51. City of Houston 911 Production Server System Platform, Houston, Texas, Pioneer Technical Documentation, April 30, 2002
52. HEC Project Sign-in Sheets
    a. Functional Design Session, November 13, 2001
    b. Functional Design Review, January 7, 2002
    c. Functional Acceptance Test – CAD, February 3, 2003
53. Policy to Direct and Monitor Technology Efforts, November 25, 2002
54. Commission on State Emergency Communications, Best Practices for Basic 911 System Training, Training Manual
55. HEC Status 3/25/03, 4/3/03, 4/10/03, 8/17/03, 9/29/03
56. Altaris Status, 9/11/03
57. Houston Altaris® CAD Call taker Train-the-Trainer Schedule
58. Alartis® Computer Aided Dispatch System and Records Management System Project Implementation Plan, December 14, 2001
59. Memorandum of Understanding – CAD Functional Acceptance Testing
60. HEC FSD Evaluation Exceptions Identified 3/29/2002
61. CAD Failover Load Test Report, July 15-16, 2003, Performance Certification
62. HEC Polices and Procedures, January 20, 2005
63. Altaris® CAD Programmer Training Materials
64. Altaris® CAD Call Taker and Dispatch Training Manuals
65. Altaris® Cad Initial System Configuration
66. Altaris® CADLIVE, INTLIVE, MISLIVE Data Dictionary
67. Altaris® CAD and MSS As Built Documentation
68. SIRT List, All Items
69. Change Order List, All Items
70. Altaris® Computer Aided Dispatch System and Records Management System Project Implementation Plan, December 14, 2001
71. Altaris® CAD Command Statistic Report for 2005, January 12, 2005

Appendix B Operations of Call Takers and Dispatchers

Figure B-1 shows the operation of call takers and dispatchers. The Neutral 911 call takers are an initial entry point to the system. They classify a call as going to Police or Fire/EMS, or refer it to another agency. They transfer the caller to either a Police or Fire/EMS call taker, referred to as a "warm-transfer." Combined events, those requiring both Fire/EMS and Police response, are transferred to Fire/EMS call takers. Neutral 911 call takers do not interact with the technical CAD system, but they do use the VESTA call management system.

HPD and HFD call takers are the interface to the public requesting services. They obtain, organize, and enter the information that is the basis for making resource decisions. They define the call type and priority, "coding" the call. Some aspects of the call taking requirements are explicitly incorporated into the CAD information entry system under the Special Instructions (SINS) feature, but there are marked differences between Police and Fire/EMS usage of that tool.

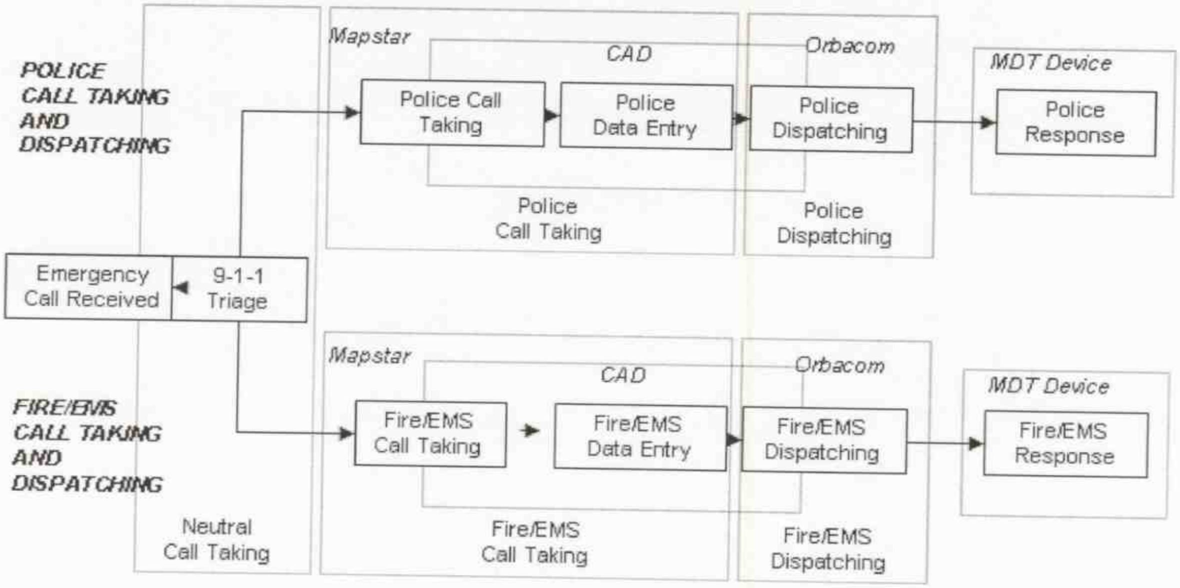

Figure B-1. Operations of Call Takers and Dispatchers

Upon completion of the basic entry of an event, the information is then passed to a dispatcher to assign, monitor, and manage a response. At this point the police call taker may terminate the call, but the Fire/EMS call takers may have responsibility for the delivery of "pre-arrival instructions," the coaching of the caller to take medical action prior to arrival of a medical unit. The dispatch operations between the HFD and HPD have important distinctions. The diversity of response possibilities is larger on the Fire/EMS side, choosing among types of equipment and possible combinations (engines, ladder, tower, BLS ambulances, ALS ambulances, Paramedic vehicles, command officers). There is automatic support by the CAD system for selection of asset combinations. The continuous service delivery from the dispatcher is limited, with no direct involvement in safety issues.

The variety of police dispatch choices are typically much more limited in terms of type of response, although some specialized unit selection is occasionally involved. Practically, if not officially defined, the police dispatchers do provide some degree of load management for the officers in the field, making certain that the load on the officer is not driven by a simple "closest officer" algorithm that might overload one officer. There is a very important continuous service connection from the officer to the dispatcher that is unique to the police side of dispatch.

The analysis of the operations against the initial system design showed major differences and expectations. The roll out of the new CAD system was expected to have minimal disruption to the police call taking and police dispatching processing. The expectation by police dispatchers was that the system would be modified to fit their existing police dispatch processes and that departmental policies and procedures would not be affected. This is consistent with the terms of the acquisition of the new system as an upgrade to the existing police CAD system. In contrast to this view, the Fire/EMS participated in the new CAD system project with the expectation that the implementation of the new CAD system would result in changes to their business processing, but like the police dispatching staff, no expectations existed for changes in the departmental reporting structure or impacts to their existing departmental policies and procedures.

The newly formed HEC organization took on the role of integrating call taking and dispatching business processes in anticipation that a single call taking and call dispatching process and procedure would be followed when utilizing the new CAD system. Furthermore, the HEC organization began to work towards standardizing staff policies and procedures as they saw their role as a "service organization" to the Houston Police and Fire Departments with overall responsibility and accountability for Houston's Emergency Services' call taking and dispatching functions.

Appendix C System Availability Concepts and Calculations

Concepts and Definitions

A system has recurrent up periods (operating) and down periods (in maintenance/repair) in its life cycle. MTBF (Mean Time Between Failure) and MTTR (Mean Time To Repair) are two widely used statistics in availability theory to measure how frequent failure incidents are likely to occur and how fast a repair can be done.

Availability can be evaluated by two standard measurements:

- Operational Availability = Total Uptime / Assessment Period = 1 - Total Downtime / Assessment Period, where the computation takes into consideration all corrective repair times, preventive maintenance times, and administrative and logistics delay times. This is assessed from end-users' perspective: whenever the system cannot be used due to either planned or unplanned events, the system is viewed as unavailable.
- Inherent Availability = MTBF / (MTBF + MTTR), where the computation excludes preventive maintenance times and administrative and logistics delay times. Also known as intrinsic availability, this measurement based on only failure outages that required corrective repairs, is basically reflecting the system reliability and the ability to recover from failures. MTBF is estimated by total assessment period divided by the number of outages. MTTR is estimated by total repair time divided by the number of repairs.

More details on relevant concepts and definitions can be found in:

U.S. Department of Defense Handbook 3235.1-H "*Test & Evaluation of System Reliability, Availability, and Maintainability*", 1982.

U.S. Department of Defense Handbook MIL-HDBK-338B "*Electronic Reliability Design Handbook,*" 1998.

Calculations of System Availability

If the system life cycle is considered to start from the first day when the system went live for conducting the acceptance test in a live operation environment, then the assessment start time was September 23, 2004 04:00:00, and the data of incidents B1 through B10 and A1 through A7 should all be considered for the availability calculation. If the system life cycle is considered to start from the system acceptance date, then the assessment start time was September 23, 2004, 04:00:00, and only the data of incidents A1 through A7 should be considered.

The parameters and calculations for operational availability are shown in Table C-1.

Table C-1. Operational Availability Calculations

		Assessment Period (hour)	Incidents considered	Total Downtime (hour)	$A_o = 1 - TD/AP$
System life cycle started from go-live date	Overall System	11924.00	B1 – B10 A1 – A7	41.90	**0.9965**
	CAD/RMS	11924.00	B1 – B10 A1 – A3	23.73	**0.9980**
System life cycle started from acceptance date	Overall System	9480.00	A1 – A7	34.25	**0.9964**
	CAD/RMS	9480.00	A1 – A3	16.08	**0.9983**

When calculating inherent availability, the last two incidents (A6 and A7) classified as preventive maintenance are not counted.

The parameters and calculations for inherent availability are shown in Table C-2.

Table C-2. Inherent Availability Calculations

		MTBF (hour)	Incidents considered	MTTR (hour)	$A_i = MTBF/(MTBF+MTTR)$
System life cycle started from go-live date	Overall System	794.93	B1 – B10 A1 – A5	2.38	**0.9970**
	CAD/RMS	993.67	B1 – B10 A1 – A2	0.89	**0.9991**
System life cycle started from acceptance date	Overall System	1896.00	A1 – A5	5.62	**0.9970**
	CAD/RMS	4740.00	A1 – A2	1.54	**0.9997**

Calculations of Confidence Limit for System Availability

Assume the times between failure and the repair times all have exponential distributions. For the inherent availability A_i, it can be shown that the $(1-\alpha)$ one-sided confidence interval is given by:

$$P\left(A_i \geq \frac{\theta}{\theta + \phi \times F_{1-\alpha,2n,2n}}\right) = 1 - \alpha,$$

where n is the number of failures, θ is the estimated MTBF, ϕ is the estimated MTTR, and $F_{1-\alpha,2n,2n}$ is the F-statistic such that $P(Z \leq F_{1-\alpha,2n,2n}) = 1 - \alpha$ for any random variable Z with an F-distribution.

Using the outage data for the overall system since the go-live date, the confidence limit and corresponding confidence level for the inherent availability A_i are computed and tabulated in Table C-3. The confidence limit can be interpreted as the availability target, and the confidence level indicates the possibility for reaching that target.

Table C-3. Confidence Limit for Inherent Availability A_i of the Overall System Since Go-Live Date

$A_i \geq$ Confidence Limit	Confidence Level
0.9991	0.05%
0.9989	0.50%
0.9984	5.00%
0.9970	50.00%
0.9952	90.00%
0.9945	95.00%

The first row reads: Probability$(A_i \geq 0.9991) = 0.0005$. This means there is extremely low confidence (0.0005) that the Inherent Availability of HEC could reach 0.999. Usually, analysis of a reliability model for the architecture can help identify which components would contribute the most to the overall system unavailability.

The probability expression $\Pr(A_i \geq a) = p$ is equivalent to $\Pr(A_i < a) = 1 - p$. Thus, the third row indicates we are 95% confident that the inherent availability of HEC is lower than 0.9984. That means we can predict with 95% confidence that, if nothing is to be improved, the overall HEC system downtime will be at least 14 hours per year.

For the Operational Availability A_o, there is no simple close form expression for representing the confidence level of A_o. Monte Carlo simulation was used for obtaining the approximated confidence limits and confidence levels, which are shown in Table C-4.

Table C-4. Confidence Limit for Operational Availability A_o of the Overall System Since Go-Live Date

$A_i \geq$ Confidence Limit	Confidence Level
0.9983	5%
0.9977	25%
0.9970	50%
0.9962	75%
0.9949	95%

These results for A_o are very similar to that for A_i.

The same methods are used to calculate the confidence limits for the availability of CAD/RMS alone. The same calculations are repeated for the assessment period that started after the acceptance. These results are discussed in Section 4.2.5.

Analysis of the Tradeoffs Between Reliability and Maintainability

For the 0.999 availability, reducing just one hour in repair time will be as effective as adding 41 days of uptime between two failures. (Whether this approach is more economical in the long run will be subject to further tradeoff analysis, taking into account of an additional set of criteria including finance, support goals, and other relevant factors.) Improving MTTR has better leverage than improving MTBF for increasing the availability value.

Figure C-1 shows the estimated MTBF calculated after each incident cycle after the system go-live date. For example, the third data point is calculated as follows: dividing the total elapsed time until the end of the third incident by three. This chart indicates that the MTBF is getting better (longer) but is not yet reaching a steady state, implying that the integrated public safety data system has not passed the so-called "infant mortality" stage.