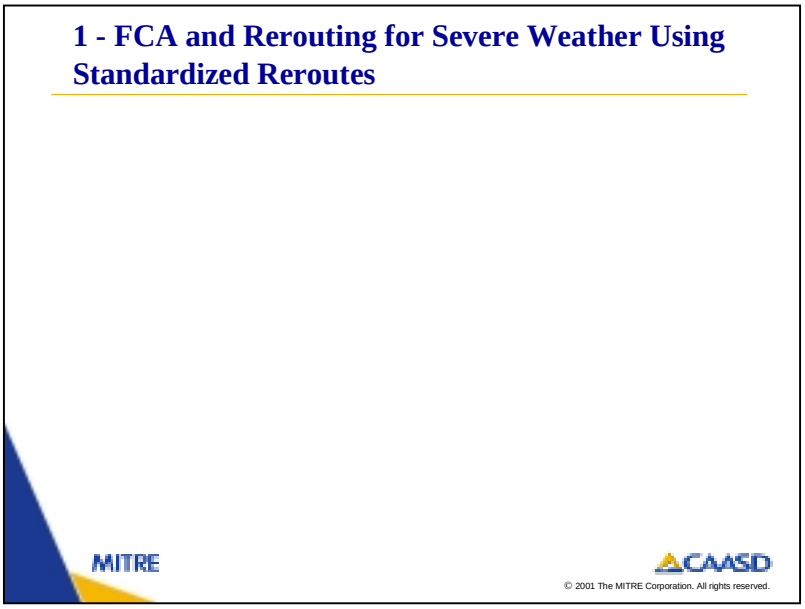
Canned Evaluation Scenario Instructions



Introduction

- **This evaluation session will involve operational scenarios similar to the ones you experienced during training.**
- **The purpose of the session is for you to help us determine, based on the knowledge of the CRCT functions you gained in training, how you would apply the functions to the kinds of operational scenarios you were exposed to during training. The instructions you receive for each scenario will be less detailed than they were during the training and you will have more freedom to decide which CRCT features you wish to use in each operational situation. You may decide to perform steps similar to the actions you were introduced to in the training and/or you may prefer to use the tools differently than the ways you were shown in training. The MITRE/CAASD evaluation facilitator will provide advice on using the functions if you need it.**
- **Following each scenario the facilitator will ask a short series of questions (5–10 min.) and we will write down your answers. Once you complete all scenarios there will be a slightly longer series of questions (45–60 min.) A copy of the questions is included in your training materials for your reference.**

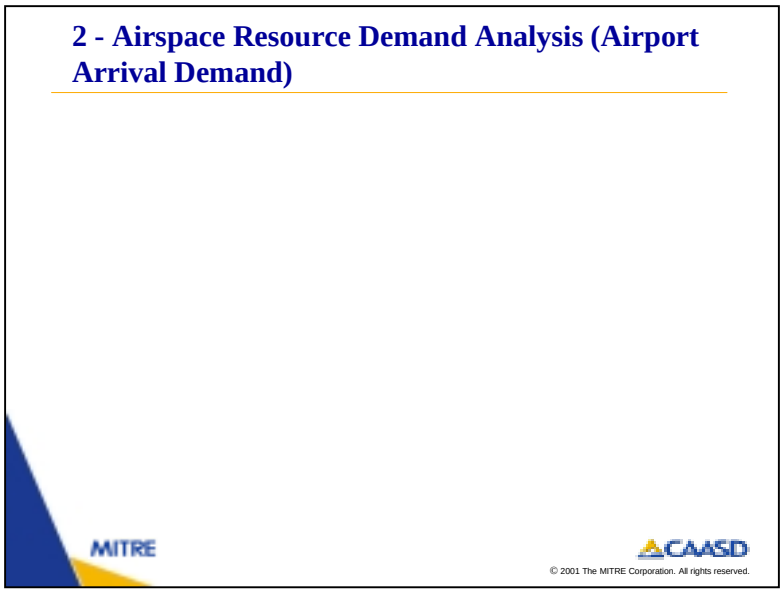
MITRE CAASD



In this exercise you will analyze the flow through an area of severe convective weather, and develop rerouting strategies for a mass of convective weather forecast over the Midwest.

STEPS:

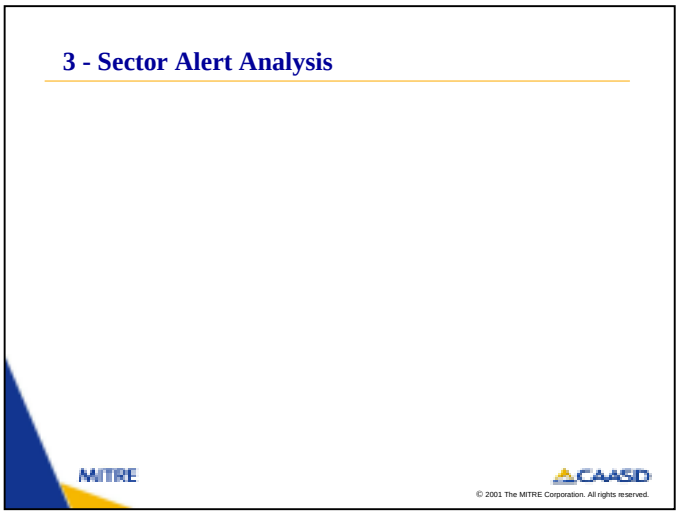
- Create an FCA that uses the Playbook play, "WEST_VUZ" (ZID: WEST_IIU).
- Select a filter group and remove it from the FCA.
- Select another filter group and change its reroute.
- Save the FCA under a new name (do not use the default "MOD1" name, but change it to something else).
- In the Rerouting window, remove two flights from the reroute set entirely.
- View at least two displays that will help you assess the impact of the reroute.



In this exercise you will analyze CVG arrival demand (note, for ZKC, use STL arrivals, start with same time frame).

STEPS:

- Find all arrivals at CVG 1800 to 2330. (note, for ZKC, use STL arrivals with same time frame).
- See if inactive flights at a particular airport or in a region (center) are contributing to the demand.
- Determine the busiest time(s) of the arrival push and conduct further analysis using at least two CRCT displays, to get a better sense of the demand during that time, and possible strategies.



In this exercise you will plot reroutes around an alerted sector, through an adjacent sector(s).

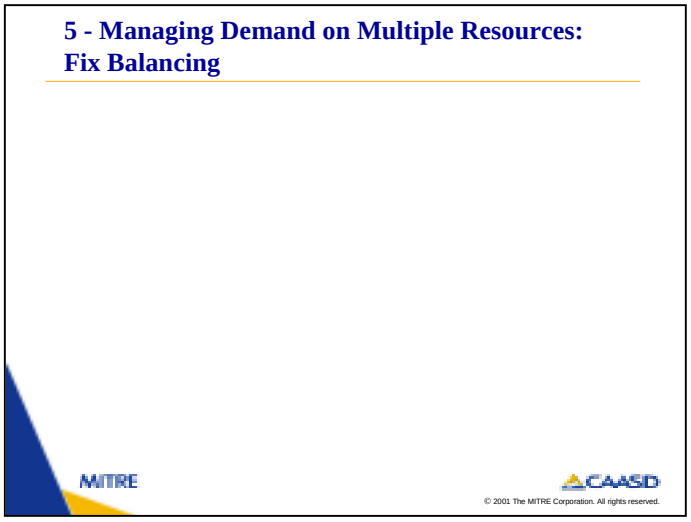
STEPS:

- Notice that sector alerts are occurring in ZID (ZKC).
- Assess the nature of the alert in ZID88 (for ZKC, could use ZKC84 or 31)
- Imagine that you decide to prevent the overload by rerouting flights through an adjacent sector. Select a sector and the flights to reroute, then evaluate the reroute.

In this exercise you are checking to see whether a given HVR is currently needed right now.

STEPS:

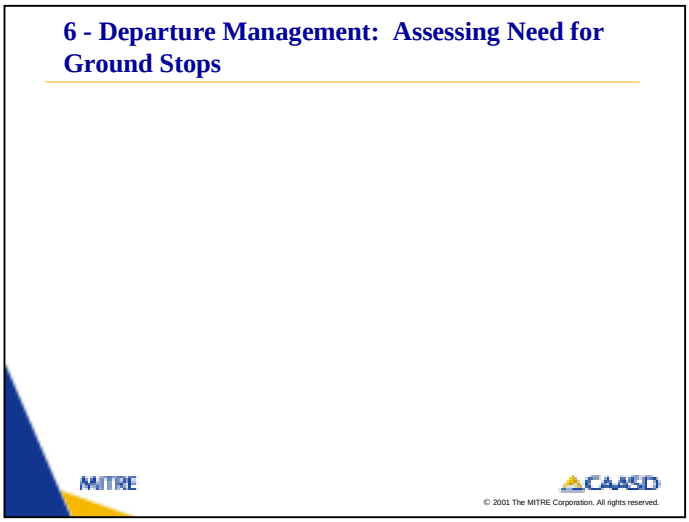
The HVR is 20 MIT for CVG arrivals from ZOB, ZKC, ZAU, ZTL from 1900Z-2100Z. Use whatever combination of CRCT functions will help you determine if the HVR is needed.



In this exercise imagine that you are working at ZAU—or in your own center collaborating with ZAU. Special Traffic Management Procedures are in effect at MDW due to a special event in Chicago and excessive demand at ORD. Imagine that you need to move some aircraft from one arrival stream to another.

STEPS:

- Using the FCA Definition window, define an FCA for Midway arrivals. Use the default start and end times.
- List the flights in the flow from the southeast (ZKC: southwest flow) and select three individual flights from this list. Assess the effect of rerouting these around to the southwest arrival.
- Create a new reroute set, selecting a different set of individual flights.
- Analyze the effects of the two different reroute options, using at least two different CRCT displays.



In this exercise a mass of convective weather may necessitate a ground delay program or ground stop. You will go through the steps a TMC at ATCSCC, ZAU—or adjacent center collaborating with ZAU—might go through in order to assess the departure demand at the airport and help decide the need for TFM initiatives.

STEPS:

- View weather.
- Draw FCA around the weather and specify speed=15 and heading=100. You may accept the default two-hour time period.
- Determine which CVG departures will impact the weather.
- Where possible, attempt to reroute some of the flights on EON, TTH, FLM, CTW.
- Will the reroute solve the problem?

Appendix B

Questions During Initial Evaluation after Each Canned Scenario

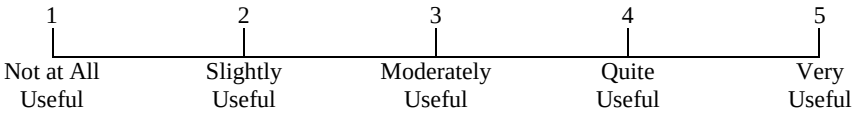
Debrief Questions

CRCT 2001 Evaluations

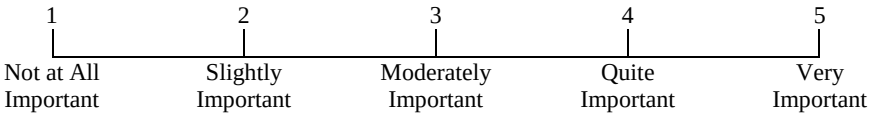
These questions will be asked and recorded by a CAASD facilitator, along with any relevant comments. The TMU CRCT evaluator will not be identified by name or other identifying information on the recording form or in any report resulting from the evaluation. The TMU CRCT evaluator will have a copy of this form in front of him/her for reference during the interview but will not write on the form. All recording of responses will be done by the CAASD facilitator.

Date:	Scenario:	CAASD ID:	TMC Evaluator ID:

1. In this scenario, how useful was each of the listed CRCT functions for your decision making (i.e., how much did the function, as implemented in CRCT, assist you in making a decision)?



And, how important was each of the listed CRCT functions (i.e. how important is it that this function be implemented)?



	Function	Usefulness: 1-5	Importance: 1-5	Comments
1	Current traffic display			
2	Future traffic display			
3	FCA definition window			

4	Moving FCA			
5	Crossing segment			
6	Rerouting			
7	FCA list			
8	NAS Monitor			
9	Sector Count Monitor			
10	Time in Sector Display			
11	FCA Demand Graph			
12	Reroute FCA (e.g., Playbook)			
13	Other			
14	Other			

2. In this scenario, would you have communicated CRCT information to others at your facility,and/or another facility? Yes ☐ No ☐

2a. If Yes, to whom?

_____

_____

3. In making a decision during this scenario, would you have requested information from other facilities?

Yes ☐ No ☐

3a. If Yes, from whom?

_____

_____

4. What decision(s) would you have made based on the use of CRCT functions in this scenario?

_____

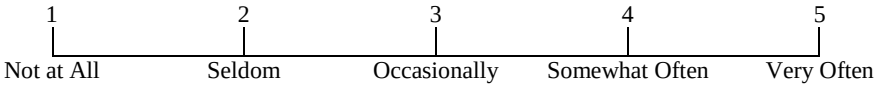
_____

4a. To whom would you have communicated your actual decision(s)?

_____

_____

5. When encountering a situation like this in the future, how often do you expect you will use CRCT functions?



Why?

_____
_____
_____

6. How would you have handled this scenario differently if none of the CRCT functions had been available to you?

_____
_____
_____

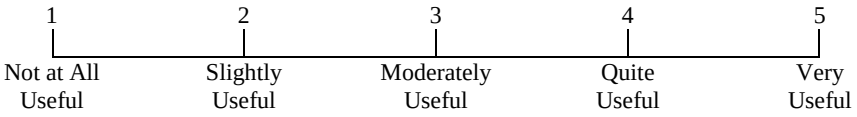
Appendix C

Questions During Initial Evaluation at End of Canned Scenario Session

Date:		CAASD ID:	TMC Evaluator ID:

Part 1: Use and Usefulness of CRCT Functions

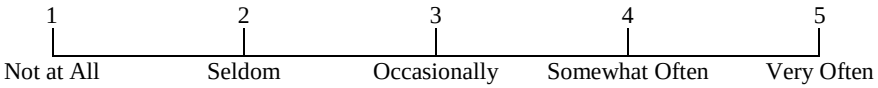
1. In general, how useful do you think CRCT functions are for each of the following tasks (i.e., how much did the function assist you in making decisions)?



	Task	Usefulness: 1-5	Comments (e.g., CRCT function used)
1	Planning/evaluating Severe Weather strategies		
2	Assessing future sector demand		
3	Assessing airport departure/arrival demand		
4	Analyzing/responding to sector alerts		
5	Fix balancing		
6	Evaluating sector combine/decombine		
7	Preparing for telcons		
8	Evaluating need for proposed restriction		
9	Evaluating current need for HVR		
10	Modeling altitude capping		
11	STMP		

12	ESP		
13	Planning offloads during deicing		
14	Assessing need for ground stops		
15	Other_		
16	Other_		

2. Do you expect that if CRCT capabilities continued to be available in the future, you would use them:



2.a Why?

_____

_____

Part 2: Advantages/Disadvantages/Improvements

3. In what ways do you believe the CRCT functions can assist you in performing your job (i.e., what advantages do CRCT functions provide)?

_____

_____

4. What disadvantages do you believe might result from using CRCT functions in performing your job?

_____

_____

5. What additional capabilities would you like to see included in TFM tools to support each of the following tasks?

	Task	Additional Capabilities
1	Planning/evaluating Severe Weather strategies	
2	Assessing future sector demand	
3	Assessing airport departure/arrival demand	
4	Analyzing/responding to sector alerts	
5	Fix balancing	
6	Evaluating sector combine/decombine	
7	Preparing for telcons	
8	Evaluating need for proposed restriction	
9	Evaluating current need for HVR	
10	Modeling altitude capping	
11	STMP	
12	ESP	
13	Planning offloads during deicing	
14	Assessing need for ground stops	
15	Other_	
16	Other_	

6. Name any other ways that CRCT could be improved.

_____

_____

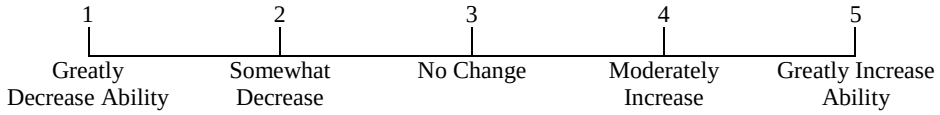
Part 3: Effects of CRCT Use

7. If CRCT functions were implemented, what changes would result in your relationship with ATCSCC, ARTCC's, Areas, Other? (depending on facility)

_____

_____

8. How do you believe the use of CRCT functions would affect flow management's ability to make appropriate decisions regarding restrictions/initiatives (e.g., whether to apply initiatives and what the initiatives should be)?

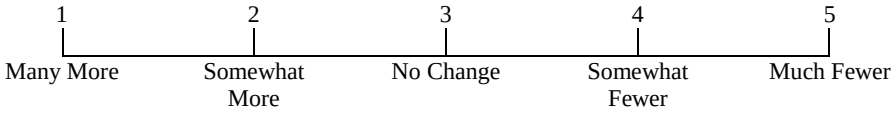


8a. Why?

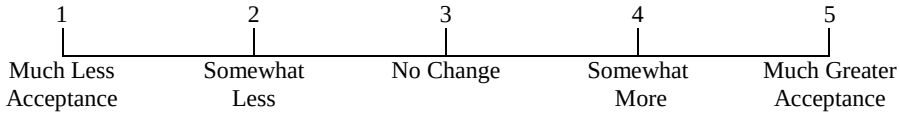
_____

_____

9. How do you believe the use of CRCT functions would affect the overall number of flow management restrictions/initiatives?



10. How do you believe the use of CRCT functions would affect the ARTCC/TMU acceptance of ATCSCC or Areas' acceptance of TMU initiatives (depending on facility)?



10a. Why?

_____

_____

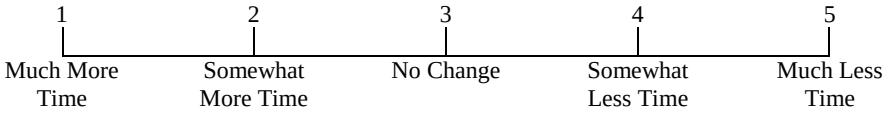
11. How do you believe the use of CRCT functions would affect the airspace users?

_____

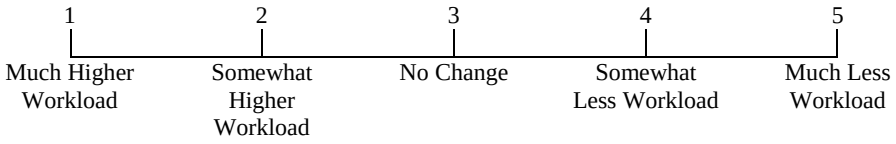
_____

_____

12. How do you believe the use of CRCT functions would affect the <u>time</u> it takes to plan and execute reroutes?

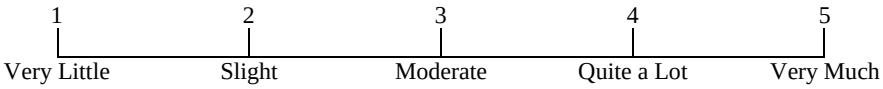


13. How do you believe the use of CRCT functions would affect your overall workload?



Part 4: Confidence

14. In general, how much confidence do you have in the predictive information provided by CRCT?



Why?

_____

_____

15. Does your confidence in the CRCT's ability to predict future traffic depend on the operational situation (i.e. severe weather) and/or the task? Yes ☐ No ☐

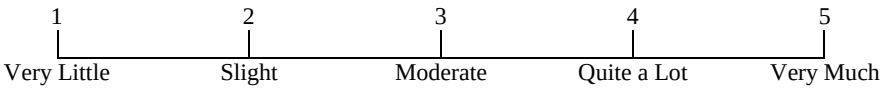
Please explain.

_____

_____

Part 5: Training

16. In general, how much confidence do you have in your ability to use CRCT to analyze the traffic situation, and plan/analyze traffic management initiatives?



Appendix D

Interview at Conclusion of Real-Time Evaluation Period

	B	C	D	E	F
1		**Debrief Questions - CRCT 2001 Evaluation**			
2		**These questions will be asked and recorded by a CAASD facilitator, along with any relevant comments.** ***The TMU CRCT evaluator will not be identified by name or other idenfifying information on the recording form or in any report resulting from the evaluation. The TMU CRCT evaluator will have a copy of this form in front of him/her for reference during the interview but will not write on the form. All recording of responses will be done by the CAASD facilitator.***			
3		**Question**			
4	**1**	Throughout the test period, how many hours per week did you operate the CRCT prototype during daily operations?			
5	**1a**	Throughout the test period, how many problems did you analyze per week using the CRCT prototype during daily operations? Use the following scale: 1 = none, ...2 = 1-3 per week,...3 = 4-6 per week, ...4 = 6-10 per week,...5 = More Than 10 per week			
6					
7	**2**	2.In what capacity did you use the CRCT prototype? Use the 1-5 scale described above.			
8		Position		Frequency (1-5)	Comments
9		TMC IC			
10		TMC			
11		Other			
12					
13	**3**	3. For which tasks or operational situations did you use the CRCT functions? How frequently? (1-Not at All ...2-Seldom...3-Occasionally...4-Somewhat Often...5-Very Often)			
14		Task		Frequency (1-5)	Comments or Additional Capabilities to Support this Task
15	1	Planning/evaluating Severe Weather strategies			
16	2	Assessing future sector demand			
17	3	Assessing airport departure/arrival demand			
18	4	Analyzing/responding to sector alerts			
19	5	Fix balancing			
20	6	Evaluating sector combine/decombine			
21	7	Preparing for telcons			
22	8	Evaluating need for proposed restriction			
23	9	Evaluating current need for HVR			
24	10	Modeling altitude capping			
25	11	STMP			
26	12	TFR			
27	13	ESP			
28	14	SWAP			
29	15	Planning offloads			
30	16	Assessing need for ground stops			
31	17	Other_			
32	18	Other_			
33					
34					
35	**4a.**	How useful was each of the listed CRCT functions (i.e., how much did the function, as implemented in CRCT, assist you in your analysis and/or decision making)? (1-Not at All Useful...2-Slightly Useful...3-Moderately Useful...4-Quite Useful...5-Very Useful			
36	**4b.**	How frequently did you use the listed CRCT functions?(1-Not at All ...2-Seldom...3-Occasionally...4-Somewhat Often...5-Very Often)			
37					
38		Function	Usefulness (1-5)	Frequency (1-5)	Comments
39	**1**	**Traffic Display (overall)**			
40		Ability to center Traffic Display on Fix (by selecting/typing fix)			
41		Selecting a reroute set or combination of reroute sets to show on Traffic Display			
42	**2**	**Future Traffic Display (overall)**			
43		Ability to continuously move forward in time (e.g., Slider)			
44		Ability to distinguish rerouted aircraft (e.g., filled circle vs. aircraft icons)			
45		Ability to distinguish active vs. inactive flights (e.g., color coding of circles)			

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46	3	**FCA functions (overall)**			
47		Filtering FCA by arrival/departure airport or ARTCC			
48		Filtering FCA by flights routed through specified ARTCC			
49		Filtering FCA by contents of route (airway/fix)			
50		Filtering FCA by AC performance class (heavy/jet/turboprop/prop)			
51		Filtering FCA by ACID			
52		Ability to specify reroute within FCA Definition window (i.e., “Reroute this way” field)			
53		Ability to store and retrieve plays (i.e., FCA with Reroutes)			
54		Ability to associate FCAs and Reroute Sets (i.e., selecting associated reroute set in FCA Definition Window)			
55		FCA Demand Graph FCA entry count graphing option			
56		FCA Demand Graph FCA occupancy graphing option			
57		FCA List – amount of information in list entry			
58		FCA List Sorting capability			
59		FCA List –displaying/hiding of multiple lists (e.g., FCA1, FCA2, …)			
60	4	**Rerouting definition and analysis (overall)**			
61		Reroute Sets Window (activate, create, delete, merge)			
62		Reroutes within FCA using multiple filter groups (e.g., Playbook plays)			
63		Ability to store and retrieve reroute text in the Text Edit window			
64		Defining reroute using traffic display			
65		Selecting flight(s) for reroute from FCA List using pop-up menu			
66		Selecting flights for reroute using Load from (FCA) List			
67		Selecting flight(s) for reroute by clicking time in sector display			
68		Selecting flight(s) for reroute from flight information window using pop-up menu			
69		Selecting flight(s) for reroute using crossing segment			
70		Defining or changing reroute using text edit			
71		Altitude rerouting			
72		Analyzing reroutes using Future Traffic Display			
73		Analyzing reroutes using FCA Demand Graphs			
74		Analyzing reroutes using NAS Monitor			
75		Analyzing reroutes using Sector Count Monitor			
76		Analyzing reroutes using Time in Sector display			
77	4a	**Playbook functions (overall)**			
78		Selecting/opening the desired Playbook play			
79		Modifying the Playbook plays			
80		Inclusion of airspace as part of playbook FCA (e.g., STL_EAST)			
81		Display predefined (e.g., Playbook) reroutes on Traffic Display			
82		Display labeled original routes and reroutes on Traffic Display			
83		Display text-edited playbook Reroutes on Traffic Display			
84		Automatic creation of reroute set and evaluation of reroute impact, upon applying FCA			
85		Pref Routes Window			
86	5	**NAS Monitor (overall)**			
87		Number of alerted (red and yellow) sectors in center			
88		15 minute-period divisions			
89		Range of time shown (i.e, 2 hours)			
90	6	**Alert Summary Display (overall)**			
91	7	**Sector Count Monitor (overall)**			
92		Sector counts (number) for sectors in ARTCC predicted to exceed MAP (red/yellow)			
93		Sector counts (number) for sectors in ARTCC not predicted to exceed MAP (green)			
94		MAP value for sectors			
95		Color coding of red, yellow, and green sectors			
96		15 minute-period divisions			
97		Range of time shown (e.g., 4 hours)			
98		Reroute set sector counts for red/yellow sectors			
99		Reroute set sector counts for green sectors			
100		Color coding to distinguish changed sector counts (i.e. light blue and dark blue borders)			
101	8	**Time in Sector charts (overall)**			
102		List of individual aircraft predicted to be in sector			
103		Center info for aircraft in list			
104		Ability to distinguish active vs. inactive flights in list (e.g., color coding of ACID)			

	B	C	D	E	F
105		15 minute window with 1 minute periods			
106		Options for display (i.e., TIS or AC bars)			
107		Sorting Capability			
108		Color coding of 1 minute periods			
109	**9**	**Printing Capability (overall)**			
110	**10**	**General window management (e.g., switching between windows, bringing desired window into view)**			
111	**11**	**General list management (e.g., adding, sorting, and deleting items in FCA list, Rerouting window, and other lists)**			
112	**12**	**Other**			
113	**13**	**Other**			
114					
115					
116	5a.	In your opinion, how important is it that the CRCT functions listed below be implemented in ETMS			
117		(i.e, priority for implementation):			
118		**1 = Not at all 2 = Slightly Important 3 = Moderately Important 4 = Quite Important 5 = Very Important**			
119	5b.	Name any ways that these functions could be improved, and rate the importance of the suggested improvement):			
120		**1 = Not at all 2 = Slightly Important 3 = Moderately Important 4 = Quite Important 5 = Very Important**			
121		Function	5a: Importance (1-5)	5b: Suggested Improvement	Improvement Rating: 1-5 (refers to Suggested Improvement, column to right)
122	1	Traffic Display			
123	2	Future Traffic Display			
124	3	FCA functions			
125	4	Rerouting definition and analysis			
126	4a	Playbook functions			
127	5	NAS Monitor			
128	6	Alert Summary Display			
129	7	Sector Count Monitor			
130	8	Time in Sector charts			
131	9	Printing Capability			
132	10	Window management capabilities			
133	11	List management capabilities			
134	12	Other			
135	13	Other			
136					
137	5c.	Name any other ways that CRCT could be improved.			
138					
139	**Part 3: Effects of CRCT Use**				
140					
141	6	How do you believe the use of CRCT functions would affect flow management's ability to make appropriate decisions regarding restrictions/initiatives (e.g., whether to apply initiatives and what the initiatives should be)? 1 = very much degraded, 2 = somewhat degraded, 3 = no change, 4 = somewhat improved, 5 = very much improved			
142					
143					
144	7	How do you believe the use of CRCT functions would affect the overall number of flow management restrictions/initiatives? (1-Many More...2-Somewhat More...3-No Change...4-Somewhat Fewer...5-Much Fewer)			
145					
146					

	B	C	D	E	F
147	8	*Answer the following question at ATCSCC: If CRCT functions were implemented, what changes would occur in the relationship between ARTCC TMCs and the ATCSCC (for example, would ARTCC/TMU acceptance of ATCSCC initiatives be improved)? 1 = very much degraded, 2 = somewhat degraded, 3 = no change, 4 = somewhat improved, 5 = very much improved			
148		*Answer the following question at ARTCC: If CRCT functions were implemented, what changes would occur in the relationship between Areas and TMUs (for example, would Areas' acceptance of TMU initiatives be improved)? 1 = very much degraded, 2 = somewhat degraded, 3 = no change, 4 = somewhat improved, 5 = very much improved			
149					
150					
151	9	How do you believe the use of CRCT functions would affect the airspace users? (1-Very Much Burden...2-Moderate Burden...3-No Change...4-Moderate Benefit ...5-Very Much Benefit)			
152					
153					
154	10	How would the use of CRCT functions affect the time it took to plan and execute reroutes? (1-Much More Time ...2-Somewhat More Time...3-No Change...4-Somewhat Less Time...5-Much Less Time)			
155					
156	11	How would the use of CRCT functions (in particular, interacting with the workstation) affect your overall workload? (1-Much Higher Workload...2-Somewhat Higher Workload...3-No Change...4-Somewhat Less Workload...5-Much Less Workload)			
157					
158	12	How would the use of CRCT functions affect your collaboration and coordination workload? (1-Much Higher Workload...2-Somewhat Higher Workload...3-No Change...4-Somewhat Less Workload...5-Much Less Workload)			
159					
160					
161		**Part 4: Confidence**			
162					
163	13	In general, how much confidence do you have in the predictive information provided by CRCT? (1-Very Little...2-Slight...3-Moderate...4-Quite a Lot...5-Very Much)			
164					
165	13a	Why?			
166					
167	14	Is your confidence in CRCT's predictive ability to future traffic dependent on the operational situations, like weather or traffic volume? (Yes/No)			
168					
169	14a	Please explain.			
170	15	Separate question: Is your confidence in CRCT's predictive ability to future traffic dependent on the task you are performing, such as rerouting, restriction analysis, sector volume analysis, etc.? (Yes/No)			
171	15a	Please explain.			
172					
173					

Appendix E

TCARS Instructions and Scale

TFM Capabilities Acceptance Rating Scale (TCARS) Guidelines and Definitions

Guidelines and Definitions

Guidelines For Numerical Rating

Procedure:

1. Start at the top left-hand corner of the page.
2. Answer each yes/no question according to the scenario that you just experienced.
3. Use the definitions below to make the judgments.
4. Circle **one** number from 1 to 10 that **best** reflects your experience in the scenario that you just experienced.
5. Please add comments to explain your rating.

Definitions

System:

The system means **everything** in the TFM environment, primarily meaning two things:

- the TMC's performance
- the performance of all decision support systems including but not limited to the latest ETMS release, FSM, and DSR.

Also consider the operation of the entire environment you work within, that is, the airspace users and other members of the ATC system (areas, other TMUs, ARTCCs/ATCSCC).

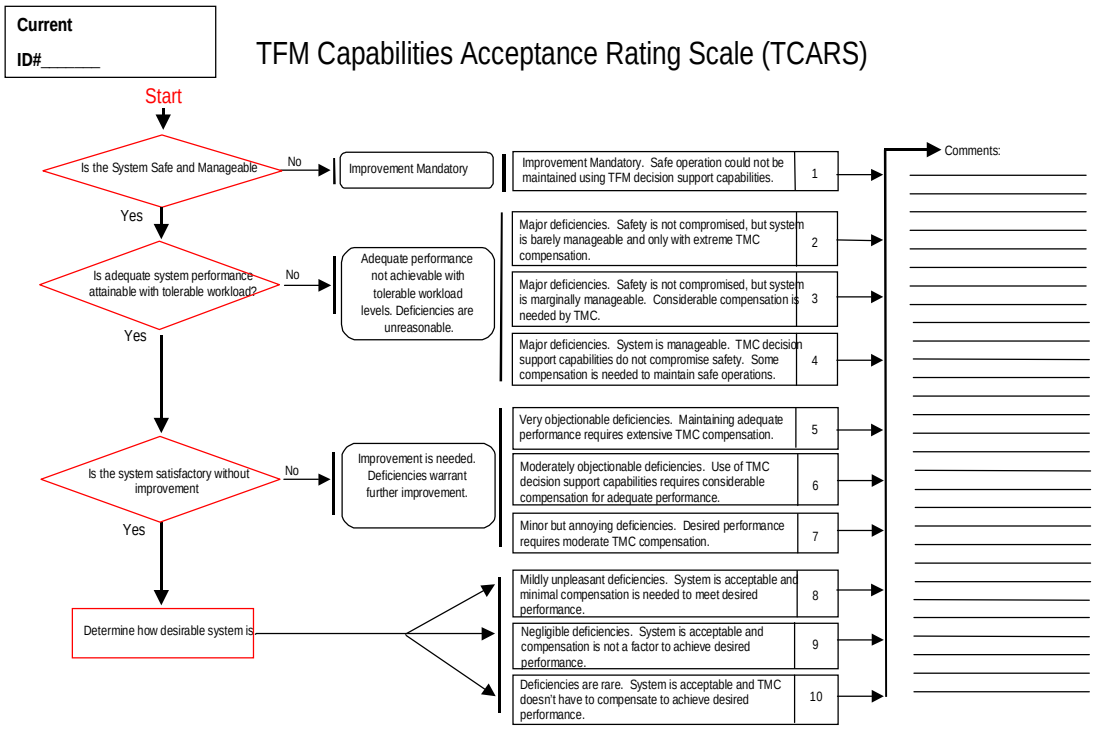
For rating 1 ("Current"), the "system" refers to the system including the latest ETMS release and all other decision support tools you currently have available to you, NOT INCLUDING any capabilities that you may have seen in the CRCT prototype.

For rating 2 ("FCA"), the "system" refers to the system as it would be if the new FCA *filtering* capabilities demonstrated in the CRCT prototype, were available as part of the ETMS system, in addition to all other decision support tools you currently have available to you.

For rating 3 ("FCA+rerouting"), the "system" refers to the system as it would be if all the FCA and REROUTING capabilities demonstrated in the CRCT prototype, were available as part of the ETMS system, in addition to all other decision support tools you currently have available to you.

Compensation:

Compensation means any additional activity -- physical (for example, activating additional displays) or mental -- required on the part of the TMC to make up for deficiencies in the overall system, and the amount and difficulty of this activity that is necessary.

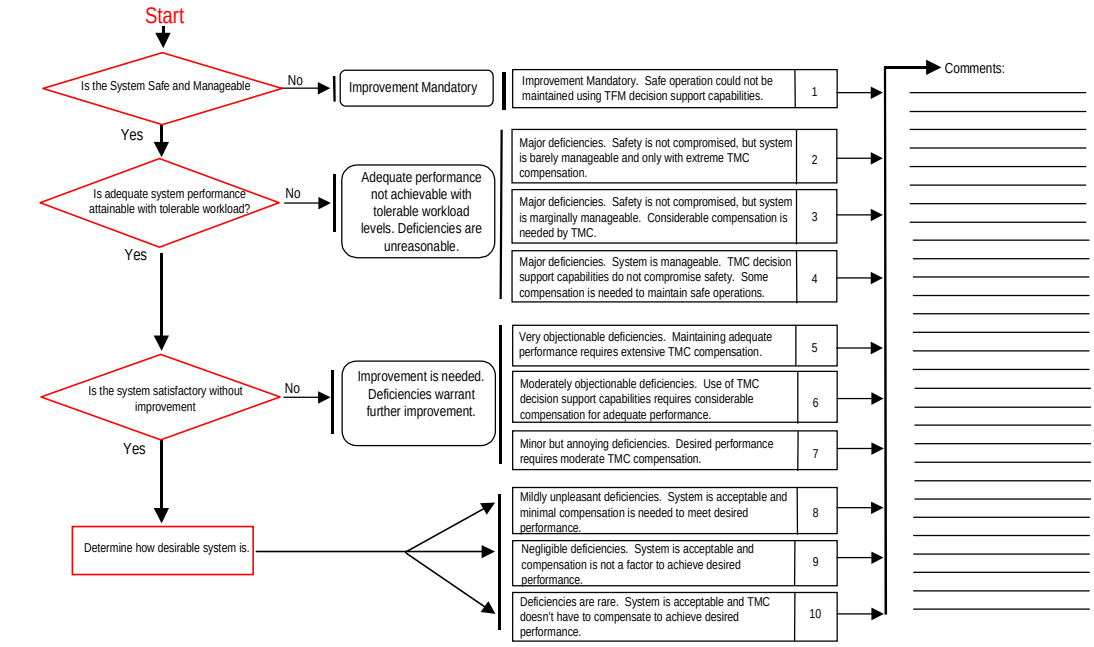


This slide, and the next two, show the three TCARS sheets that were handed out to each TMC. Each TCARS flowchart was identical except for the labeling in the upper left corner (Current, FCA, or FCA+Rerouting); these labels were defined in the instructions (preceding slide). Numerical responses and comments were recorded by a CAASD facilitator.

FCA

ID#_____

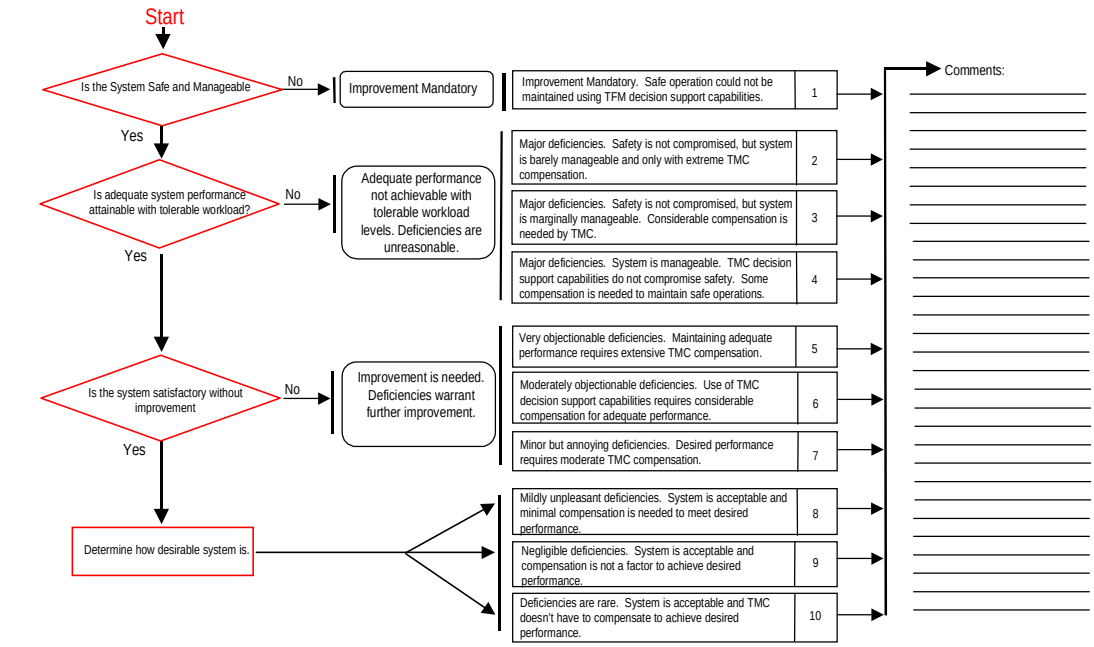
TFM Capabilities Acceptance Rating Scale (TCARS)



FCA & Rerouting

ID#_____

TFM Capabilities Acceptance Rating Scale (TCARS)



Glossary

ARTCC	Air Route Traffic Control Center
ATTSCC	Air Traffic Control System Command Center
CAASD	Center for Advanced Aviation System Development
CE	Concept Exploration
CD	Concept Development
CCT	CRCT Core Team
CRCT	Collaborative Routing Coordination Tools
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
FSD	Full-Scale Development
FSM	Flight Schedule Monitor
FTD	Future Traffic Display
FY	Fiscal Year
HCI	Human Computer Interface
HVR	Historically Validated Restriction
MIT	Miles-In-Trail
MOU	Memorandum of Understanding
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association

PD	Prototype Development
R&D	Research and Development
SCM	Sector Count Monitor
TCARS	TFM Capabilities Acceptance Rating Scale
TFM	Traffic Management Coordinators
TIM	Technical Interchange Meeting
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
VNTSC	Volpe National Transportation Systems Center
ZID	Indianapolis ARTCC
ZKC	Kansas City ARTCC