

Colorado Mayday

Field Operational Test Project

Project Summary Report

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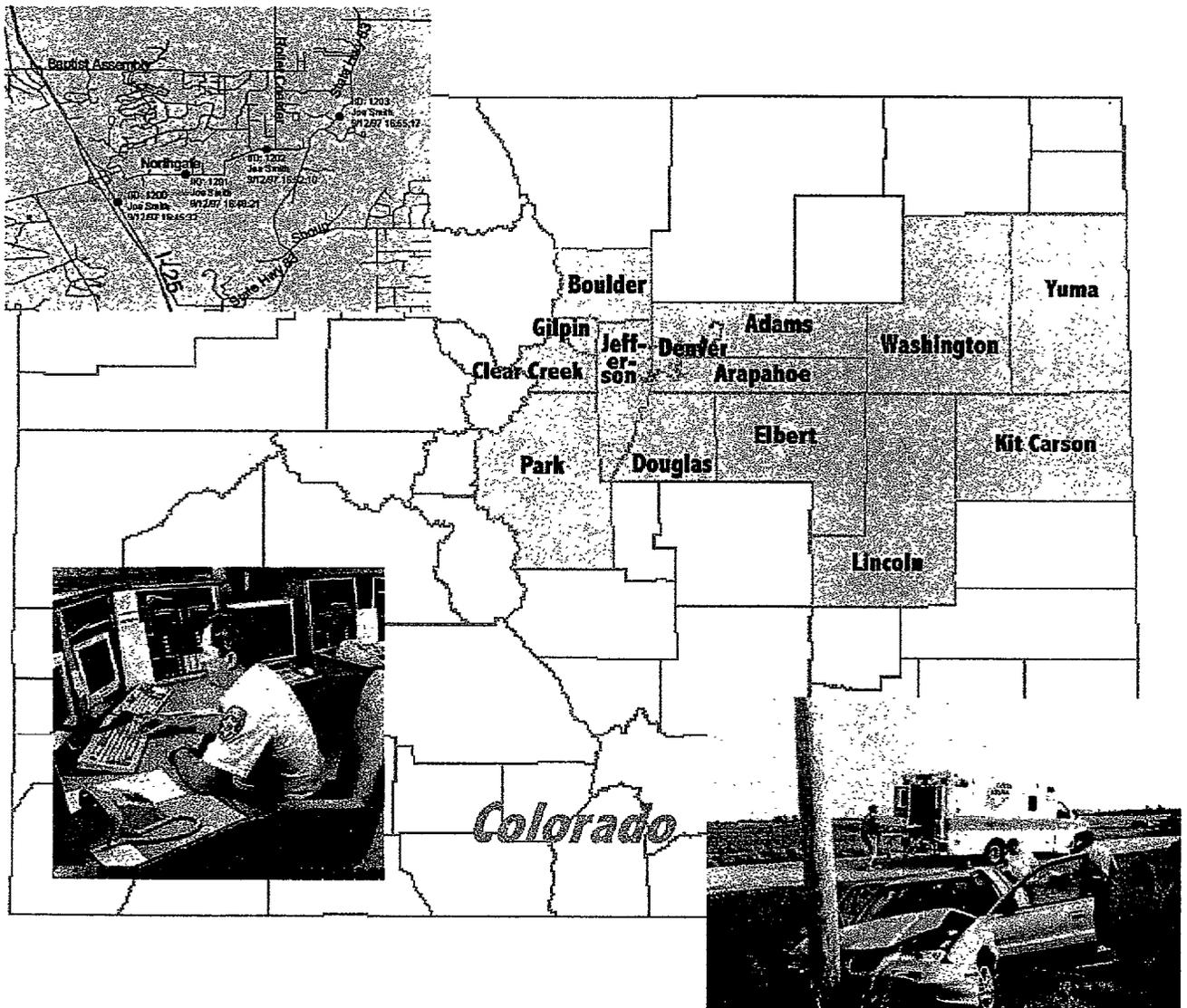
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Project Summary Report



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EXECUTIVE SUMMARY

The Colorado Mayday Field Operational Test was intended to develop and test an in-vehicle device that could be manually triggered in an accident or emergency and would report the vehicle location along with other vehicle-specific information. The project was proposed to the Federal Highway Administration (FHWA) in January 1994, and testing commenced in early 1995. Three phases were planned, of which two were completed. The first phase assessed the design and technical performance of the Mayday system through limited testing. The second phase tested the system in real-world conditions on a small-scale basis. The final phase was to be a full-scale test involving 2000 motorists that would use the system in actual emergencies. The Summary Project Report documents the findings of the of the operational test, including lessons learned and recommendations arising from the obstacles and issues encountered.

When the Colorado Mayday Operational Test began there were no Mayday type systems in field operation, and this project was an opportunity to test the feasibility of the concept. The feasibility included the technical performance of such a system as well as the institutional, legal and financial issues that it might experience. The project goals established for this project were:

- To implement and evaluate a low-cost personal security system that allows users to request roadside assistance via an automated system that provides the responder with detailed information on the location and type of assistance required;
- To identify the structure, responsibilities and service levels of a traveler assistance center necessary to commercially operate such a system, and to hand over the operational test system to such a center at the conclusion of the project; and
- To improve the provision of emergency services to in-need motorists by the implementation of the Mayday architecture and related procedures.

Because Phase III was not undertaken, the goals of the project were not fully achieved. However, the completed phases and the experiences documented in this final report provided many insights that identify the issues that other Mayday type system deployment can expect to encounter.

EVALUATION GOALS AND OBJECTIVES

The project evaluation had a series of goals and objectives designed to measure how effectively the Colorado Mayday project achieved each of its project goals. The goals and

objectives are listed here along with a brief summary of the project’s effectiveness in achieving them.

Goal #1 *To evaluate the effectiveness of the selected architecture in providing Mayday capabilities.*

Through Phases I and II, summarized in sections three and four, the capability of the Mayday system to effectively determine vehicle location in latitude and longitude coordinates, transmit that location data to a dispatch center and connect the caller via voice communications to a dispatcher was tested. Phase I testing was performed by the Mayday project team and generated better results than the second phase, which used volunteers testing in real-world simulations.

Objective: *Evaluate the ability of the communications system to transmit the required messages.*

The Colorado Mayday system, which used analog cellular phone as the m-vehicle communication medium, throughout the test area shown in section 2.6, proved reliable. The following table summarizes the rate of all call attempts that resulted in a valid location determination being transmitted to the processing center.

	Good cellular signal strength	Marginal cellular signal strength	Poor cellular signal strength
Phase I successful data transmission rate	88%	86%	85%
Phase II successful data transmission rate	73%	N/A	N/A

N/A = Not applicable

Table 1. Data transmission reliability

In phase II, the system was not tested in conditions when the cellular strength was not good. As was generally true of the system’s performance, Phase I results were better than those for Phase II.

Objective: *Evaluate the coverage provided by the communications systems.*

During Phase I, tests were performed throughout the test area, by the evaluation team. These tests were chosen specifically to test the cellular coverage of an even distribution of test points along both rural and urban highways and interstates. The result of 444 tests was that in 71% of the tests the cellular signal was at least two-thirds of full strength, or “good” for data and voice communication. The other 29% were either marginal or poor, meaning that

data transmission may be unreliable.

There was no cellular strength testing during Phase II because testing was performed by individuals who often did not document tests that failed.

Objective: *Evaluate the ability of the in-vehicle device to permit users to request assistance.*

Focus groups conducted in Phase I resulted in a series of recommendations for improving the button box, which is the part of the in-vehicle device that is used by the driver to trigger a Mayday call. The focus group results are detailed in section 3.5. Most users felt that a simple button box is preferable, but it should allow the user to identify who should respond to their request, such as a police, emergency medical or fire department.

Phase II participants were surveyed on their perception of the system to serve them in a variety of circumstances. One primary concern of many participants was that the system did not operate on a consistent basis. Much of this can be attributed to ongoing modifications and improvements that were made by NAVSYS which interfered with service during Phase II. Survey responses also indicated that the system would be difficult to use in accidents involving traumatic injuries. This is because the system required manual activation. Further survey detail can be found in section 4.4.1.

Objective: *Evaluate the ability of the TIDGET7 location device to provide suitable location accuracy.*

Suitable location accuracy was never clearly defined by the project team because no benchmarks had been set by previous projects or technologies. However, since the project began, the Federal Communications Commission (FCC) has developed a series of possible rules for locating cellular 911 callers. The rules require that 67% of all cellular 911 calls be locatable within 125 meters of the caller's actual location, potentially as early as 2003. During Phase I testing, the system successfully met the FCC rule requirement when nearly 75% of all test attempts resulted in a location identification within 100 meters of the actual call location. However, during Phase II, the system did not meet this rule. Forty percent of Phase II call attempts were identified within 100 meters. It is important to note that the FCC rule is not yet enforced, and was not the determining criteria in this project's success or failure. However, if this rule is enacted, all Mayday type systems will be required to function to the level it specifies. Phase I location accuracy results can be found in section 3.4.3.2, and Phase II location accuracy results can be found in section 4.4.2.2.

Objective: *Evaluate the ability of the workstation to receive and display assistance request messages to the right level of detail.*

During Phase I, the Colorado State Patrol (CSP) dispatchers operated a simulation Mayday

dispatch station for two weeks. The purpose of this demonstration was to collect feedback that would help shape the displays and information provided by the station. Dispatchers expressed a desire for a simple display that individually identified each Mayday incident and provided only the most essential information about it. Most changes identified by the dispatchers, and documents in section 3.6, were incorporated into the dispatch workstation by NAVSYS.

There are concerns within the emergency responders about the frequency with which the digital map database is updated. However, because the project was terminated at the conclusion of Phase II, it was not within the evaluation's scope to identify how often updates should be made and the impact of their not being updated.

Objective: *Evaluate the ability of the system to provide response information to the end user.*

The survey conducted in Phase II asked participants how “understandable” the messages provided by the in-vehicle equipment were. Messages sent to the user are given to the user through a combination of text messages on the LCD display of the cellular handset, and through the blinking lights on the button box. All participants stated that the messages to users and the status of the users’ calls were “understandable” or better. More detail can be found in section 4.4.1.1.

Objective: *Evaluate the accuracy and suitability of the map databases used within the project.*

The digital maps initially used during Phase I were developed by the Colorado Department of Transportation (CDOT). They were not designed to serve for the Mayday system's purposes, and did not provide enough information on street names and landmarks to be suitable. Digital maps developed by the Wessex Corporation were used in Phase II and most likely would have been used in Phase III. The Wessex map databases were enhanced versions of the U.S. Census Bureau's Topographically Integrated Geographic and Referencing System (TIGER) maps. The Wessex maps resolved the issues that arose with the CDOT maps and provided an accuracy to within six meters anywhere within the state. This accuracy was adequate for the Colorado Mayday project.

The quality of the map is crucial to the success of a Mayday system. Some digital maps are derived directly from cartographic maps without Global Positioning System (GPS) correction, and locations can be shown several hundred feet or more away from their actual latitude and longitude. When an incident location is reported by GPS, it may be shown on an inaccurate map as being hundreds of feet from the actual location. This problem can be compounded in urban settings where streets and buildings are often close together. The Wessex maps proved to identify locations within ten to fifteen feet of the actual sites.

Goal #2 *To evaluate the impact of the Mayday system on emergency response times.*

Phases I and II did not involve the system's use during actual emergencies, during which emergency response time would have been measured. The second goal of the evaluation was dependent on a full-scale deployment in Phase III.

Objective: *Evaluate emergency response times with and without the Mayday system.*

The evaluation of emergency response times was to be performed by comparing the pre-Mayday and post-Mayday average response times for emergencies in geographic zones. It was anticipated that the improved location information would result in quicker average response times for the aggregate of calls in each zone.

Objective: *Evaluate the ability of the system to direct emergency services to the exact location, vehicle and person in distress.*

The ability to direct emergency response services to the location of an incident was also to be determined through real-world experience in Phase III. A significant issue was encountered during the planning of Phase III regarding dispatcher-response communications. There is currently no standard means for dealing with Mayday calls from the dispatcher perspective. There is not additional training or a specific way to respond to such calls, neither is there a defined way to send the exact location information to emergency services that are responding. Recommendations for the dispatch handling of Mayday type calls can be found in section 7.4.5.

Objective: *Evaluate the usefulness of the additional information the system can provide on the assistance requester.*

While the practical use of the additional information was not explored during the project, CSP dispatchers made recommendations about what specific information they felt would help them provide positive identification to emergency services in the field. The dispatchers stated that the following information should appear with each incident reported:

- the make, model, year and color of the calling vehicle;
- the license plate number and vehicle identification number (VIN);
- the name of the registered owner; and
- the phone number of the calling cellular phone.

Objective: *Evaluate any disbenefits associated with dispatch operators not having direct voice contact with the requester.*

All Colorado Mayday calls were intended to transmit the location information electronically

and then automatically transfer to voice mode so that the dispatchers could talk directly to the caller. However, there were many potential situations where this would not be possible. They include when the system successfully completed the data transfer, but failed to switch to voice mode, and times when the caller might be too injured or traumatized to complete the call. In these cases, the dispatcher has to determine the appropriate response based solely on the request that was made through the button box and the location information. During Phase III, the way dispatch handled such calls and what disbenefits resulted were to be evaluated. No other tests were performed to determine the disbenefits and, therefore, none are documented in this report.

Goal #3: *To evaluate the potential for the Mayday system to be nationally implemented.*

Throughout Phase III the market potential and commercial feasibility of the Mayday system was to be evaluated through a series of efforts during Phase III. The efforts included user surveys and the assessment of the system's benefits and disbenefits. Additionally, through Phase III, the project team was to explore various commercial opportunities and the advantages and disadvantages of these would have been explored. Because Phase III did not take place, this goal was not achieved in its entirety. However, during the project, other Mayday-type systems were commercially deployed and are supported entirely by the private sector. These systems, specifically Ford's Rescu and General Motor (GM) OnStar, are discussed briefly in section 5.3.2.

Objective: *Identify the costs of widespread implementation to end users and the public sector.*

A cost structure was never fully defined during this project. This is because the costs were highly dependent on the types of service provided and the structure of the operating organization. These issues were to be resolved through Phase III. Other Mayday type systems, such as Ford Rescu and GM OnStar charge monthly fees near \$20 a month, with an initial system cost of \$1000 per vehicle. These costs include the provision of a variety of other traveler assistance services. The Colorado Mayday system was designed to be low-cost and would have most likely been priced below other commercially deployed systems. Specific cost issues, such as revenue sharing and the costs to Public Service Answering Points (PSAP) in terms of hardware and additional staffing were not explored in this project.

Objective: *Evaluate the market response to the Mayday system.*

The ultimate test of the Mayday system would be through the response of the 2000 users planned in Phase III. However, the marketing focus groups conducted in Phase I and the surveys and interviews performed in Phase II provide a limited view of market response. The overall impression of the focus group participants was that the system would be a great benefit to them. Their stated preference was to buy such a system given a \$20 a month or

lower service charge, and an initial hardware cost of under \$500. Their impression was based solely on a system that provided Mayday service to the driver. It did not include other traveler assistance services. Since the focus groups, Ford and GM have introduced their similar systems, and it is not clear what impact they have on the market's perception of a Colorado Mayday system. The focus group results are detailed in section 3.5.

Phase II surveys interviews did not focus on costs, but on the users' perception of Colorado Mayday's technical performance. Although there were several technical setbacks during this testing, the participants indicated an interest in continuing to use the system beyond the official testing period. Most believed that the system reliability was improving and would be reliable enough for real-world use.

Objective: *Evaluate the potential for added value services to make the system more attractive to the end user.*

The set of potential value-added services identified by the Mayday team are contained in Appendix A. The ability to locate a vehicle anywhere allows for a wide variety of additional services beyond Mayday. These include:

- person finding;
- stolen/vehicle locating/tracking;
- personalized, real-time traveler information;
- probe vehicle travel time reporting;
- yellow pages type tourist information; and
- navigational aid.

Objective: *Evaluate the level of public sector buy-in to the proposed operating organization concept developed within the project.*

The explicit buy-in of the public sector agencies was never collected during the Colorado Mayday Operational Test because it was felt that the level of acceptance would be predicated by the success of Phase III. During the project several indicators of the public position were ascertained the Mayday project team.

The project was initially to have CSP as the PSAP. Their participation was based heavily on one employee's enthusiasm for the technology and its potential. When that employee left, CSP's interest in participating waned. The primary reasons for their lack of interest were because of a perception that the system would increase dispatcher workloads, or require additional staffing, and the potential liability that the system could impose on CSP. Another factor was the cost of the Mayday dispatch center hardware, which CSP did not want to pay for. Another PSAP, Adams County Communication (ADCOM) backed out of a possible agreement to serve as the project's PSAP because of liability and equipment ownership and maintenance requirements.

The withdrawal of these two potential PSAPs indicate a reluctance, at least in the Denver metropolitan area, to accept and respond to Mayday type calls. No Colorado-based PSAPs are currently equipped to handle the location data, and few can afford the high cost of equipment and frequent map database updates. The issues that led to the withdrawal of the two PSAPs are described in more detail in section five.

Goal #4: To Evaluate the impact of the Mayday system on the overall transportation system.

No impacts were made to the transportation system during Phases I and II, since testers did not use it during emergencies, and did not disrupt traffic when testing. During Phase III, the potentially quicker response to emergencies may have had a positive impact on the transportation system by removing the incidents from traffic and restoring blocked lanes more quickly. Because there were no real-world incidents to measure, there are no results for this objective.

Objective: Identify the potential incident response time savings due to the Mayday system.

Objective: Identify the costs of congestion and other disbenefits due to the types of situations that can be impacted by implementation of a Mayday system.

Objective: Identify overall benefits based on different levels of Mayday system penetration.

LESSONS LEARNED

Part of purpose of the Colorado Mayday operational test was to identify issues, barriers and opportunities for deployment and implementation that could not be anticipated through planning. Throughout the first two phases and the planning stage for Phase III, a series of lessons were learned by the project team that may serve to better prepare future operational tests and Mayday system deployments. The lessons learned are divided into four sections:

- technical;
- marketing;
- institutional; and
- legal.

Colorado Mayday Technical Lessons Learned

The Mayday system had technical performance limitations that were unanticipated or whose

impacts were not fully understood before the wide-area deployments that occurred in Phases I and II, as detailed in section 6.2. It was found that the TIDGET7 is a suitable device for Mayday services. It has the advantages over a standard GPS receiver of a faster time to collect location information, potentially cheaper manufacturing costs, and more reliability because of its simplicity. The primary disadvantage is that it is not a self-contained location determination device and therefore relies on an additional communication link to determine a vehicle's location.

Colorado Mayday was severely limited in the type of cellular phones that could be used by participants. A series of project decisions led to the system being designed to accommodate only one model and brand of phone. During the project, the cellular phone manufacturer Nokia discontinued the designated phone making it less attractive to potential project participants. Had this problem been foreseen, the project team would have specified that the system support a wide range of participants' phones.

One limitation of the NAVSYS TIDGET7 design is its ability to only accurately determine locations within a 150 kilometer radius of the processing center. Outside of this range, the system did not accurately determine locations. NAVSYS has resolved this problem in other systems they produce, but not in the TIDGET7 used in Colorado Mayday.

When the Colorado Mayday Operational Test began, there was no national ITS architecture which defined the conceptual structure of Mayday systems. Colorado Mayday, however, fits the architecture that has been developed since. It occupies a portion of the Mayday Market Package which provides Mayday to remote travelers.

In 1996, the FHWA assigned five organizations as Standards Development Organizations (SDO). The SDOs were tasked with identifying and developing standards for Intelligent Transportation systems. Colorado Mayday predated the SDO efforts by more than two years, and as such selected an open, non-proprietary that best fit the project's needs. Currently, the SDOs have not defined a set of standards for Mayday systems and it is unknown whether the Colorado Mayday standard is compatible with the standard they select.

Colorado Mayday Marketing Lessons Learned

From contract award to the end of Phase II, Colorado Mayday lasted over three years. During that time, two commercial Mayday type systems were deployed. Ford Rescu and GM OnStar have shifted what people know about and expect from Mayday type systems. Both commercial systems are built into new vehicles and offer Mayday as one of a suite of GPS-based traveler services. Mayday focus group participants indicated that the Mayday system was a good value, but this was prior to the advertising and promotion of Rescu and OnStar. The promotion and advertising conducted by these projects has been much more aggressive and deep than anything the Colorado Mayday project has done, and the awareness of Rescu and OnStar is more universal. No focus groups have been conducted since, but it

is likely that participants would expect a system that provides a suite of services similar to those they can receive from the available commercial systems.

The efforts to recruit participants for each of the phases were hampered by a lack of a strong recruitment and marketing plan. In operational tests, a strong, realistic plan is crucial because of the experimental nature of the testing. The plan will help attract a sufficient number of suitable, committed and educated participants which will in turn result in quality data.

Colorado Mayday Institutional Lessons Learned

Many of the issues that prevented the Colorado Mayday project from proceeding with Phase III were institutional and could have been avoided with better foresight at the project's inception. Stronger, more binding agreements between the various partners would particularly benefit operational tests, which are often prone to delays, technical glitches and setbacks. It would keep partners involved throughout difficult periods, and better help them to understand that delays are common. A weak Memorandum of Understanding (MOU) allowed several partners, including the cellular companies and CSP, to leave the project because they were not clear on their roles and what was required from them for the project's success.

A funding barrier may be encountered by Mayday systems that intend to provide location information directly into PSAPs. Most rural PSAPs are on limited budgets and cannot afford to purchase the additional equipment required to receive and display Mayday caller information. Currently, Colorado has a surcharge on cellular phone owners of \$0.75 per month. This finances the handling of cellular 911 calls, but it does not include purchasing Mayday equipment. This equipment could cost as much as \$150,000 per PSAP, including digital maps. In Colorado there are 63 PSAPs and the total cost to equip them to receive Mayday could be more than nine million dollars.

The FCC has developed a plan that would force cellular manufacturers and service providers to develop a system for locating callers within 125 meters of their actual location. How FCC implements the 125 meter rule and the specific requirements may significantly impact existing Mayday type systems. Additionally, the rules may require PSAPs to equip themselves to handle emergency callers' location information.

One significant lesson learned by the project team was the impacts of public sector involvement in technology development. Between the inception of Colorado Mayday and when Phase III was in the planning stages, several other commercially funded Mayday type projects had achieved a higher level of public awareness and commercial success. Colorado Mayday remained true to its original project plans from the outset, while these other projects were able to more easily adapt to the market they were serving. The Mayday project team set out to achieve the goals they established partially to gain funding from FHWA and not

from the commercial sector. In pursuit of that funding, the project was not flexible enough to adapt to the market, and that adversely affected its potential to be commercially sustainable. The Colorado Mayday project team believes that this could have been avoided if the project team had a more complete understanding of the system during the initial stages. Better direction could have been provided earlier to address the specific partner and market needs.

Colorado Mayday Institutional Lessons Learned

The Colorado Mayday Operational Test explored the anticipated legal issues through research, but also encountered unanticipated legal concerns from the dispatch community. The legal research resulted in an analysis of the potential issues that could arise from a Mayday system, liability for dispatchers and the information processors is limited to their negligence or malicious activity. However, the ability to identify locations and respond to a new type of emergency call may result in “special service” that widens the amount of liability and damages that the dispatcher and processor can be responsible for.

During negotiations with PSAPs that were interested in participating in Phase III. Both ADCOM and CSP required indemnification and at least one million dollars of liability insurance from the vendor in order to participate. This insurance would have been available to the PSAPs for all legal disputes arising from the Mayday system. The vendor did not want a close relationship with dispatching agencies and would not provide the indemnification. Additionally, the liability insurance proved too costly for the vendor to supply.

RECOMMENDATIONS

Resulting from the Colorado Mayday experiences and lessons learned are a series of recommendations for other field operational tests and Mayday type programs. The project recommendations are discussed in section seven. They are divided into four sections:

- technical;
- marketing;
- institutional; and
- legal.

Colorado Mayday Technical Recommendations

Colorado Mayday Phase II, and most likely Phase III, was limited in its deployment because the system worked well with only one brand and model of cellular phones. Operational tests that use new technologies should be designed from the outset to be adaptable. New

technologies are still evolving and their capabilities and limitations are constantly changing. By allowing the Mayday system to be built around a single cellular phone, the project team was unable to take advantage of the improvements in analog cellular, and ended up with an in-vehicle device built around an obsolete phone.

The Colorado Mayday system was built to display information to dispatchers on a single workstation. Because most PSAPs have multiple dispatch stations, the additional station did not integrate well. One potential dispatch group withdrew from the project because the information could not be provided to the existing dispatch workstations through dynamic switching. Future Mayday type systems should be able to adapt to the PSAP environment and the dispatchers should not be required to alter their roles and responsibilities any more than is necessary.

Colorado Mayday Marketing Recommendations

Recruitment efforts during Colorado Mayday were constrained by resource and technology limitations. It was also unanticipated what level of recruitment would be necessary to attract the required number of suitable participants. The Multi-Jurisdictional Mayday Committee, a technical committee of the ENTERPRISE Program, has developed a series of recruitment recommendations based on the experience of several states that have had similar recruiting experiences. These recommendations are included in Appendix C, and they are recommended by the Colorado Mayday project team.

Additionally, it is recommended that operational test project teams specifically identify the level of effort each project team member's roles and responsibilities in the recruitment process. The project manager should insure that all efforts are made to the committed levels.

Colorado Mayday Institutional Recommendations

The primary recommendation resulting from this project is that the MOU that is developed at the project's beginning be binding and specifically identify the roles and responsibilities of each project member. With evolving technologies, there are a variety of issues that can arise and discourage particular team members. A strong MOU and contract will keep members involved and participating until they can see the benefits of their efforts.

Outreach is also essential at all stages of project development. Team members must be involved and aware of the project's progress at all times. Project resistance or support can arise from members of the partner organizations that are not directly involved in the project. Information should therefore be spread beyond just those that are directly involved in the project and to the entire organizations.

Field Operational Tests are likely to encounter many barriers and opportunities, as Colorado Mayday did. The projects should be flexible enough to adapt and take advantage of

opportunities and avoid barriers. It is recommended that project steering committees and other oversight agencies assess the true benefits available from a test and allow projects to adjust or change the mission.

A strategy for funding the response to Mayday type calls should be developed. Current cellular 911 funding in Colorado is collected and disbursed locally to PSAPs that are financially strapped to meet their existing requirements. The current funding level does not support the purchase and deployment of Mayday type equipment in the state's PSAPs, and these will be necessary for a fully deployed Mayday system with the same objectives as Colorado Mayday.

Colorado Mayday Legal Recommendations

As this project attempted to change PSAPs a different set of legal concerns became barriers. Because one goal of this project was to determine the feasibility of a national Mayday system, a large number of PSAPs would ultimately have to be involved. Operational tests should explore not only the legal issues facing the project partners but also those of any potential participants once the project is fully-deployed.

I. INTRODUCTION

The Colorado Mayday Operational Test was one of the first projects to explore personal emergency location systems. The innovative technologies that were designed and developed during the project were still in the experimental stage. As a test, it was expected that not all components would always work. In fact, most components were continuously modified and improved based on the testing results. This report documents the successes and difficulties of working with new technologies to improve traveler emergency response. It is a summary of the project's efforts, obstacles and opportunities.

The Colorado Mayday Final Report is comprised of seven sections. The first section is the introduction and describes the initial project goals and objectives. It also reviews the evaluation goals and objectives. These will create a context for understanding the efforts and results of the project. The second section provides an overview of the technology used in the Colorado Mayday operational test, and the partners who actively participated in the project. Section three provides a summary of the results of Phase I - Detailed System Design. Section four discusses the results of Phase II - Initial System Trial. Section five is a review of the events that led up to the potential full-scale deployment in Phase III. The sixth section discusses the lessons learned by the Colorado Mayday project team throughout the project. The final section summarizes the recommendations that have resulted from the Colorado Mayday project.

1.1 COLORADO MAYDAY OVERVIEW

In 1996, 56 percent of all the vehicles involved in fatal crashes were involved in crashes that occurred in rural areas. Although rural areas accounted for only 38 percent of total vehicle miles of travel in 1995, the fatality rate in those areas was 2.6 per 100 million vehicle miles traveled, compared with 1.1 in urban areas. The fatality rate on rural Interstate highways was 1.2 per 100 million vehicle miles traveled in 1995, compared with 0.6 on urban Interstates. During 1996, 86 percent of drivers involved in rural fatal crashes were driving within their state of residency at the time of the crash.¹ The rural issues that contribute to highway deaths is the frequent inability of response organizations personnel to reach an injured motorists in a timely fashion because of longer distances and the lack of communication infrastructure in rural areas. Reduced traffic flow and fewer opportunities for acts of "Good Samaritans" also impact rural emergency response. These factors led to the need for better means for detecting and locating accidents in rural areas. Mayday devices were conceived to address this need.

¹Bureau Transportation Statistics, Fatality Analysis Reporting System - Rural Statistics, 1996

Colorado Mayday was a means for providing a device in every vehicle that can be triggered in the event of an accident to inform an emergency dispatch center that assistance is required. It provided the latitude and longitude coordinates of the vehicle's location to the control center. Colorado Mayday combined two relatively recent technological advances, Global Positioning Systems (GPS) and cellular telephones. GPS can identify the location of a vehicle to within ten meters. Cellular telephones provide affordable, wireless two-way communications to the general public. These two technologies provided the ability to locate a vehicle anywhere on the globe, and the ability to communicate that location, along with other information, over vast areas of North America.

When the concept for the Colorado Mayday project was developed in 1993, three obstacles prevented the establishment of a viable Mayday network across North America:

1. Creating an organizational infrastructure to coordinate the activities of the many agencies, both public and private, that must cooperate in establishing a network;
2. Defining a standard communications link between the vehicle and the control center; and
3. Reducing the overall cost of the system to a level low enough to be marketable to the average consumer.

This Colorado Mayday project aimed to address each of these issues, through the operational test of an innovative system architecture, in sufficient detail to allow a Mayday operating company to be set up and begin the national deployment of the Mayday.

The Colorado Mayday project team was managed by the Colorado Department of Transportation for ENTERPRISE. The NAVSYS Corporation was the system integrator for this project and developed the TIDGET7 based in-vehicle units and Mayday control center workstations. The TIDGET7 location device is an innovative, low-cost GPS receiver developed by NAVSYS. Castle Rock Consultants served as the independent evaluators. Other partners also participated in the project and their roles are discussed in section 1.4.

1.2 MAYDAY PROJECT GOALS AND OBJECTIVES

The overall goals of this operational test were linked to the needs identified by the Federal Highway Administration in the operational test proposal solicitation and to those identified by the National ITS Program Plan. The goals and objectives also reflected the desires of the various project partners who made contributions. The overall goals of this project were:

- To implement and evaluate a low-cost personal security system that allows users to

request roadside assistance via an automated system that provides the responding party with detailed information on the location and type of assistance required;

- To identify the necessary structure, responsibilities and service levels of a traveler assistance center necessary to commercially operate such a system and to hand over the operational test system to such a center at the conclusion of the project; and
- To improve the provision of emergency services to in-need motorists by the implementation of the Mayday architecture and related procedures.

From these overall goals, a series of objectives were developed. These objectives relate to the actual activities and technical considerations that were planned to achieve the above goals. The technical objectives were:

- Trial a low-cost location device, communications links and control center operations (the Mayday system) over a wide area covering multiple geographies and terrains with a large number of vehicles (> 2,000). The number of vehicles was chosen because it provided a high probability of several incidents requiring emergency response over the eighteen month test.
- Evaluate the impacts of the Mayday system and response network on emergency response activities, times and public safety.
- Evaluate in-vehicle human factors requirements for a Mayday system; including identification of appropriate categories for transmitting the nature of the request for help; evaluation of appropriate methods for selecting the nature of the request; identification of alternative triggering methods; and investigation of the format, content and the appropriate level of interaction for confirmation messages.
- Identify and address control center human factors issues including: system interaction, map display, geographic attributes, display methods and dispatcher/driver interaction.
- Evaluate alternative communication architectures for implementation of a Mayday system including identification of the level of coverage that could be supported by expansion of the operational test architecture and the steps necessary to provide the required national coverage.
- Evaluate the vehicle location accuracy requirements to support the Mayday application in rural and urban areas.
- Establish draft standards for Mayday sensors, mobile communications and operations centers, including physical interfaces, message formats and message content that

support North American International Traveler Information Interchange Standards (ITIS) and the utilization of a variety of communications systems.

- Identify institutional issues associated with the widespread implementation of the Mayday system architecture, including identification of the structure of a nationally acceptable Mayday response center public/private partnership; and identification of cost structures or alternative funding measures that can support the operation of the control center and can be adopted by the national public/private partnership.
- Evaluate dispatch center needs including map database quality for local routing of emergency services; portability of control center architecture to other dispatch centers; and integration with existing computer-aided dispatch systems.
- Quantify liability issues associated with the implementation of a Mayday system which provides manual or automated assistance request functionality.
- Identify and evaluate potential added value services that would make the system more attractive to end users, including: in-vehicle provision of information concerning geographic location, local services and real-time traveler data; and remote location of vehicle or confirmation of safety by a third party.
- Assess the potential market response to the availability of a Mayday system.
- Determine feasibility and structure of a public/private partnership or corporate entity required to sustain commercial operation of the system.
- Identify the issues and effectively disseminate project results to the appropriate community to permit handover of the operation of the operational test Mayday system to a suitable organization at the end of the project.

1.3 EVALUATION GOALS AND OBJECTIVES

The purpose of the evaluation was to provide feedback to the ITS community. This was to identify the value of the technologies, architectures and tools applied in Colorado Mayday, and to disseminate the lessons learned through the deployment of Mayday. The goals and objectives of the evaluation follow.

Goal #1: *To evaluate the effectiveness of the selected architecture in providing Mayday capabilities.*

Related objectives:

- Evaluate the ability of the communications system to transmit the required messages.
- Evaluate the coverage provided by the communications systems.
- Evaluate the ability of the in-vehicle device to permit users to request assistance.
- Evaluate the ability of the TIDGET7 location device to provide suitable location accuracy.
- Evaluate the ability of the workstation to receive and display assistance request messages to the right level of detail.
- Evaluate the ability of the system to provide response information to the end user.
- Evaluate the accuracy and suitability of the map databases used within the project.

Goal #2: *To evaluate the impact of the Mayday system on emergency response times.*

Related objectives:

- Evaluate emergency response times with and without the Mayday system.
- Evaluate the ability of the system to direct emergency services to the exact location, vehicle and person in distress.
- Evaluate the usefulness of the additional information the system can provide on the assistance requestor.
- Evaluate any disbenefits associated with dispatch operators not having direct voice contact with the requestor.

Goal #3: *Evaluate the potential for the M&day system to be nationally implemented*

Related objectives:

- Identify the costs of widespread implementation to end users and the public sector.
- Evaluate the market response to the Mayday system.
- Evaluate the potential for added value services to make the system more attractive to the end user.
- Evaluate the level of public sector buy-in to the proposed operating organization concept developed within the project.

Goal #4: *Evaluate the impact of the Mayday system on the overall transportation system.*

Related objectives:

- Identify the potential incident response time savings due to the Mayday system.
- Identify the costs of congestion and other disbenefits due to the types of situations that can be impacted by implementation of a Mayday system.

- Identify overall benefits based on different levels of Mayday system penetration.

1.4 PARTNERS AND PARTICIPANTS

This section provides a description of the partners and participants of the Colorado Mayday operational test. Several members of the team did not participate throughout the entire project, and the extent of their participation is noted.

1.4.1 The ENTERPRISE Program

ENTERPRISE represents a forum for collaborative research, development and deployment ventures reflecting the interests of governmental entities and industrial groups. It was established by a group of U.S. states through the mechanism of a federal State Planning and Research (SPR) pooled fund. The program is currently supported by the following U.S., Canadian and European member agencies:

- Arizona Department of Transportation;
- Colorado Department of Transportation;
- Dutch Ministry of Transport, Rijkswaterstaat;
- Iowa Department of Transportation;
- Minnesota Department of Transportation;
- Ontario Ministry of Transportation;
- Virginia Department of Transportation;
- Washington State Department of Transportation;
- Federal Highway Administration; and
- Transport Canada.

ENTERPRISE periodically selects project concepts for research and test that are of interests to the members. The implementation of selected projects is pursued through allocation of ENTERPRISE funds and partnerships with the private sector. Funding of \$50,000 was allocated to pursue a joint effort in this area. ENTERPRISE subsequently identified the proposed project team.

Role in Colorado Mayday Project

ENTERPRISE undertook two principal roles within this project. First, ENTERPRISE provided overall project coordination and administration including distribution of funds and monitoring of the financial status of the project. Second, ENTERPRISE provided the platform for multi-state input to and review of the design of the Mayday system including technical standards, structure of the operating organization, added value services and other

institutional issues.

Based on Colorado Mayday and other operational tests underway, ENTERPRISE established the Multi-jurisdictional Mayday (MJM) technical committee, which involves representatives from four Mayday projects in the United States, as well as other members active in the Mayday arena. Their goal in relation to this project was to identify a set of standards that would be open and non-proprietary, and their use will allow for a network of Mayday systems capable of operating over state and jurisdictional borders. The MJM technical committee continues as a forum for Mayday projects to coordinate their efforts.

1.4.2 NAVSYS

NAVSYS was founded in 1986 by Dr. Alison Brown with the purpose of providing services in systems engineering and systems analysis related primarily to the Navstar/GPS. NAVSYS, today, is dedicated to promoting the use of GPS in a wide variety of commercial and military applications. The company actively participates with a number of organizations in the design and development of GPS-related product lines.

Role in Colorado Mayday Project

NAVSYS was a partner in the proposed Mayday project team. NAVSYS performed the role of system integrator for the Mayday project and supplied the in-vehicle hardware and the operational test Mayday workstation. System integration tasks included developing the system specifications-in conjunction with Castle Rock Consultants, and integrating the in-vehicle hardware and Mayday workstation with the mobile communication equipment and the ARC/INFO GIS package.

NAVSYS designed and built the Mayday sensors used to support the Mayday operational test. NAVSYS integrated and tested the Mayday workstation and associated communication and GPS hardware for installation at CSP Headquarters.

1.4.3 ESRI

Environmental Systems Research Institute (ESRI) was founded in 1969 as a research organization devoted to developing new techniques for managing geographical information. ESRI pioneered the development and application of a number of products and services for organizations interested in geographic analysis and mapping. ESRI is a full-service GIS company--developing, marketing and supporting the ARC/INFO@ GIS software package, and provides a range of services including needs assessments, software development, database design and development, workshops, and other consulting services to a wide variety of clients around the world.

Description of ARC/INFO Product

ARC/INFO enables the input, analysis, management and display of all forms of spatial data. ARC/INFO can generate high-quality maps, perform sophisticated analyses, and build custom maps and tables for specific applications.

Role in Colorado Mayday Project

ESRI is a partner in the proposed Mayday project team. ESRI provided a copy of the ARC/INFO GIS and supported the customization and integration of the package with the other Mayday application software. This effort included installation of the software on the control center workstation, training system users and technical consultation on customization and interface of the ARC/INFO package.

1.4.4 Cellular, Inc.

Cellular, Inc. is a cellular communications company which operates, manages and finances cellular telephone systems. Cellular, Inc. focuses primarily on the mountain and plains regions of the U.S., largely in rural service areas (RSAs). The company is the U.S.'s eighth-largest wireline RSA cellular company and provides cellular coverage over more than 6,000 highway miles.

Role in Colorado Mayday Project

Cellular, Inc. was an original partner in the Mayday project. Cellular Inc.'s primary role was to provide technical support on the integration of the Mayday system components with the cellular telephone and to assist with the identification of operational test end users from its customer base. Cellular Inc.'s participation did not cover the entire test period. They did not actively participate beyond Phase I.

1.4.5 Castle Rock Consultants

Castle Rock Consultants (CRC) was established in 1984 to apply the benefits of advanced technology to highway transportation. Since then, CRC has built a record of achievement and expertise across the entire ITS spectrum. CRC specializes in the research, development, application and evaluation of ITS technologies. The company serves private and public sector clients throughout North America, Europe and the Far East.

CRC currently provides technical support to Colorado Mayday partner ENTERPRISE. This includes coordination of meetings and workshops as well as definition and investigation of the technical projects undertaken by ENTERPRISE. CRC is also undertaking much of the

technical work to define International Traveler information Interchange Standards (ITIS) for ENTERPRISE.

Role in Colorado Mayday Project

CRC provided evaluation support to this project. CRC documented many technical and operational aspects of the project, including writing system specifications, operational procedures and user guides. CRC also defined and implemented the acceptance testing activities of the project.

CRC performed the project evaluation. This effort included the definition of evaluation goals, objectives, measures of effectiveness, partner responsibilities and evaluation methods. CRC supervised data collection and management activities. CRC also performed the analysis of the evaluation data and coordinated the development of the interim and final reports.

1.4.6 Colorado State Patrol

Colorado State Patrol (CSP) operates a dispatch center that serves Colorado travelers making cellular 911 calls. Through the dispatch center, CSP could initiate emergency response by state patrol, fire, paramedics or local authorities. The dispatchers were specifically trained to deal with traveler emergencies.

Role in Colorado Mayday Project

CSP was to serve as the dispatch center during the Colorado Mayday project. During Phase I the CSP dispatchers provided human factors feedback on the dispatch workstation display design. They also learned how the system would operate and had the processing center and dispatch station installed in their operations center. Before Phase II, management shifts occurred at CSP and the level of support provided to the project declined. They did not participate in Phase II and the equipment was moved to another facility.

1.4.7 FHWA

FHWA is supporting continued research and deployment of ITS systems that have shown proven benefits in enhancing the productivity and safety of the surface transportation system. The FHWA has funded a series of operational tests that provide emerging technology developers with the capital and direction to develop potentially cost- and life-saving transportation systems. Federal support for ITS, which has spurred activity in all sectors, was authorized formally by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), a landmark transportation authorization bill that provided funding for ITS research, development, and testing deployment. The majority of money spent at the discretion of the

FHWA has gone to fund operational tests and priority corridors.*

Role in Colorado Mayday Project

FHWA provided a significant portion of the project's funding. They also provided national perspective and direction to the project. Their role was to insure that the goals and objectives of the project were consistent with national needs. Members of the FHWA oversaw the project from inception to termination and served on the project steering committee.

2FHWA Joint Program Office, Regarding the Intelligent Transportation Systems Program, 1997

2. PROJECT OVERVIEW

2.1 INTRODUCTION

The Colorado Mayday project was to be undertaken in three phases. The first phase included the design of the prototype system and limited testing to ensure that it performed at acceptable levels. During this phase, human factors were assessed through focus groups and surveys with the intention of using the feedback to modify the system for future phases. The second phase was a limited scale deployment that would better assess the system's performance in real-world conditions. It also was used to identify the perception of users to the system. During both Phase I and II there was no testing of the system in actual emergencies. Phase III was a full-scale test deployment using 2000 drivers that would use the system during actual emergencies. During this phase, the impact of the system on emergency response times and the transportation network were to be tested and evaluated. In this section, the Colorado Mayday system and the activities of each phase are discussed.

2.2 MAYDAY OPERATIONAL TEST PHASES

There were initially three phases planned for the Colorado Mayday Operational Test. The goals and objectives of each Phase are briefly described here.

2.2.1 Phase I - Detailed System Design

Phase I involved the development of a prototype of the Colorado Mayday System that would be used throughout all three phases. This development included the following:

- Developed system specifications;
- Development and construction of the Mayday processing and display station, which included the processing and dispatch centers;
- Completion of the digital map database for the test area;
- Construction and testing of five prototype In-Vehicle Units;
- Investigation potential added value services;
- Investigate liability issues; and
- Evaluate the prototype system.

2.2.2 Phase II - Initial System Trial

Phase II involved a limited-scale system test, which was to include fifty selected participants that would test the Mayday system under simulated emergency situations. The following work was performed during Phase II:

- Mayday workstation installed at Colorado State Patrol;
- Construction of 50 In-Vehicle Units;
- Trial vehicles equipped with In-Vehicle Units;
- Participant testing was conducted; and
- System evaluated based on the results of the participant testing.

2.2.3 Phase III - Full-Scale Test

Phase III was initially planned to be a full test using 2000 participants that would test the equipment during real emergency conditions. The number of units to be deployed in Phase III was later reduced to 1000, as detailed in Section Five. The following work was to be performed during Phase III:

- Develop operational procedures;
- Recruit 2000 test participants;
- Install 2000 In-Vehicle Units;
- Operate Mayday control center to respond to emergency requests;
- Evaluate Full-scale test;
- Develop a final report; and
- Hand over Mayday to an operating company.

For reasons more fully explained in Section Five, Phase III was not undertaken.

2.3 COLORADO MAYDAY SYSTEM COMPONENTS

The Colorado Mayday system is comprised of three principal elements, as follows:

Mayday In-Vehicle Unit The In-Vehicle Unit (IVU) houses the TIDGET7 low-cost location device which provides the GPS data from which the vehicle position can be derived; the button box used to operate the system and request assistance; and the interface equipment used to control the communications system.

Communications System A two-way communications link that can transmit request

information to the control center and receive confirmation messages from the control center. For the Colorado Mayday Operational Test, the communication link was analog cellular. Users were required to use one of two Nokia brand telephones: the C-15 or variations of the C-16. Eventually, the system was proved most compatible only with the C-16.

Mayday control center equipment The control center receives all the emergency assistance request originating from the IVUs. The requests are processed identifying the vehicle location and type of assistance required. The control center routes the request to the appropriate response agency and notifies the motorist of the action taken and the anticipated response time.

2.3.1 In-Vehicle Unit

The IVU was comprised of the GPS antenna, TIDGET7 button box and driver interface, and the communications control unit. The TIDGET7 location device was a low-cost sensor able to store a snapshot of raw data from any GPS satellites that were currently in sight of the unit's antenna. The snapshot could then be analyzed at the control center to identify the location of the unit when the snapshot was taken.

The button box and driver interface provided the means for the user to activate the system. Different buttons were provided to request different types of assistance. The buttons available to users during this operational test were: Emergency; Test; Cancel; and a button whose purpose would be determined later. Emergency was to be used for emergency situations, such as being run-off-the road, an accident or medical problem. The purpose of the Test button was strictly for this operational test. It was to be used by test participants when they tested equipment

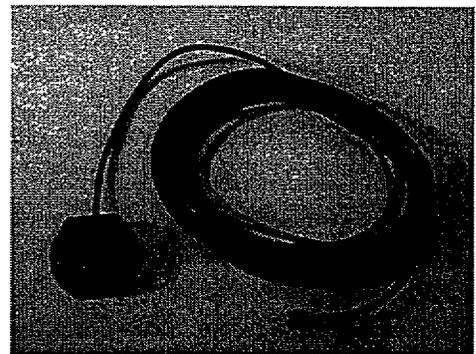


Figure 2.3.1 GPS Antenna

and wanted control center personnel to know there were no emergencies. The cancel request button was for the event of accidental system activation. It was learned during discussions with CSP that they would ignore the cancel request on all calls. Their policy for canceled calls would be that no canceled calls could be disregarded because the cancel button may have been pressed accidentally.

Through a pair of small lights, the button box indicated the status of the requestor's assistance call. It indicated whether the system was on or off, dialing the control center, transmitting data, or ready for voice communication. The LCD screen of the telephone

provides further information on request status. LCD Text messages indicated whether the request call was connected to the control center, sending data, ready for voice communication or being attempted again.

The final part of the Mayday in-vehicle equipment was the communications control module, which linked to analog cellular for Colorado Mayday. The module was responsible for accepting the appropriate message information from the button box, formatting it for the communications system, controlling the in-vehicle communications equipment to establish a connection to the appropriate control center, communicating the message, verifying receipt of the message at the control center and routing any incoming response messages to the appropriate device. In the case of cellular telephones, the communications module was primarily a cellular data modem and a cellular telephone control interface.

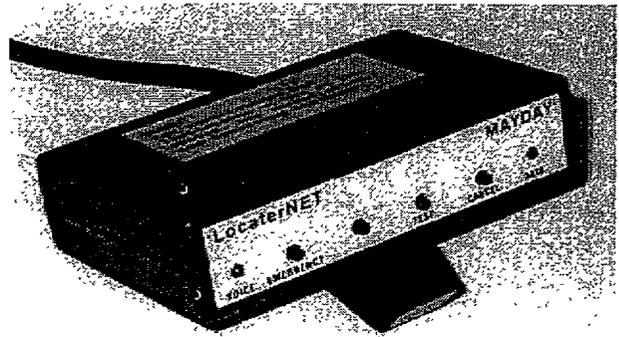


Figure 2.3.2 Button Box

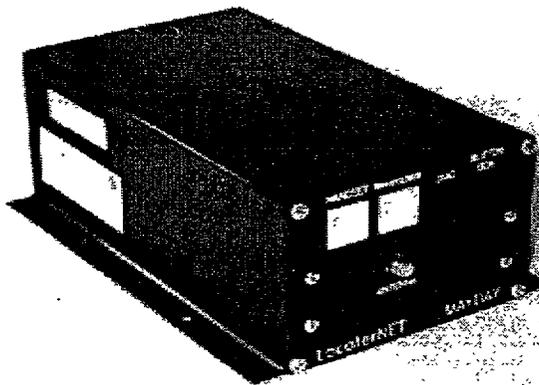


Figure 2.3.3 Communications control module - houses TIDGET

The button box was mounted in-dash or clipped to the sun visor. The TIDGET7 and communications control module were housed in a single box that could be placed under a seat, or mounted in the trunk. The TIDGET7 antenna, and cellular antenna, were magnetically mounted on a flat portion of the car exterior, such as the roof of the car, where their lines of sight are not blocked by the car.

2.3.2 Communications System

Figure 2.3.4 is a conceptual drawing of the various communications used by the Colorado Mayday system.

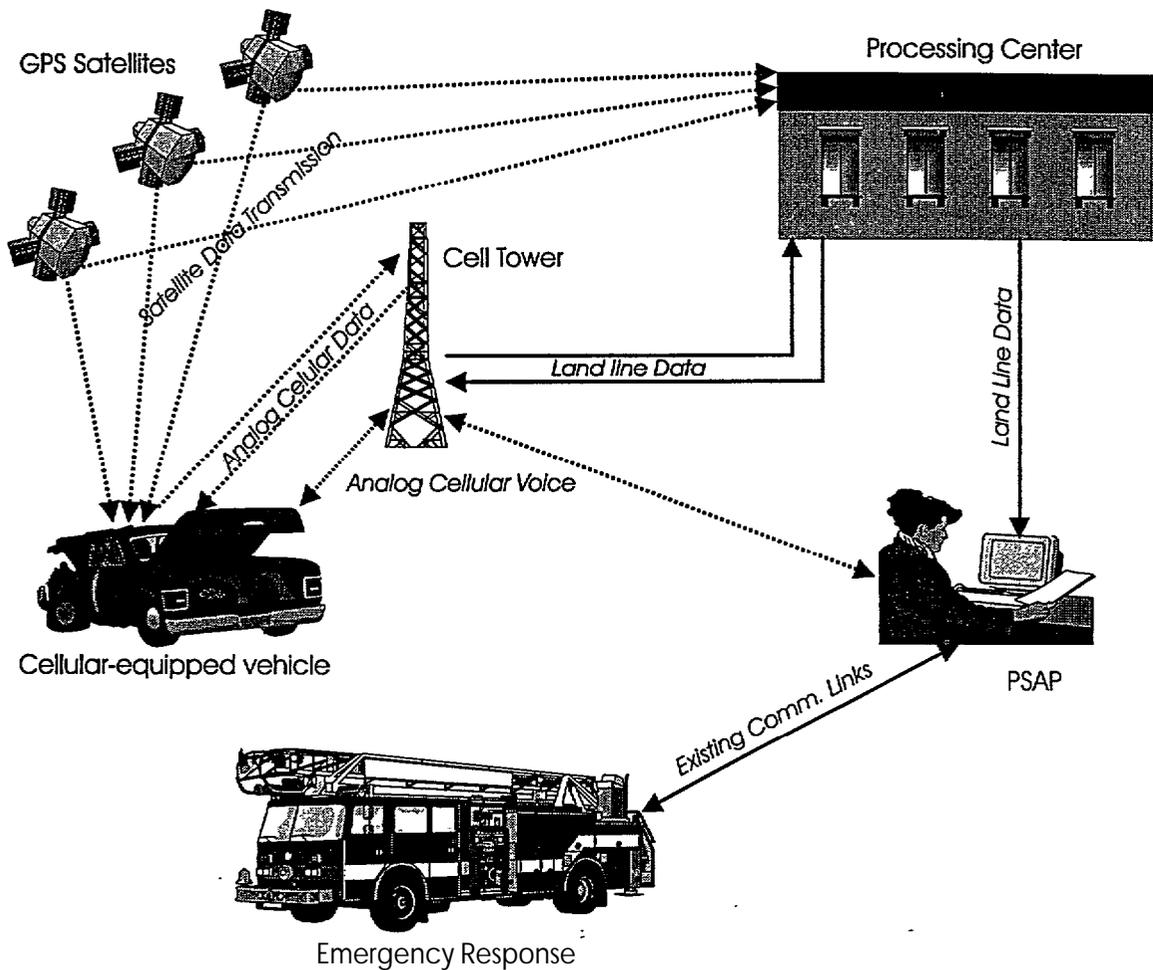


Figure 2.3.4 Conceptual Drawing of Colorado Mayday Communications

GPS data was transmitted over radio by satellites and collected by GPS sensors at the vehicle requesting assistance, and the processing center. The emergency request and GPS data were transmitted from the vehicle to the processing center by analog cellular. The cellular call was received at the nearest cellular tower and then transmitted on to the processing center through traditional land line. The cellular coverage in the test area was comprehensive, and cellular telephone was the most used wireless two-way communications system. The LCD screen on the cellular telephone provided the user with text updates on call status.

Vehicle location and requestor data was sent from the processing center to the Public Service Answering Point (PSAP) using traditional land line. Once the requestor's analog cellular phone completed the data transmission call it would dial the PSAP and create a voice link between the dispatcher and the requestor.

When the dispatcher at the PSAP had received the request, the appropriate emergency response agencies were contacted through the PUP-Responder communication links.

For test participants, cellular telephones were installed in the vehicles in the normal installation manner. The control center was connected to the mobile communications systems via conventional dial-up landline telephone.

2.3.3 Processing and Dispatch Center

The Colorado Mayday Processing Center was a network of servers that accept GPS information from the IVUs, and with that GPS information, calculated a location. The location of the device (along with any other user information) was then passed on to the dispatch station. Figure 2.3.5 is a snapshot of the dispatch screen, showing a typical call, and the accompanying record as they would appear on the dispatch screen.

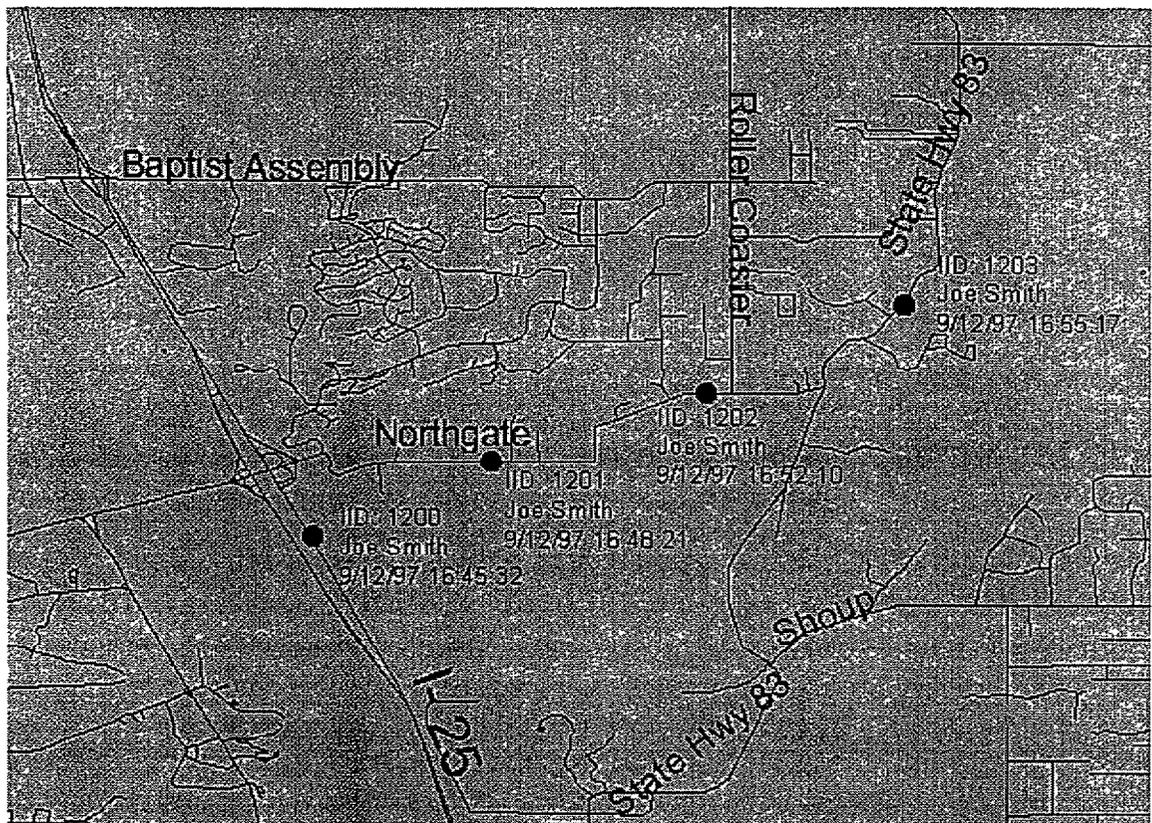


Figure 2.3.5 Typical Mayday Dispatch Screen

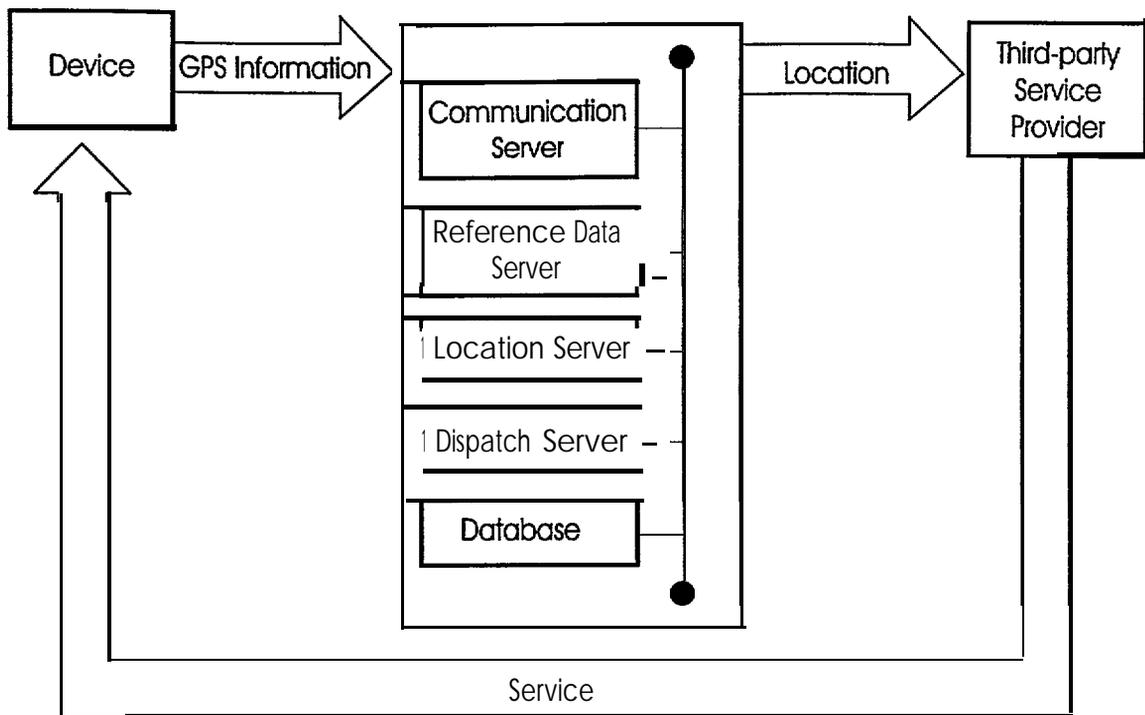


Figure 2.3.6 Processing Center Structure

The processing center was composed of the following servers:

Communication Servers

The responsibilities of the Communication Servers were to act as a gateway between the IVUs and the Processing Center, to accept identification and GPS information from the device, and to place all device information into the database.

Reference Data Server

The Reference Data Server was responsible for keeping precise and up to date information in two areas: ephemeris and differential corrections. Connected to the Reference Data Server (or "RDS") was dedicated GPS hardware. This hardware was hooked up to an antenna that was placed in a surveyed location. This took a snapshot of the GPS satellites from the processing center. Ephemeris data is the number of satellites that are visible and their locations in the sky.

Location Server

The location server implemented advanced GPS algorithms to perform two main tasks. The first task was tracking. Tracking is the process of taking raw GPS information from the device and identifying each of the visible satellites in the data. The second task was navigation. Navigation is the

process of calculating a position (latitude, longitude, and altitude) from GPS information.

Dispatch Server

Once a location had been calculated from a set of GPS information, this location, and other information, it was passed to a dispatch station?

2.4 COLORADO MAYDAY REQUEST PROCESS

Figure 2.4.1 is a conceptual drawing of a Colorado Mayday request from incident to response.

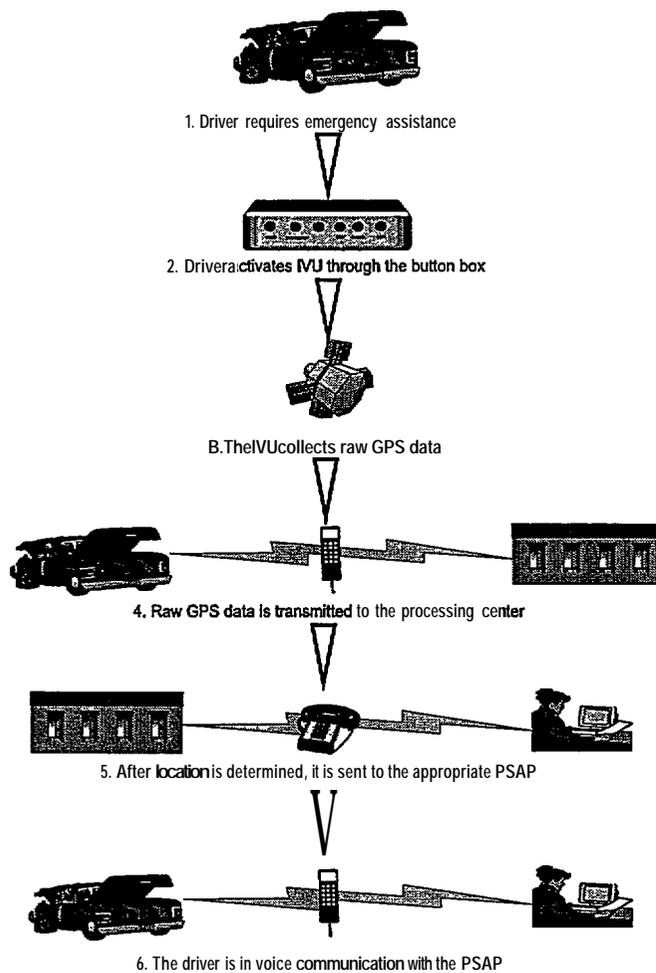


Figure 2.4.1 Colorado Mayday Request Process

1. ***Driver requires emergency assistance.*** The Colorado Mayday system is used when the driver encounters an emergency, such as a health problem, accident or threat to his life.
2. ***Driver activates IVU through the button box*** As soon as the emergency occurs, the driver presses the appropriate button on the IVU. This activates the Colorado Mayday system.
3. ***The IVU collects raw GPS data*** When the IVU button is pressed, the Mayday system collects raw GPS data through the vehicle-mounted antenna. This information is used to determine the vehicle's location.
4. ***Raw GPS data is transmitted to the processing center.*** After the antenna collects the raw GPS data, the cellular phone is activated to transmit this data to the processing center. At the processing center, additional GPS data is used to calculate a location solution.
5. ***After location is determined, it is sent to the appropriate PSAP.*** The vehicle location solution, as well as information about the driver and vehicle from the processing center's databases is sent on to the PSAP. The PSAP will dispatch the appropriate emergency response team.
6. ***The driver is in voice communication with the PSAP.*** Simultaneous to the location, driver and vehicle information reaching the PSAP, the IVU will dial the PSAP through the the cellular phone. The driver can then speak to the PSAP, confirming the vehicle location and providing further detail on the emergency.

2.5 PATH OF A COLORADO MAYDAY CALL

Once an IW is activated, the raw GPS data is collected by the TIDGET7 by way of the roof-mounted antenna. This information is sent to the Processing Center where the location is determined. If no location information is transmitted, then the call falls automatically into voice mode. If enough information is provided to determine a location, the location is identified and transmitted to the dispatch center. If there are no errors or other limitations known at the processing center, the determined location is believed to be within 100 meters and it is sent without any error notifications or warning flags. If there are known errors or other conditions that may prevent the location solution from being accurate, the location is sent to the dispatch center with a warning or error flag that identifies any potential problems. Once the raw GPS data has been sent to the processing center and that data transmission call is complete, the IVU will switch to voice mode and dial the dispatch center. The path of a Mayday call is illustrated in Figure 2.5.1.

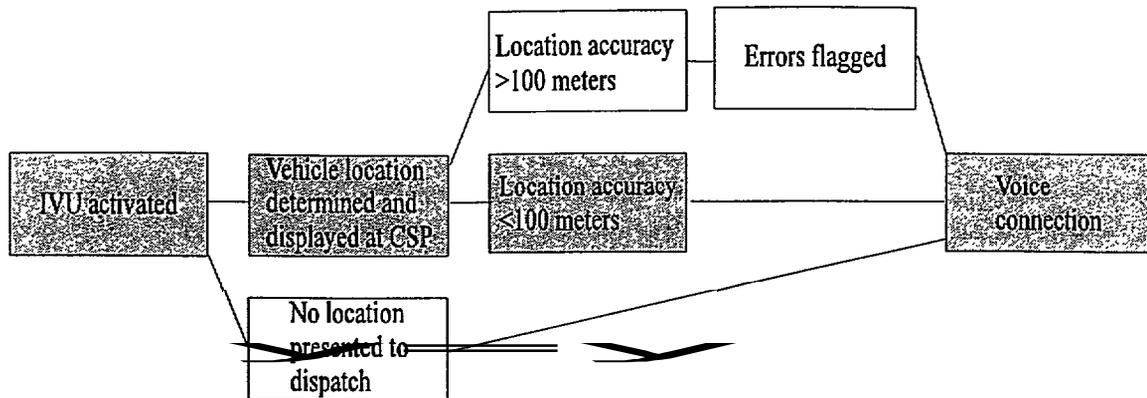


Figure 2.5.1 Path of a Mayday Call

2.6 DESCRIPTION OF GPS

GPS uses satellite triangulation to pin-point the exact location of a user on the Earth's surface. Consisting of 24 non-geostationary satellites in 6 orbital planes, the NAVSTARs operate 20,200 km above the Earth at an angle of 55 degrees, providing at least five in view of any area of the planet at any one time. In the case of the Colorado Mayday, the MJ receives satellite signals through the roof-mounted antenna and transmits these as raw information to the processing center through the TIDGET7 and cellular phone.

To triangulate, a GPS sensor collects signals from the satellites. The distance the signal travels from the satellite is imbedded in the satellite's broadcast signal. By collecting enough of these satellite signals, the location can be triangulated by triangulating the embedded distances. For most GPS receivers that calculate location on-site, four to five satellites must be used for an accurate solution. The Colorado Mayday system is unique from other GPS receivers in that much of the data processing, and time-stamping, is performed at the processing center. This, in part, allows the system to reliably calculate accurate solutions based on the position of only three satellites.

The final part of a correct positioning is to resolve any errors encountered. These occur in part from the atmosphere not being a vacuum, which slows down the radio waves (as the speed of light is only constant in a vacuum). However! the largest source of error has come about as a direct consequence of the wide availability of GPS receivers. The United States Armed Forces have made a significant effort to make the system inaccurate with intentional errors and background noise, primarily to stop terrorists from taking advantage of the targeting system. This degrading of accuracy is called Selective Availability (SA), giving the noise free channels to the military only. The Colorado Mayday processing center corrected the reported locations with corrective algorithms designed to counteract the SA background noise.

2.7 TEST AREA

The test area of this project corresponded to the dispatch area of the CSP center in Denver, which was originally planned to be responsible for the operation of the Mayday control center and dispatching assistance in response to emergency requests. The proposed test area covered over 12,000 square miles in fourteen counties. This test area was used for Phase I. During Phase II, the test area was increased to cover the Eastern Plain of Colorado. The test area included all areas east of the Continental Divide.

Within the test area was a wide range of different terrains covering open plains, mountains and a busy metropolitan area. A variety of traveler and vehicle types traveled in the test area, including business travelers, commuters, commercial travelers, and a large amount of leisure traffic, particularly skiers during the inclement winter months. Interstates 25 and 70 traversed the test area. Figure 2.7.1 shows the counties included in the original test area.

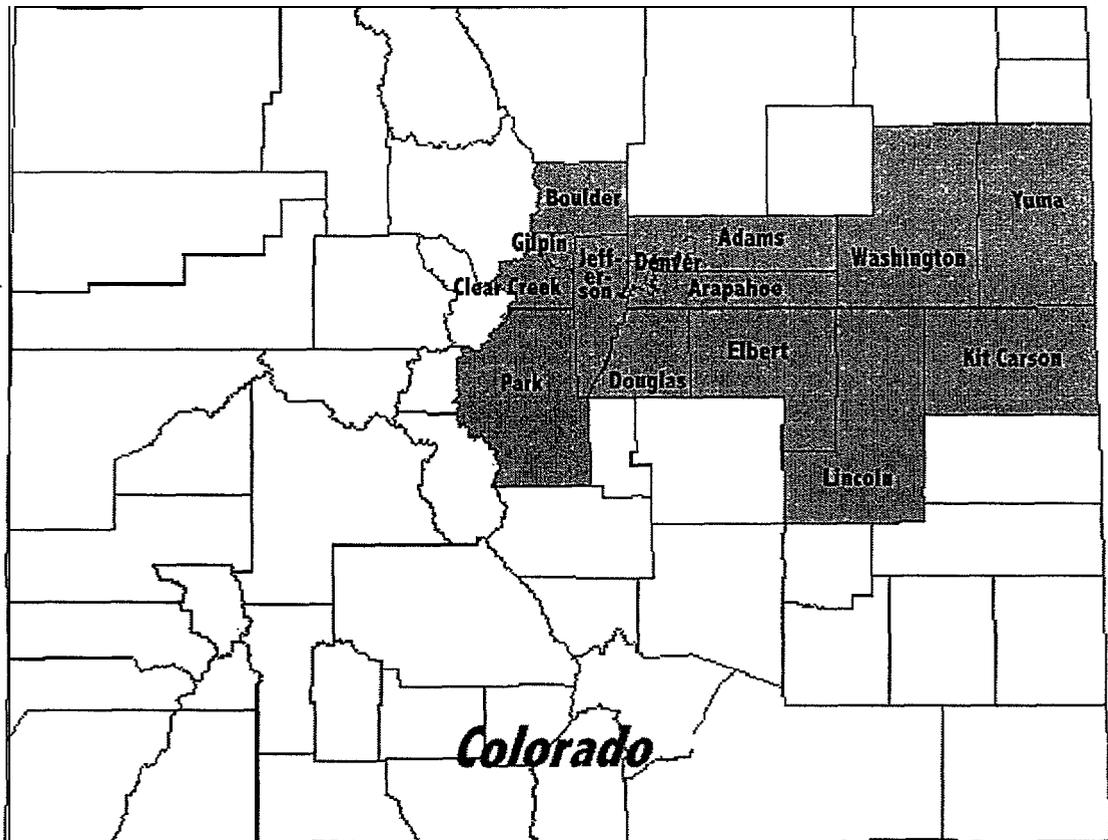


figure 2.7. 1 Colorado Mayday Test Area

3. PHASE I-DETAILED SYSTEM DESIGN

3.1 INTRODUCTION

During Phase I, the Colorado Mayday prototypes were built and tested. Each component was in its prototype phase and would change during this phase and Phase II. The culmination of this phase was the testing and evaluation of the equipment with the objective of determining whether the components were suitable for expanded Phase II testing.

3.2 GOALS AND OBJECTIVES ADDRESSED IN PHASE I

During Phase I, the Colorado Mayday system was built and underwent its first testing. This testing included the technical performance and the human factors assessment of the equipment and idea. Phase I was undertaken to ensure that the system performed well enough to support the larger deployments. The results of this Phase were used to modify and improve the system for future phases. Because the system was only being tested by project team members, only the first goal and its objectives were addressed. They were:

Goal #1: *To evaluate the effectiveness of the selected architecture in providing Mayday capabilities.*

Related objectives:

- Evaluate the ability of the communications system to transmit the required messages.
- Evaluate the coverage provided by the communications systems.
- Evaluate the ability of the in-vehicle device to permit users to request assistance.
- Evaluate the ability of the TIDGET7 location device to provide suitable location accuracy.
- Evaluate the ability of the workstation to receive and display assistance request messages to the right level of detail.
- Evaluate the ability of the system to provide response information to the end user.
- Evaluate the accuracy and suitability of the map databases used within the project.

Goal#2: *To evaluate the impact of the Mayday system on emergency response times.*

Related objectives:

- Evaluate the usefulness of the additional information the system can provide on the assistance requestor.

- Evaluate any disbenefits associated with dispatch operators not having direct voice contact with the requestor.

Goal #3: Evaluate the potential for the Mayday system to be nationally implemented

Related objectives:

- Evaluate the market response to the Mayday system.
- Evaluate the potential for added value services to make the system more attractive to the end user.

3.3 PHASE I ACTIVITIES

In order to reach achieve a functioning Mayday prototype, several activities had to be undertaken. They are summarized here. A full description of the results of this phase can be found in the “Colorado Mayday Phase I Summary Report.” This section describes the results of each effort undertaken during Phase I.

3.3.1 System Specifications

In this task; the project team prepared a detailed system architecture and a series of individual component and interface specifications. These documents were used as a guide for individual component design and ensured that the components effectively worked together.

The system architecture identified each of the individual system components and how they link to each other. The individual component specifications provided a detailed description of the required functionality of each component. This included input and output requirements, display requirements, speed of operation of various functions and size constraints. The specifications also covered any other externally driven requirements such as power consumption, database structures, or equipment requirements for a particular piece of software.

The documents resulting from this task were a set of draft standards for the construction of a Mayday system and the handling and routing of messages within such a system. The ITIS Mayday system specifications documents are included in Appendix E. It was initially anticipated that the development of these specifications would be an iterative process in that the specifications would undergo changes in parallel with component design activities. Additionally, national efforts at standardization of Mayday systems had not begun in 1994.

3.3.2 Development and Construction of the Mayday Processing and Display Station

The Mayday processing and display station used during Phase I and Phase II consisted of several servers connected in series, as described in section 2.3.3. This series of servers were developed and deployed at the CSP dispatch center. GPS antennae were installed on the CSP building rooftop, after a surveying crew exactly located the latitude and longitude of the installation point.

3.3.3 Completion of the Map Database

Six of the test area's 14 counties needed to be digitized in order to complete the CDOT digital map coverage of the test area. This activity required collection, compilation and verification of source maps. This effort was undertaken by CDOT and was completed for use on the dispatch station during Phases I and II. This map was not specifically designed for Mayday type uses, however, the project team initially believed that it would be sufficient for the Colorado Mayday project. Before Phase II commenced, it was found that the CDOT map was neither accurate enough, nor did it provide enough information, to serve the project needs. It was replaced by commercially developed maps.

3.3.4 Constructed Prototype IVU

Five prototype TIDGET7 Mayday units were built and installed for testing. These units included TIDGET7 sensors, a prototype button box, and the hardware required to interface with a cellular phone. The button box could initiate emergency calls through the operator request (button). The TIDGET7 was suitable for installation on the roof of a car, while the button box was built for sun visor- or dashboard-type installation. The prototype IVUs were used during Phase I to test the communications interface and perform an initial human factors study on the ease of operation of the button box. A detailed description of the IVU is in section 2.3.1.

3.3.5 Implemented the Prototype System Evaluation

This was a trial before the full Phase I prototype testing. It identified unanticipated issues in the testing of the Mayday prototypes through the use of the prototype workstation installed in the NAVSYS lab and a single prototype IVU. The effort in this task included implementing the experimental approach, data collection, data analysis and reporting. Additionally, the technical and human factors issues identified during this procedure were to influence final system design prior to larger scale production for Phase II. At this stage, the system was working as anticipated, and the Phase I efforts and large scale production

proceeded.

3.3.6 Investigated Potential Added Value Services

The Colorado Mayday system was designed to be a stand-alone Mayday system. However, it was envisioned that other functions could be incorporated into an integrated device. Many of the value-added services that were identified during this task have been implemented by other Mayday type systems, such as General Motors' OnStar and Lincoln/Mercury's Rescu.

This task focused on the identification of other services or capabilities that could be generally supported by the Mayday architecture. This analysis was undertaken with a view to determining ways of making the system more attractive and possibly more cost effective to the end user or to the control center operator. The results from these analyses and investigations were to provide input to the definition of the operating company/public/private partnership requirements and to the overall system evaluation.

The additional services that were investigated included: person finding, stolen vehicle location, personalized Automated Traveler Information Services (ATIS) using in-vehicle interface, probe vehicle travel time reporting, yellow pages/tourist information by specific location, and personalized directions from current location. The documentation of this effort is described in more detail in Appendix A.

3.3.7 Investigated Liability Issues

The law firm of Miller & Welch was enlisted to investigate, quantify and make recommendations on the liability and other legal issues associated with the Mayday system. The issues were investigated from both the public and private perspectives. The result of Miller & Welch's work is summarized here:

Liability

1. Colorado State Patrol - Their negligence primarily involved their role as a responding "911" entity and the possible claim by a plaintiff that they were negligent in their duties. Miller & Welch cited most jurisdictions recognize in general that the police and safety departments have a duty to provide police or law enforcement assistance to the general public. However, the Mayday device may create a "special relationship" between police and the general public where the police has accepted a "special duty." The obligation of the state in such cases is often case specific.
2. Private Monitoring Companies - The liability of a private company can be limited by an agreement or contract signed by all parties, according to Miller & Welch. This amount

can be in the form of a rebate of part or all of the fees the company collects from a client. The rationale is that the monitoring company is not an insurance company, but strictly is providing a service. Exceptions to this rule are generally when the monitoring company misrepresents or misinstalls their product.

Damages

The damages that can be collected by a party should be limited to those which probably would have been avoided, had the Mayday signal been sent, received, and responded to properly. Additionally, the amount of damages that the Mayday system is responsible may be a percentage of the total damages, depending on the involvement of other liable parties. Mayday may result in similar damage claims against State Patrol and the monitoring company, if they do not respond appropriately to a call.

Privacy Concerns

Information from the Mayday system may be used by tow truck companies and others to identify recent accidents and deploy their personnel before others. Intercepting wire and wireless communications is illegal in Colorado, and any interception by a company would be a criminal offense. However, Miller & Welch said that State Patrol and monitoring companies should train their personnel about to whom they may and may not divulge certain information.

Avoidance of Limitation of Liability

Miller & Welch also identified several strategies to help the state and monitoring companies limit their exposure to liability, including purchasing insurance policies, properly enforcing existing State laws, and having users sign a contract that clearly outlines the responsibilities of each party.

The complete report “Legal Evaluation of Mayday System” provides more detail regarding each area summarized here. It can be found in Appendix B.

3.4 PHASE I-PROTO TYPE SYSTEM EVALUATION

There were two parts to the Phase I evaluation: the technical evaluation; and the human factors evaluation. The technical evaluation focused on the location accuracy and data transmission reliability of the system. The human factors evaluation examined the acceptance and usability of the Colorado Mayday system, both through testing and focus groups.

3.4.1 Technical Performance

The purpose of the Phase I technical performance evaluation was to assess system accuracy, system reliability and area of coverage. The remainder of this section is devoted to the following evaluation issues:

1. Under a range of cellular signal strengths, how accurately is the Mayday system able to locate vehicles?
2. What numbers and types of error flags are reported, and how significant is each one?
3. What is the coverage area of the system?
4. How accurate is the map database used for the dispatch computer?

Data collection occurred over a four month period, and involved the entire test area of 14 counties (shown in Figure 2.6.1). Demographics included sparsely populated remote areas, moderately populated suburban areas and densely populated urban areas. Specific locations were selected along each test route to test Mayday's performance in various surroundings, under a variety of conditions.

Cellular telephone service tested in Phase I did not include any roam features. Those areas not supported by the default cellular provider were not tested.

3.4.2 Data Items

Data was collected manually within the test vehicle and automatically through a cellular link to the Mayday Processing Center. Manual collection included:

- vehicle location plotted against 1:50,000 USGS topographical maps;
- cellular signal strength as displayed on the cellular phone LCD display; and
- vehicle latitude and longitude computed by an in-vehicle independent GPS receiver.

Data was automatically collected by triggering a roof-mounted TIDGET7 through the in-vehicle button box. At the completion of each test day, NAVSYS provided CRC with a summary of the computed vehicle location, the number of satellites tracked and any errors accompanying each transmission.

3.4.3 Technical Assessment Approach

A two step data analysis approach was used to assess system accuracy under a variety of cellular conditions. Step One determined in which cases and under what conditions the system computed a valid position. In Step Two, valid positions were assessed for locational accuracy.

3.4.3.2 Determination of valid positions

The cellular coverage at every point where a test was made has been placed into three categories as follows:

1. **Good Cellular Coverage.** Optimum or nearly optimum cellular signal strength. Typically, this indicates good line quality capable of supporting good quality voice calls and occurs within metropolitan areas, on the Interstates and within a mile of a cellular transmission tower.
2. **Marginal Cellular Coverage.** Very good to good cellular signal strength. Frequently, a voice call at this strength will suffer from occasional static, but the call will not be dropped. Data is more sensitive than voice to static, and may suffer from this level of coverage quality. Typically this is found farther from cellular towers and in rural communities.
3. **Poor Cellular Coverage.** Little or no cellular signal strength. Voice calls at this strength are almost impossible and susceptible to being dropped or fading. Data will not transmit. This coverage is usually associated with crackling, static and occasional periods with no service during the call.

A valid position is defined as a solution without any error flags in the GPS solution or vehicle location message. System generated reports supplied by NAVSYS have been separated to represent the total number of calls placed against the number of valid and invalid positions determined. Table 3.41 includes all of the tests performed and represents this comparison.

	Number of calls				
	Good cellular coverage	Marginal cellular coverage	Poor cellular coverage	Total	Percentage of all connecting calls
Valid position determined	277	71	40	388	87%
Invalid / no position determined	37	12	7	56	13%
Total calls attempted	314	83	47	444	100%

Table 3.4.1 Valid positions vs. invalid positions

The connection rate represents the percentage of time that button box activation results in a connection with the Mayday Processing Center. Connection rate was directly related to the cellular signal strength. This can be seen clearly in Table 3.42.

	Good cellular signal strength	Marginal cellular signal strength	Poor cellular signal strength
Connection rate	95%	90%	76%

Table 3.4.2 Connection rates by cellular signal strength.

3.4.3.2 Analysis of valid positions

Positions reported as valid will ultimately lead to the dispatch of an emergency response team, preferably without voice confirmation. The ability of such a team to locate the vehicle hinges on the accuracy to which the Mayday system computes the vehicle's position. CRC compared the observed latitude and longitude and the Mayday System calculated latitude and longitude at each test location. From this comparison, the absolute difference was calculated as the distance (in meters) between the observed location and the computed location. The location reported by the independent GPS receiver was used as an additional source of verification. Table 3.4.3 presents the statistical results of this comparison.

Cellular signal strength	Number of calls	Mean absolute difference	Standard deviation
Good	277	81.6	84.9
Marginal	71	71.0	32.6
Poor	39	82.1	97.8
Total	387	79.7	79.6

Table 3.4.3 Accuracy of valid positions

Table 3.4.4 presents the valid test calls separated into four categories describing absolute difference between the actual mapped location of the test point and the point identified by the Mayday system.

Cellular signal strength	Absolute difference (number of calls and percentage of calls)				
	O-99 m	100-199 m	200-299 m	300+ m	Total
Good	240 87%	26 9%	7 3%	4 1%	277 100%
Marginal	59 83%	11 16%	1 1%	0 0%	71 100%
Poor	33 85%	5 13%	0 0%	1 2%	39 100%

Table 3.4.4 Absolute difference between computed location and map-read location

It is important to note that the absolute differences do not necessarily represent system errors. Mayday system computed results were compared against map readings, which are themselves subject to inherent mapping errors and subjective interpretation.

3.4.4 Analysis of Error Flags

During Phase I testing, seven types of error flags could be encountered, warning of possibly inaccurate position determination. These error flags are described below:

INSUFF MEAS If present, indicates that an insufficient number of satellites were available to determine a solution.

RAIM ALARM	Indicates that the position solution is invalid with respect to the RAIM test. This error results in location solutions that were within 500 meters of the actual location, but not consistently off by the same amount.
0 or 1 CHANNEL	This error is the result of there not being an adequate number of satellites visible to the vehicle antenna in order to compute an accurate solution. It can occur when the vehicle is in a canyon, between tall buildings or anything else that may block the path between the satellite and TIDGET7 . This error usually resulted in either no solution or a highly inaccurate and imprecise solution.
GDOP HIGH	Indicates that the position solution is inaccurate due to poor satellite geometry.
TWTERORR	Indicates an error was detected in the vehicle location message. This error was not encountered in Phase I testing.
RES TOO HIGH	Indicates too high a value in the residual test (representing the difference in observed distance from vehicle to satellite and actual difference).
MSG DELAY	Indicates that an unacceptable delay has occurred in capturing the TIDGET7 information. This error was not encountered in Phase I testing.

The severity of the error, in terms of the validity of the computed location, depends on which flag is encountered. The following is an explanation of the implications of each error encountered during Phase I testing:

1. INSUFF MEAS - This indicates that the system did not receive enough information from the TIDGET7 and no location is determined. Though it was originally intended to indicate that not enough satellites were visible to the TIDGET7 antenna, it is generally associated with a poor cellular connection. It was the error most frequently encountered in Phase I testing, accounting for more than half of the errors.
2. RES TOO HIGH and RAIM ALARM - In most cases the computer can still compute a solution but the results can be 10 to 30 kilometers off. In the presence of either error the dispatcher should always attempt to speak with the driver to obtain the correct location.
3. GDOP HIGH - This is an minor that often does not noticeably affect the solution accuracy. Of the 12 times that GDOP HIGH was encountered, more than half of the absolute differences were 100 meters or less and the average absolute difference was 166

meters. GDOP HIGH represented about 24% of the error flags seen in Phase I testing. Given that locations computed in the presence of a GDOP HIGH flag were still accurate. Three of the flagged locations were within 100 meters of accuracy.

Table 3.4.5 presents the frequency of occurrence of the various error flags.

Error flag	Cellular signal strength			
	Good	Marginal	Poor	Total
INSUFF MEAS	11	13	7	31
RAIM ALARM	2	3	1	6
RES TOO HIGH	1	0	1	2
GDOP HIGH	9	3	0	12
0 OR 1 CHANNEL	0	0	0	0
MSG DELAY	0	0	0	0
TWT ERROR	0	0	0	0

Table 3.4.5 Frequency of error messages by cellular signal strength.

Table 3.4.6 shows the success rate of calls to accurately locate a test, based on the number of total calls attempted, including those that connected, didn't connect, valid and invalid solutions.

Cellular Signal Strength	Absolute difference (number of calls and percentage of calls)											
	Error Message		0-99 m		100-199 m		200-299 m		300+ m		Total	
Good	23	8%	240	80%	26	9%	7	2%	4	1%	300	100%
Marginal	19	21%	59	66%	11	12%	1	1%	0	0%	90	100%
Poor	9	19%	33	69%	5	10%	0	0%	1	2%	48	100%

Table 3.4.6 Absolute Difference including all valid and invalid attempts

3.4.6 Map databases

All points were manually plotted on USGS 1:50,000 maps since the digital map display was not ready for evaluation purposes during Phase I. The digital map display would have

automatically overlaid test locations on the digital maps, which might have resulted in a higher level of accuracy. Errors in manual point placement would have been eliminated, and more exact placement of all points would have been likely.

3.5 HUMAN FACTORS

The human factors assessment focused on two user groups: the traveling public, whose needs were evaluated using formal focus groups; and Colorado State Patrol dispatchers, the concerns of which were established through an operable Mayday dispatch demonstration and subsequent focus group. The results of these assessments are presented below.

3.5.1 Human Factors Assessment: Traveling Public

Two focus groups, involving the traveling public, were arranged and professionally facilitated. Participants of the focus groups were separated by sex in order to foster more open and interactive conversations. Participants were selected by random telephone calls and the following general criteria:

- ownership of a cellular phone - a spread of owners vs. non-owners in each group;
- driving habits - at least half of each group must drive 30 or more miles per day;
- age - spread between 21-65+;
- total household income - spread between \$25,000-65,000+, biased towards higher incomes; and
- occupation - a variety of occupations.

Eight women and twelve men participated in the two hour sessions, which were audio taped and observed. Several slides and handouts were used to clarify the components and operation of the Mayday system.

Bruce Hutton, of the University of Denver, moderated the groups using a protocol developed with guidance from CRC. The protocol stimulated discussions about participants' previous driving experiences, driving concerns, the Mayday concept, perceptions of the current design and, market issues. Results of these discussions are presented as follows:

- Driving experiences and concerns;
- The Mayday concept and perceptions of the current design; and
- Market issues.

3.5.2 Driving Experiences and Concerns

The male participants were primarily concerned with the possibility of vehicle break-downs, while the women were concerned about the risks of accidents. Both groups expressed serious concern about car-jackings or violence, especially in the event of car problems. Most of the participants had been involved in or observed some sort of driving mishap and at least one of the participants in each group had been in a major accident.

3.5.3 Perceptions of the Mayday Concept and Current Design

To introduce the discussion of the Mayday concept, Dr. Hutton presented a little background on the basic design of the system, including a brief, non-technical explanation of how the GPS ties into the system. When he finished his explanation, Dr. Hutton probed the focus group participants for reactions.

The women were immediately skeptical of the system. They questioned the added value of the Mayday system over a regular cellular phone and were quick to point out limitations of the cellular network as a data transmission medium, especially in the mountains. Both groups suggested that satellite communications might be a better means to transmit data than cellular phone, hoping to resolve the problems of poor line quality and home service areas. The men immediately recognized the value of the GPS for location information, whereas a few of the women, who did not fully understand how GPS works, were concerned about the Big Brother implications of a system that transmits the location to a command center.

Both groups also brought up the need for automatic activation, in case the occupants of the vehicle are unconscious. Though this was cited as an important feature, there were also concerns about false alarms. Just as important was the durability of the system; both groups wanted a system that would survive any crash.

In both groups, the conversation turned, unprompted, to car-jackings. Most of the participants were concerned with this possibility, more so than the possibility of running off the road in the snow. In the ensuing conversation participants debated the optimal design for the system so it could be used in the event of a car jacking. Design considerations included eliminating the callback so a car-jacker would not know the police were aware of the situation and only having one button so the system could be triggered discretely, without the need to discern which button is being pushed.

Contrary to the car jacking discussion, there was a strong consensus in both groups to have a test button and a way to cancel an erroneous call. The conflict between the need for a simple button box and the need for both a test button and a cancel button meant there was no consensus on how simple or complex the box should be.

Men and women differed slightly on who they would like the system to summon in case of activation. Both groups agreed on police and emergency medical assistance. Additionally, the men were interested in road service and tow trucks whereas the women wanted to be able to contact their personal homes and the fire department. When discussing roadside assistance, the men were very concerned with being able to have the towing company of their choice in their profile in order to avoid the outrageous prices of many towing companies.

When asked what was the single most important feature of the system, participants responded with the following: reliability, peace of mind, safety, location information, ability to access emergency assistance from any location, affordability, obsolescence and transportability. Reliability was clearly significant, with many of the participants citing it as the most important feature.

3.5.4 Market issues

To open the discussion of market issues, the participants were asked what they expected to pay for such a unit. Responses for the cost solely of the in-vehicle-unit ranged in price from \$100-300 (women) and \$300-800 (men) with the stipulation that transmission reliability must be almost perfect. When offered the price of \$150 with a \$5 to \$20/month charge for the service, most of the participants agreed this was a reasonable price and, more importantly, that they would buy the unit.

There was interest in a variety of marketing schemes, especially leasing, which both groups suggested as an option. The primary reason for the interest in leasing was to avoid purchasing soon-to-be-outdated technology, though participants recognized that the changing technology may preclude an affordable lease.

The women were far more concerned with price structures and aware of various current pricing schemes. They suggested that providing the Mayday unit free of charge and then charging a higher monthly fee might be an attractive option. As another option, some of the participants were interested in the ability to rent the units for short periods of time for use during vacations.

3.6 HUMAN FACTORS ASSESSMENT: DISPATCHERS

A simulation dispatcher workstation was operated by Colorado State Patrol dispatchers for approximately two weeks. Dispatchers were asked to fill out response surveys following each demonstration session, and an informal focus group involving dispatcher representatives followed this demonstration.

The purpose of the demonstration was not to demonstrate the ultimate configuration and operation of the system, but rather to obtain preliminary feedback from dispatchers about which issues are important to the acceptance of a user workstation. The following is a summary of the dispatchers' responses to the demonstration.

3.6.1 Overview

The majority of the dispatchers' comments regarded the slowness of the demonstration system and the system's tendency to crash. Based upon these and other responses from the dispatchers, CRC has cited the following issues as critical to the dispatcher acceptance of the Mayday system.

- system speed;
- system reliability;
- user Friendliness;
- map usability;
- information overload; and
- dispatcher training.

3.6.2 Description of Critical Issues

3.6.2.1 System speed

Dispatchers expressed the need for the system to not hinder the rate at which they currently answer and process calls, and dispatch required response vehicles.

3.6.2.2 System reliability

Dispatchers were frustrated with the tendency of the demonstration to crash, and freeze up. They expressed that the system should perform reliably, with minimal failures.

3.6.2.3 User friendliness

The dispatchers cited their preferences for a very user friendly system, requiring minimal computer experience. Specific issues which surfaced regarding the user-friendliness were:

- understandable and usable icons;
- comments written in an understandable language;
- easily maneuverable windows and maps;
- warning tones indicating Mayday calls; and
- safeguards against improperly altering system files.

3.6.2.4 Usable maps

The map database used in the demonstration lacked sufficient detail to be useful to the dispatchers. Dispatchers indicated that highway numbers and road names were essential, and addresses and locations of police stations, fire stations and hospitals on the maps would be helpful additions to the maps. Also desired were certain landmarks that the Colorado State Patrol uses, and the CSP district and troop boundaries.

The road name issue was resolved for Phase II, when the TIGER 92 digital maps were used instead of the CDOT developed maps. The system was able to identify the road names in the vicinity of any incident. Addresses were not added at any time. Neither were other features such as police and fire stations or CSP troop boundaries.

3.6.2.5 Information overload

Dispatchers expressed concern about receiving more information about the distressed vehicle than is necessary. Dispatchers expressed an interest in receiving minimal information in an easily read and understood format. The “minimal” vehicle information CSP requested to accompany the vehicle position is:

- the make, model, year and color of the vehicle;
- the license plate number;
- the vehicle identification number (VIN);
- the name of the registered owner (or troop for CSP cars); and
- the phone number of the cellular phone in the vehicle.

One dispatcher mentioned that the secondary information could be presented on a different screen that the dispatcher could bring up if he or she needed it.

3.7 ACTIVITIES PRIOR TO PHASE II

At the completion of the formal testing performed in Phase I, the system was performing to the expectations of the project team. One of the purposes of the first Phase was to verify the performance of the system before the manufacture of the equipment needed for Phases II and III.

There were many technological changes that took place throughout Phase I. Prior to moving forward with Phase II, the independent evaluator felt that additional testing of the system was necessary to ensure that it still performed to the level it had during Phase I. This testing went through several iterations as NAVSYS modified and refined the various system components. The start of Phase II was delayed by almost a year before the system was deemed functional

enough for Phase II. At this point, the steering committee directed NAVSYS to move forward with the manufacture of 2000 IVUs.

NAVSYS ended the first phase planning to build the 2000 units to accommodate Motorola and Nokia cellular phones. Their assumption moving forward was that the Motorola vehicle-based phones were plentiful and would provide a large enough pool to select Phase II and Phase III participants from. They also believed that little modification would be needed for the Motorola phones to work with their IVUs. Both of these assumptions proved false. The system only worked with Motorola phones through a “cellular connector,” which is a modem-like device that added \$200,000 dollars to the cost of each Mayday IVU. The additional cost could not be absorbed by the project budget. In light of this fact, NAVSYS attempted to work with several manufacturers who built cellular connectors into their phones at no charge, however, only Nokia provided the technical specification for their phones. NAVSYS redesigned the system to optimize performance with the Nokia C-15 and C-16 phones. In light of the limitations on the other phone system, a decision to exclusively use the Nokia C-15 and C-16 analog cellular phones was made by the project team.

Before the project could move forward, the first fifty of the 2000 IVUs had to be produced for use in Phase II. The manufacturer contracted by NAVSYS to produce the IVUs delayed their production several times due to quality control issues. The units were to be delivered in early 1996, but actually were not produced until later in the year.

Prior to Phase II the key supporter of Colorado Mayday at CSP left her position and the new staff was not as enthusiastic about Mayday. The Colorado Mayday project team decided that the new environment at CSP was not stable enough to ensure the appropriate level of support. The processing center and dispatch station were removed from CSP, and prior to Phase II testing they were installed at the NAVSYS offices in Colorado Springs.

With the number of changes and delays that occurred between Phases I and II, the project steering committee directed further acceptance. As part of the evaluation efforts, a considerable number of tests were performed. During the acceptance testing, NAVSYS continued to refine and modify the system. It was accepted as suitable for Phase II testing in February, 1997.

4. PHASE II - INITIAL SYSTEM TEST

4.1 INTRODUCTION

The Phase II evaluation of the Mayday project was designed to identify the performance of the system with a larger number of prototype units to more fully exercise the system architecture in a real-world environment. In addition, it evaluated the response of people that could potentially be end-users of the system design.

The Phase II evaluation focused on exercising the system over the complete test area and evaluating its performance under multiple request scenarios. The intent was to make testing in Phase II a small-scale simulation of the full-deployment planned for Phase III. A group of users was asked to conduct frequent tests and document their experiences, both in terms of system performance and usability. Additionally, the independent evaluators and the Colorado Department of Transportation performed additional tests to ensure that a satisfactory amount of data was available for the system performance evaluation. This section describes the results of each effort undertaken during Phase II.

4.2 GOALS AND OBJECT WAS ADDRESSED IN PHASE II

Phase II was used to explore the real-world performance of the Colorado Mayday system. Additionally, the use of participants that were not part of the project allowed for further exploration of the human factors and market potential of the Mayday system. The goals and objectives partially or fully addressed in this phase were:

Goal #1: *To evaluate the effectiveness of the selected architecture in providing Mayday capabilities.*

Related objectives:

- Evaluate the ability of the communications system to transmit the required messages.
- Evaluate the coverage provided by the communications systems.
- Evaluate the ability of the in-vehicle device to permit users to request assistance.
- Evaluate the ability of the TIDGET⁷ location device to provide suitable location accuracy.
- Evaluate the ability of the workstation to receive and display assistance request messages to the right level of detail.
- Evaluate the ability of the system to provide response information to the end user.
- Evaluate the accuracy and suitability of the map databases used within the project.

Goal #3: Evaluate the potential for the Mayday system to be nationally implemented.

Related objectives:

- Evaluate the market response to the Mayday system.

4.3 PHASE II ACTIVITIES

In order to move toward full deployment with the prototype proven satisfactory in Phase I, a number of rigorous test activities were performed. The activities are summarized here.

4.3.1 Installation of the Mayday Control Center at State Patrol

In this task the Mayday Control Center was installed and tested at the CSP Headquarters. This included the physical installation of the Location Server, Reference Data Server, Communications Server, and the Display Computer into the State Patrol Dispatch Center. The GPS reference receiver was installed in the building, as well as the appropriate GPS antenna cables. It was not directly connected to the State Patrol's dispatch center and operated as a stand-alone unit with its own telephone lines for data and voice communication.

Prior to the participant tests in Phase II, State Patrol withdrew from the project. The control center was moved to NAVSYS in Colorado Springs for the remainder of Phase II.

4.3.2 Built IVUs

50 Mayday units were to be built for installation on vehicles in support of the initial system trial. The units included TIDGET⁷s communication control devices, button boxes, and the necessary wiring and mounting equipment.

An initial set of communication control units were built and then had to be changed to function with the specific phones of the users. The Nokia C-15 and Motorola did not have a data toggle capability which could be used to control the transition from data transmission to voice. The Nokia C16 phones had data to voice transition capability, but required the firmware. The different firmware for the Nokia C-16 and C-16 Gold were necessary because of slightly different specifications.

4.3.3 Selection of Phase II Participants

This task consisted of three principal activities: identification of appropriate test vehicles and drivers; equipment installation and training; and field testing.

4.3.3.1 Test participant selection

Recruitment had contractually been the role of NAVSYS, however, all project partners undertook the effort to identify 50 participants. Many of those recruited for the project already had cellular phones. However, as described in section 3.7, only one specific model of phone was usable with the Colorado Mayday equipment. Many of the recruited participants withdrew from the project rather than buy a new phone.

During Stage 1, CDOT recruited 11 volunteer test participants that had or were willing to buy Nokia phones for Phase II testing. These 11 participants were unaffiliated with any member of the Colorado Mayday Operational Test team. Participant selection was based upon criteria within the following categories:

- participant's ownership or willingness to purchase a Nokia C-1 5 or Nokia C-1 6;
- willingness to complete required activities; and
- typical driving behavior.

Because of the low number of participants, three members of the Colorado Mayday team also participated in an effort to increase the number of total tests. These people were familiar with the system. A portion of Phase II focused on evaluating users' perceptions and acceptance of the system. Because their opinions were biased by their previous knowledge, the members of the Colorado Mayday team did not take part in the human factors testing.

Additionally, a single participant that was not a Mayday team member conducted further testing in a later second stage of Phase II. These tests were used strictly to assess the impact of changes made to the Colorado Mayday system during Phase II.

Mayday Phase II was originally planned to begin in early 1995 and recruitment efforts began at that time. As is with many emerging technologies, however, the optimal Mayday system design was not yet finalized due to repeated system design modifications, quality control and quality assurance issues and equipment production delays, testing didn't begin until almost two years later.

4.3.3.2 Equipment Installation, Training, and Equipment Testing

CDOT installed the IVUs for the Phase II participants. Each participant was responsible for installing his cellular phone in his vehicle as he desired, and CDOT would then install the MJ and TIDGET 7. The TIDGET 7 sensor was placed on the roof and the button box was

placed on the visor or dash of the vehicle. The communications control unit, which is the largest piece of equipment, was placed in the trunk or under a seat, depending on the driver's preference.

At the time of installation, CDOT reviewed the activities required for participants. Phase II participants were asked to perform a minimum of five tests per week for approximately 10 weeks. The specific requirements of each test were included in the Mayday Operational Test Phase II Data Log, which was provided to all participants.

The most frequent test method required a participant to trigger the MJ test button and verbally explain their position over the voice communication link to a voice mail box. Volunteers were also asked to fill in a supplementary in-vehicle log at the time of each test. Log data, both verbal and written, included the following:

- time and date of test;
- current weather conditions;
- location of vehicle, including a physical description;
- comments on the operation of the Mayday unit.

In order to familiarize the participant with the equipment and to ensure that the instructions were understood, CDOT attempted test calls with the participants and described each step of the process. The data sent by the test call was used to verify that the system was working and accurately locating the vehicle.

4.3.3.3 Field Testing

There were two stages to Phase II. During the first stage of Phase II, volunteer participants tested the equipment during their daily routine. These tests were conducted to assess the usability and acceptance of the Colorado Mayday system. During the second stage, the performance of the system's components was tested. The results of the first stage were used to evaluate Usability and Acceptance, and the results of the second stage were used to assess Technical Performance.

During Stage 1, the three team member participants performed their tests identical to the 11 non-member participants. The 14 testers drove their normal daily routes and stopped to test at times and locations chosen by themselves. The purpose of this testing was to gather data over all times of the day and at a wide variety of locations throughout the test area.

Each participant was asked to conduct five tests a week for a total of 50 tests per participant. In reality, the testing covered 15 weeks from mid-February to the end of May. Some participants were more enthusiastic than others and the number of tests varied from a total of one test for some participants, to up to 50 for a few who were more interested in the technology. In total, the 11 non-member participants contributed 206 tests. The three team

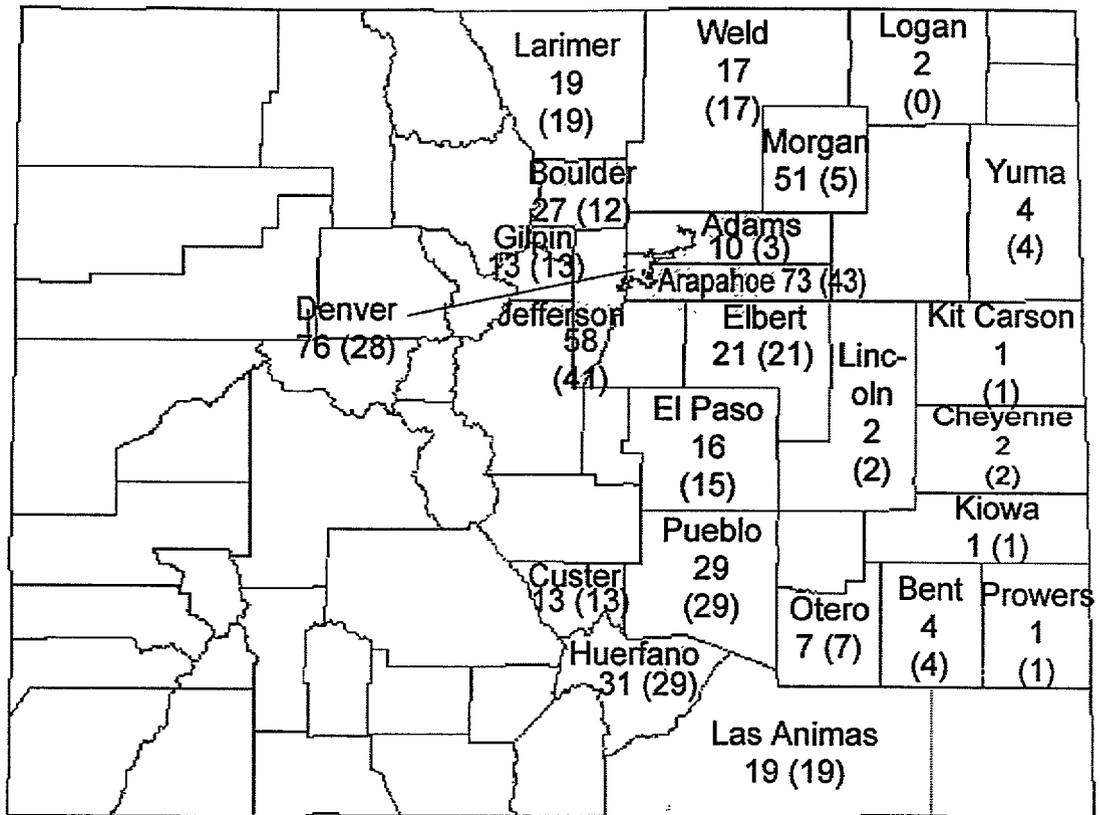


Figure 4.3.1 Stage 1 Testing (14 Participants)

member participants performed 372 tests. Figure 4.3.1 shows the number of tests for each county covered during this stage. The map shows the total number of tests conducted in each county. The number of each county's total performed by Colorado Mayday affiliated testers is indicated in parentheses.

To provide a more controlled data sample for the technical evaluation, Stage Two used a single participant who drove routes designed by the evaluator. By remaining in contact with this participant and providing her with a more complete understanding of the type of issues that were being evaluated, the results were more easily evaluated from a technical perspective. In total, the Stage 2 tester conducted 177 tests over a five day period. Figure 4.3.2 shows the test area and tests by county for the Stage 2 testing.

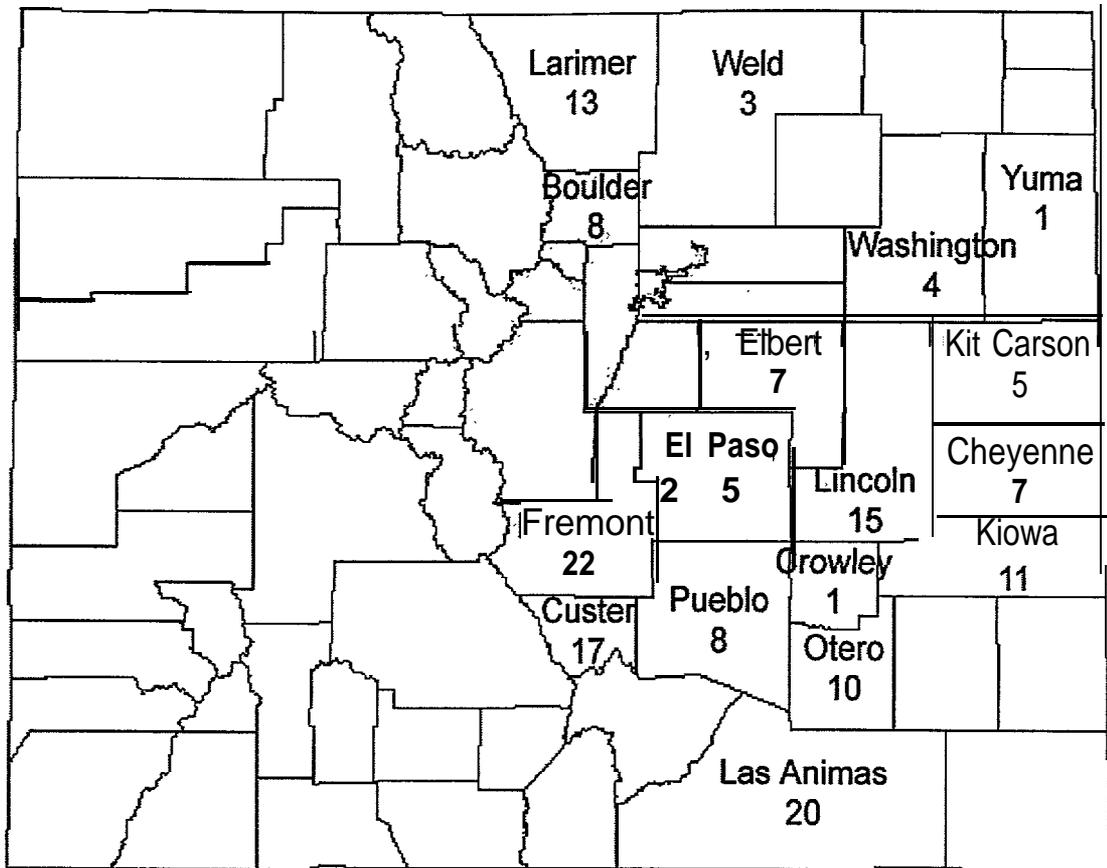


Figure 4.3.2 Stage 2 Testing (1 Participant)

4.4 PHASE II - INITIAL SYSTEM TEST EVALUATION

The Phase II evaluation focused on two areas. The first areas, Usability and Acceptance, assessed the opinions that the Phase II participants had regarding the system and IVU. The second area was the technical performance. It focused on the location accuracy and system reliability under the conditions that the typical user would encounter.

4.4.1 Usability and Acceptance

Throughout Phase II the participants were asked to document any comments about the system or its performance in their data logs. The participants were also surveyed for their impressions of the system, from both a usability and personal acceptance perspective. They were encouraged to note what they liked and disliked about the system, as well as how to

improve it. These surveys were sent only to the 11 participants that were not members of the project team. Four of the participants quit testing and declined to participate in the survey. Seven participants returned the surveys. Additional comments were collected from all participants through phone interviews and data logs.

4.4.1.1 System Usability

The seven participants' responses to the survey are listed following each question. Any analysis, and comments made by the participants, is included.

<u>Rate the ease or difficulty of using the Mayday system in your vehicle:</u>			
Very Easy 0	Easy 6	Difficult 1	Very difficult 0

Two participants stated that they had installation problems, but once those were resolved the system was easy to use. Participants indicated that when the TIDGET7 unit is stored in the trunk and the button box is attached to a visor the system is convenient and readily accessible by the driver.

Initial installation instructions are not clearly documented and most drivers would not be able to install their own units. For participants, the units were installed by the Colorado Department of Transportation, however, there- was a technical problem that prevented participants from using the unit in a 'hands-free' mode until NAVSYS provided a system upgrade. This didn't occur until after the testing had already begun.

<u>Consider the lights on four button box and the messages on the LCD screen of four phone handset and what information they give you when you are performing a test.</u>			
<u>Rate how understandable the messages from the system are:</u>			
Very understandable-1	Understandable 6	Not understandable 0	Not understandable at all 0

On the button box a solid green light indicates when the power is on. When the call is being placed, a flashing red light labeled "DATA" blinks and the Nokia phone's LCD screen reads "Calling Service Center." When the call connects and the location data is being transmitted, the red light goes to solid and the LCD screen reads "Connection Established." Finally, the green light, labeled "VOICE" flashes and the LCD screen reads "Voice Mode" when the caller is to speak to the emergency responder. Prior to testing, each participant was given a short tutorial about this process and what each step meant. After having it described to them, participants uniformly felt that the status information provided by the lights and LCD screen

was understandable and useful. The labeling and configuration of the button box was uniformly liked, however, one user believed a large, clearly labeled “emergency” button which would be easier to identify and press. Currently the Colorado Mayday button box has four buttons which are all the same color and size, and labeled similarly.

For each of the following incidents. rate the ease or difficulty of using; the Mayday unit when-			
a. You require roadside assistance for a mechanical problem:			
Very easy 3	Easy 4	Difficult 0	very difficult 0
b. You suffer a debilitating ailment that requires immediate attention:			
Very easy 0	Easy 3	Difficult 1	Very difficult 2
c. You are seriously injured in a multiple car accident:			
Very easy 0	Easy 1	Difficult 2	Very difficult 3
d. You are seriously injured in a one vehicle accident:			
Very easy 0	Easy 1	Difficult 1	Very difficult 4
e. You are run off the road:			
Very easy 1	Easy 2	Difficult 2	Very difficult 1
f. You are attacked or threatened while in your vehicle:			
Very easy 1	Easy 0	Difficult 3	Very difficult 2
g. Another vehicle needs roadside assistance:			
Very easy 2	Easy 5	Difficult 0	Very difficult 0
h. You witness a major accident, probably with injuries:			
Very easy 2	Easy 4	Difficult 1	Very difficult 0

Primarily, the configuration of the Mayday system affected how people felt it would help them in instances of potential injury. The response was generally “EASY” or “VERY EASY” in cases where participants would be uninjured and conscious, because they would be able to press the “EMERGENCY” button on their button box. However, the participants felt that the system would be “DIFFICULT” or “VERY DIFFICULT” to use if they were injured. Some respondents stated that pressing the button would be easy, but they did not anticipate being able to speak on the phone when incapacitated. Others stated that the system would be easy to use “unless I am injured,” in which case the user felt it would be very difficult. Another participant stated “I was recently injured in a car accident and I had trouble doing anything. It would be fairly easy to push the emergency button, but not use the phone.” This user did not have a hands-free phone, which is a standard feature of the Nokia C-1 6.

Another frequent comment was that the system would be difficult to use to contact emergency service providers in cases that required immediate attention, such as threat or attack. The participants felt that the time it took to complete a call was too long to be helpful. In these cases, some participants felt that it would be easier and quicker to dial 911 directly.

<u>When you make a Mayday call and it goes through on the first try, how long does it take before your call goes to “Voice Mode”?</u>				
Less than a minute 0	About a minute 3	About two minutes 4	About three minutes 0	More than three minutes 0

From the moment the participant uses the button box to try to get help to the moment the phone goes into voice-mode is usually close to two minutes. During this time, the unit collects the GPS data, dials the processing center, “handshakes” modems and sends the IVU collected data. The time to collect the GPS data and actually transmit it is a slight fraction of the overall time. The rest is spent dialing, waiting for a response from the processing center, handshaking and terminating the call. One tester noticed that the processing center was set up to not answer calls until after several rings. This delay could be crucial in an emergency. The other steps in making a Mayday call could also be shortened in time with enhanced software and hardware.

4.4.1.2 Perceived Reliability

<u>How often are you unable to successfully conduct a test because of a Mayday system malfunction?</u>			
Never 0	Rarely 1	Occasionally 5	Frequently 1

At the beginning of the testing period, the system was not operational all the time, because it was being modified. During this time, many participants reported an inability to connect to the system, or that the voice mode was not functioning. After the first two weeks, however, these issues were resolved and the system performed consistently throughout the remainder of tests.

The following issues were commonly mentioned by participants:

- No connection. Occasionally, the system would not connect at all. In most cases this happened because of poor cellular coverage where the caller was located. However, some users experienced busy signals and others indicated that cellular strength was good and there would still be no answer.
- No voice connect. The system would occasionally not follow up the data transmission with connection to the voice mode. In some cases, the system would try to switch to voice mode, but the telephone remained in the data transmission mode and so no voice communication was possible. Other times, the system was unable to make the voice connection, either because of a busy signal or misdialing by the system.
- Unable to clear system. Several participants stated that on some occasions, the phone would not clear from the previous test attempt. This meant that the system was not available for another attempt. To clear the system, the participant had to turn the vehicle off, disconnect the phone, or disconnect the IVU.
- Cancel function doesn't always work. A few participants had difficulty with the "CANCEL" function on their button box. They stated that when pressed, the call continued, and the cancel function made no difference.

<u>Would you like to participate in the next phase of the Colorado Mayday Operational Test, in which you will use your Mavday unit only for assistance in actual emergencies?</u>	
Yes 6	No 1

The participants in this phase indicated clearly that they were interested in continuing in this study. Despite some early problems, they have recognized improvements in the system made by NAVSYS and believe the system is adequately reliable for further testing. They indicated they would like to test the system in emergency situations and believe it to be a practical system for that purpose.

4.4.2 Technical Performance

The purpose of the Phase II technical evaluation was to assess the system's performance in the hands of the typical system consumer. This performance evaluation included the following areas:

- communications system - transmission reliability;
- ability of IVU to permit user to request assistance;
- location accuracy;
- the workstations ability to receive and display information accurately;
- system's ability to provide response to user; and
- accuracy and suitability of map databases.

4.4.2.1 Data Collection

A single tester conducted the tests that were used to evaluate the Phase II technical performance of the Colorado Mayday system. This tester was unaffiliated with any members of the project and evaluation team and was not knowledgeable of any Mayday technology prior to this exercise.

Route maps that covered the entire study area and avoided tests being conducted in clusters were developed by the evaluators. Each route was designed for a different day and covered a different set of highways in both rural and urban areas. In total, the tester drove for five days and covered approximately 1400 miles. Approximately 35 to 40 tests were conducted each day.

After the second day of testing, NAVSYS made additional modifications to their processing center software. These modifications were designed to reduce the number of errors that were produced after the call successfully connected. The data reflects the results prior to and after these modifications.

The tester was instructed to not conduct any tests in areas where cellular coverage was poor because performance in various cellular coverages was effectively assessed in Phase I. These results are available in the "Mayday Operational Test Phase I Evaluation Summary Report." Poor cellular coverage was defined as anywhere with audible static, and where the phone's strength indicator was below four of six bars.

4.4.2.2 Data Performance Results

A two step data analysis approach was used to assess system accuracy under a variety of cellular conditions. The first step determined the rate at which the system computed valid solutions, and what conditions prevented it from doing so. The second step assessed the accuracy of locations that were identified as valid.

Step One: Determination of valid positions

Each time the in-vehicle Mayday button box is activated, two phone calls must be made to complete a successful Mayday request. The first call transmits the raw GPS data and other vehicle-based information to the processing center, where a location solution is generated, and the caller's identification code is related to his or her record in processing center database. The second call, which does not occur until the first is complete, goes to the dispatch center and provides voice communication link between the caller and the service response personnel.

If the first call is not completed on its first attempt, then the IVU attempts it up to two more times before stopping. Reasons that the call might not be completed include:

- poor cellular coverage;
- a busy signal at the processing center;
- receiving hardware not turned on;
- unsuccessful data “handshake”; and
- Communications Control Unit or phone causes the processing center number to be dialed incorrectly.

Table 4.4.1 shows all calls that were attempted and the frequency with which there was no connection on the first call. Instances where a weak cellular signal was noted have been excluded. Additionally, this data comes only from written data logs since no voice communication was possible if the first connection was not made.

County	Total Number of Attempts	Connections	No Connections
Boulder	8	6	2
Custer	17	10	7
Cheyenne	7	7	0
Crowley	1	1	0
Elbert	7	6	1
El Paso	25	23	2
Fremont	22	18	4
Kiowa	11	9	2
Kit Carson	5	5	0
Larimer	13	10	3
Las Animas	20	16	4
Lincoln	15	15	4
Otero	10	8	2

Pueblo	8	1	7
Washington	4	4	0
Weld	3	3	0
Yuma	1	0	1
Total	177	142 (80%)	35 (20%)

Table 4.4.1 Data Connection Rate

Once the connection is made and the data transferred, a valid position is a solution without any error flags in the GPS solution or vehicle location message. System generated reports supplied by NAVSYS have been separated to represent the total number of calls placed compared to the number of valid and invalid positions determined.

During Phase I testing, two types of error flags were encountered, warning of possibly inaccurate position determination. These error flags are described in section 3.4.2.

Table 4.4.2 shows the number and rate of successful connections for all calls that successfully connected and exchanged data.

Total Number of Tests Yielding Solutions		0 or 1 Channel Error	RAIM Error Warning	Total Valid Tests
Prior to software modifications	55	0 (0%)	11 (20%)	44 (80%)
After software modifications	87	2 (2%)	0 (0%)	85 (98%)
TOTAL	142	2 (1%)	11 (8%)	129 (91%)

Table 4.4.2 Valid positions vs. Invalid positions

Combining the results of the connection rates and valid solution rates for connected calls provides the total rate at which attempts successfully reach the processing center. This represents the likelihood of a Mayday system user having a call attempt reaching the Processing Center after activating their IVU. This is shown in Table 4.4.3.

Total Attempts		No Connections	Errors	Total Valid Solutions
Prior to software modifications	71	16 (23%)	11 (15%)	44 (62%)
After software modifications	106	19 (18%)	2 (2%)	85 (80%)
Total	177	35 (20%)	13 (6%)	129 (73%)

Table 4.4. Valid position rate from all attempts

Step Two: Analysis of valid positions

Positions reported as valid will ultimately lead to the dispatch of an emergency response team, preferably both with and without voice confirmation. The ability of such a team to locate the vehicle depends on the accuracy to which the Mayday system computes the vehicle’s position. CRC compared the observed latitude and longitude and the Mayday System calculated latitude and longitude at each test location. From this comparison, the absolute difference was calculated as the distance (in meters) between the reported location and the location determined by the Mayday system.

Of the 129 tests that yielded valid solutions, 127 were geo-located and compared to the reported location of the tester. The remaining two could not be checked because of insufficient information in the written log or because of insufficient information on the dispatch map display. Table 4.4.4 lists the results of the comparison between the reported’ locations and the Mayday System determined location by county. All tests with errors or warnings have been excluded form this table because their locations are known to be inaccurate.

Tests recorded as being less than 100 meters (“<100 m”) are where the solution generated by the Mayday System was within 100 meters of the reported location. The actual distance could be within a few feet or within up to 100 meters. The general belief is that if the system is accurate within 100 meters, then emergency responders should be able to quickly find the distressed vehicles, especially in rural settings. Less than 200 meters (“<200 m’) represents those tests where the generated solution was between 100 and 200 meters from the reported location. In most cases it is believed au emergency responder would still be able to locate a vehicle in a quick fashion with this information. Finally, more than 200 meters (“>200 m”) represents all tests where the solution was more than 200 meters from the reported location. Some of these were greater than a mile from the reported site. In these cases, it would be difficult for emergency responders to locate the distressed vehicle based on the generated solution.

County	0-99 m	100-199 m	>200 m	Total Solutions
Boulder	3	0	0	3
Custer	1	6	3	10
Cheyenne	2	0	5	7
Crowley	0	1	0	1
Elbert	3	2	0	5
El Paso	11	2	7	20
Fremont	14	1	3	18
Kiowa	6	1	2	9
Kit Carson	3	2	0	5
Larimer	3	0	1	4
Las Animas	14	0	1	15
Lincoln	0	3	12	15
Otero	5	1	1	7
Pueblo	1	0	0	1
Washington	1	2	1	4
Weld	0	0	3	3
Yuma	0	0	0	0
Total	67 (53%)	21 (17%)	39 (31%)	127

Table 4.4.4 Locational Accuracy

The above table includes 24 consecutive tests where the generated solution was consistently approximately 2000 feet away from the actual location. These tests were conducted while the Mayday system was undergoing its software modifications. If these 24 tests are not included in the test set, the results are:

	<100 m	<200 m	<200m	Total Solutions
Total	67 (66%)	21(21%)	15 (15%)	103

Table 4.4.5 Accuracy results with outlying data removed

Before software modifications were made, 71 tests were attempted, yielding 44 valid solutions. After software modifications were made, and excluding the 24 consecutive errant tests, 61 tests with solutions were generated. The geo-located solution of 59 of these were compared against the locations given in written logs. The results prior to and after software modifications are shown in Table 4.4.6.

Total Valid Solutions		0-99 m	100-199 m	>200 m
Prior to software modifications	44	25 (57%)	10 (23%)	9 (20%)
After software modifications	59	42 (71%)	11 (19%)	6 (10%)
Total	103	67 (65%)	21 (20%)	15 (15%)

Table 4.4.6 Accuracy results before and after software modifications.

Previously, in Table 4.4.3, the percentage of tests resulting in valid solutions was determined. By combining that with the number of the valid solutions that were also accurate, the percentage of all test attempts that produced accurate solutions can be determined. Table 4.4.7 shows the rate at which the system accurately located the simulated motorist in distress during the Phase II testing. The two tests whose locations could not be identified and the 24 errant tests have been removed from the data set, resulting in 151 tests.

	Total Attempts	Accuracy				
		No Connection	Errors 100-200 m	100-200 m	>200 m	m
Prior to software modifications	71	16 (23%)	11 (15%)	25 (35%)	10 (14%)	9 (13%)
After software modifications	80	19 (24%)	2 (3%)	42 (53%)	11(14%)	6 (8%)
Total	151	35 (23%)	13 (9%)	67 (44%)	21 (14%)	15 (10%)

Table 4.4.7 Accuracy of Colorado Mayday with respect to all test attempts.

4.4.2.3 Communications Coverage

During the two stages of Phase II, tests were conducted in a total of 28 of Colorado's 63 counties. These counties and their populations are listed in table 4.4.8. These counties contain almost 90% of Colorado's 3.3 million residents.

County	Population
Adams	265,038
Arapahoe	391,511
Bent	5,048
Boulder	225,339
Cheyenne	2,397
Crowley	3,946
Custer	1,926
Denver	467,610
Douglas	60,391
Elbert	9,646
El Paso	397,014
Fremont	32,273
Gilpin	3,070
Huerfano	6,009

County	Population
Jefferson	438,430
Kit Carson	7,140
Kiowa	1,688
Larimer	186,136
Las Animas	13,765
Lincoln	4,529
Logan	17,567
Morgan	21,939
Otero	20,185
Pueblo	123,051
Prowers	13,347
Washington	4,812
Weld	131,821
Yuma	8,954

Table 4.4.8 Counties covered in Phase II

Throughout the most densely covered counties, which also have Interstate freeways running through them, the cellular coverage is relatively strong and reliable for Mayday calls. However, in the less densely populated counties, where the roads are smaller and have considerably lower average daily traffic, the coverage often ranges from marginal to non-existent. In marginal and non-existent coverage, analog cellular systems are unreliable in transmitting data. This is because of the inability to make a connection or the interference, service disruptions and static that affect the communication link.

4.4.2.4 Voice Performance Results

During the second stage, from which the data performance was taken, the voice link was inoperable. Therefore, for voice performance, the following data is from the first stage of Phase II testing. The first stage, as described in Section 2, included 11 unaffiliated participants and 3 participants directly related to the Colorado Mayday evaluation.

Once the data call is completed, meaning that all data is transmitted from the vehicle to the processing center, then the system attempts to make the voice communication link. In commercial deployment of the Mayday system, this link will be the direct voice connection between a vehicle and dispatch center. There are several reasons that the caller might not successfully be able to describe his or her incident. These include:

- a busy signal at the dispatch center;
- no answer by the voice communication respondent;
- cellular phone still in data transmission mode;

- voice cannot be heard by caller; and
- TIDGET7 or phone fails to make connection.

Table 4.4.9 shows the results of 352 attempts. Each of these calls successfully completed the data exchange portion of the call, and these results only reflect the system attempts at establishing a voice connection.

	Total Calls Going to Voice Mode	Successful Voice Communication	No Voice Communication
Total	352	302 (86%)	50 (14%)

Table 4.4.9 Voice mode rate for all Phase II Stage 1 attempts

When these voice communication rates are applied to the data from Phase II, Stage 2, then of the 142 calls that successfully transmitted data to the processing center, it is estimated that 20 would not have successfully made a voice contact with the dispatcher.

The Colorado Mayday system is designed for the data to arrive in advance of the voice call so that the dispatcher is prepared to speak with the driver. If the voice connection is unsuccessful, or if the caller cannot speak, then the dispatcher will react under the assumption that it is an emergency and dispatch a response team. The voice connection with the driver can prevent this response in the case of a false alarm, or provide more information so that the dispatcher can tailor the emergency response to address the specific problem the driver has encountered.

The vocal response of a provider is crucial to drivers in emergency situations. This is their one source of verification that their Mayday call was successfully received and that help is on its way. Fourteen percent means that one in seven callers does not receive that confirmation, and this rate is quite high. Ways to mitigate this are providing other forms of verification to the driver that the message has been received.

4.4.2.5 System Response

As described in section 4.4.2.3, the system currently relies on the dispatcher to verify that the call was successfully completed. This method, however, leaves many instances where there is no verification or response to the user. These include, but are not limited to:

- no data connection is made;
- voice connection fails; and
- the driver cannot hear the dispatcher.

Phase II participants indicated that the information provided by the lights on the button box and messages on the cellular phone screen are effective in conveying the progress of the Mayday call. However, it was also the experience of the participants that those lights were

of-ten misleading and indicated that the call was being processed, when it actually was not. An improved verification system would instill confidence in the users.

A message sent back from the processing center when data transmission is complete could serve as verification. This brief message could indicate that either the message was received in its entirety or that it was not received, since the center knows this by the successful reception of the data header and footer. This could trigger the IVU to either display on the phone's LCD screen a message that the transmission was successful or unsuccessful, or an audible verification could be made, either with a recorded voice or series of tones. This will provide the user information as to whether to re-attempt the call or not.

4.4.2.6 Map Display System

During Phase II, the digital maps were displayed on an IBM compatible Pentium based personal computer running the Microsoft Windows NT operating system. The mapping program was ArcView, a product of Environmental Systems Research Institute (ESRI). ArcView is a limited capability program based on the Geographical Information System (GIS) ArcInfo, also developed by ESRI. Its main purpose is as a display tool for maps and databases developed in the more powerful ArcInfo.

ArcView is ideal for the Mayday application. It has a host of easy to use, graphical user interface tools at the users disposal. Its display capabilities are well-suited to the Mayday use, which requires dispatchers with little or no GIS knowledge to interact with it. And it prevents them from directly manipulating or altering the actual databases and maps. Coding and database development can be done by experts through an ArcView macro language titled Avenues. Maps developed for Arc/Info are compatible with ArcView, and Arc/Info is a popular platform for map database developers. There is no concern that frequently updated maps will not be available in the next several years.

ArcView also accesses the INFO databases, or other SQL format databases. In this way, various fields of data can be recalled by the system for any driver. Additionally, multiple databases can be merged or related so that for any incident or caller, various related records can be displayed on screen beside the actual incident location.

Each ArcView map contains thousands of lines and points. The current computer's ability to display intricate graphics will be a limitation in real world conditions. The speed of the computer which housed the Mayday display was adequate for its testing purposes. However, if a large scale deployment were to occur, the system would be too slow to keep up with multiple simultaneous Mayday calls.

Each call was displayed on the map in the location that the Mayday system determined. The incident's solution was posted as a dot on the map. Alongside the incident location was the incident number and the Mayday unit owner's name. The streets in the vicinity were not

automatically shown neither are their names. Once an incident is shown, the dispatcher must determine the county it occurred in and then turn on the street layer for that county. After the roads were displayed, the dispatcher would have to select the streets that should be labeled.

This system could be streamlined with the development of an ArcView macro that identifies all streets within 5000 feet of the incident location. It could then draw these streets and label them without any effort by the dispatcher.

When multiple incidents occur, the system would display the one that is generated most recently, and unless the other incident was nearby, it would be supplanted. The display system could use a split screen or multiple, simultaneous maps to display different incidents simultaneously.

4.5 MAP DATABASES

Many digital maps, which are simply digitized versions of paper maps, are not accurate enough for Mayday purposes. This is not the case in the Colorado Mayday project. The Colorado Mayday system currently employs map databases developed by the Wessex Corporation. These maps are commercially enhanced versions of the United States Census Bureau Topologically Integrated Geographic Encoding and Referencing System (TIGER) maps. The TIGER maps are grouped by County in Colorado and each County is identified as its own entity. TIGER files contain all roads and highways that are known to the Federal government.

Wessex improved the TIGER maps by geo-coding and fitting them to be accurate with the actual land using GPS data to ensure an accuracy within 10 to 20 feet virtually everywhere in the state. They are most accurate along roadways, which is essential for Mayday purposes since the vast majority of calls will come from the roadway or adjacent to it.

The quality checking and alteration necessary for a digitized map requires extensive adjustment based on actual GPS coordinates in order to make the map consistent with GPS results. These adjustments are processes whereby the actual coordinates of a series of points are fitted to the digital map. For example, the GPS generated coordinates of a selected number of locations shown on a digital map may be collected. The coordinates on the digital map are then adjusted to match the GPS coordinates collected. The GIS application interpolates new coordinate values for all points in between.

4.6 ACTIVITIES PRIOR TO PHASE III

During Phase II, NAVSYS served as the processing and dispatch center. For Phase III, the dispatching station would have to be relocated to a PSAP that could respond to actual emergencies using a stand-alone Mayday workstation. Prior to full deployment, NAVSYS worked with several potential PSAPs and their negotiations are discussed in Section Five.

Funding going into Phase III was constrained because of higher than expected costs and a project budget that was diminishing due to the longer than expected duration of Phases I and II. The original plan to deploy 2000 units in Phase III was scaled back to 1000 units and the planned duration of the phase was decreased from 18 months to 12.

Prior to Phase III, NAVSYS also determined that the equipment worked best with the Nokia C-16 phone and recommended that only that phone be used for future testing. During Phase II, Nokia discontinued manufacturing the C-16, which meant it would be difficult for 1000 potential participants to purchase. In order to attract Phase II participants, CDOT, along with CRC and NAVSYS agreed to create a fund for purchasing phones to provide for free. This is discussed in more detail in Section Six.

5. PHASE III-FULL-SCALE TESTING

5.1 INTRODUCTION

After successful system testing during Phase I and Phase II, Phase III was to be a full-scale operational test. Two thousand participants that traveled in the project test area would be recruited to use the Colorado Mayday System in actual emergencies. The CSP dispatch center would respond to these Mayday requests and then trigger the appropriate emergency response. Through the Phase III evaluation efforts, the goals of the full-scale test were:

- to evaluate the effectiveness of the Colorado Mayday architecture in providing Mayday capabilities;
- to evaluate the impact of the Mayday system on emergency response times;
- to evaluate the potential for the Mayday system to be nationally implemented; and
- to evaluate the impact of the Mayday system on the overall transportation system.

Upon the successful completion of Phase III, the objective of the Colorado Mayday project was to hand the operational test system over to commercial center that would continue to operate it as a sustainable traveler service,

A series of barriers and issues prevented the implementation of Phase III. This section details the difficulties encountered by the Mayday Project Team at each step.

5.2 IDENTIFICATION OF PARTICIPATING DISPATCH CENTER

One of the first efforts that was to be undertaken during Phase III was defining the dispatch center operating procedures. The procedures were dependent upon the location, staffing and existing operating procedures, hardware and software at the dispatch center. As discussed in Section 4.5, the PSAP that would serve the project had not been determined yet at the end of the Phase II.

NAVSYS worked with two potential PSAPs that were interested in participating in the Colorado Mayday project. These were Adams County Communication (ADCOM) and the Cross Country Group (CCG), a private vendor with an interest in the project technology. NAVSYS also worked with CSP to try to reinstate that partnership.

5.2.1 Adams County Communications

Adams County Communications (ADCOM) is the 911 response center for Adams County, which is one of the six counties in the Denver Metropolitan area. As of 1997, Adams County had 256,000 residents which ADCOM served. ADCOM's dispatch center is APCO trained to meet the National Emergency Number Association's (NENA) requirements for dispatchers and equipment. Currently dispatchers use computer-aided dispatch stations that can handle Enhanced 911 data. ADCOM relies on both private and public sector funds for its operation budget. Its interest in the Mayday project was based on the potential revenue that such a system could generate, and to familiarize themselves with a technology that is becoming more prevalent and affects the way emergencies are responded to. ADCOM is typical of smaller, local PSAPs. Their involvement would have allowed the project to explore the issues associated with the impact of Mayday on a small PSAP. ADCOM anticipated that the Mayday response capability would become a part of PSAP operations and this offered them a low-cost entry into exploring its potential. Also, ADCOM wanted to explore the potential revenue that could be generated by Mayday and the related value-added services.

While ADCOM generally deals with emergency calls from within Adams County, they would accept calls from all participants in the Mayday project that were within Colorado. Calls that were outside Adams County would be forwarded to the appropriate PSAP along with verbal description of the vehicle location. The reasons that ADCOM decided not to participate in the Colorado Mayday project follow.

5.2.1.1 Legal Liability

From a legal perspective, a Mayday call differs from other emergency calls because of several factors, but primarily liability revolves around information that the Mayday system provides to dispatchers, and the means for sending it. The areas of liability for each of the Mayday participants are discussed in general terms in Section 3.7. The liability issues were the primary contributors to ADCOM decision not to participate in the Mayday program.

ADCOM's attorneys advised them to require that NAVSYS provide a \$1,000,000 insurance policy naming ADCOM as the beneficiary in case of any liability claims. This fund would be available to ADCOM to cover legal expenses or to pay damages. NAVSYS wanted to maintain a non-participatory relationship with the dispatcher, however, and they felt that the insurance request would tie them too closely to dispatch operations. Additionally, NAVSYS's insurance company, CBS Insurance, informed NAVSYS that despite contacting many insurance carriers, no coverage was available that would cover the liability of 911-type emergencies. If the insurance were available, it would have to be \$1,000,000 of coverage for each incident, and not in total. This would include the coverage for each time a requestor pressed a button on his button box, regardless of whether it was a test, emergency or for roadside assistance.

Another issue was ADCOM's request for total indemnification throughout the project. This meant that ADCOM would not be held responsible for any incidents resulting in liability or damage claims, and that NAVSYS would assume the full responsibility. It was established early in the project that the FHWA and CDOT both had governmental immunity from liability throughout the project. Initially, the partnership between NAVSYS and CDOT was believed to fold NAVSYS into that immunity. However, after further legal examination, it was discovered that NAVSYS did not have immunity, and would have to assume all responsibility for the project in cases of liability or damage.

5.2.2.2 Equipment ownership

As previously discussed, the major impasse reached between the Mayday team and ADCOM was over indemnification and liability. However, equipment ownership was an issue that arose during discussions. For Phase III, NAVSYS would have installed its Mayday workstation at the ADCOM PSAP. As part of this arrangement, ADCOM wanted ownership of the hardware and software, not only for the duration of the operational test, but also permanently. NAVSYS was not willing to provide this equipment, which cost \$150,000 and included mapping software, map display hardware, and the processing center.

5.2.1.3 System maintenance

ADCOM also wanted NAVSYS to provide system upkeep, maintenance and repair during the operational test at no cost to ADCOM. NAVSYS felt that if ADCOM was going to own the equipment that the maintenance-would be ADCOM's responsibility.

ADCOM wanted NAVSYS to maintain the system because they developed it and were most familiar with the most likely failure types, and because it needed to be operational as close to 100% of the time as possible. And, because ADCOM was not familiar with the system, it could not anticipate the types of problems or their frequency. What they expected from NAVSYS was, in effect, a warranty period.

Another key element of the upkeep and maintenance was the updating of the maps. As GIS use expands, more companies offer digital maps. Most available digital maps are not updated every time a road or facility is added or deleted. Rather, most commercial map developers produce annual updates. For Mayday purposes, these updates may not be frequent enough. There is the potential for vehicle accidents to appear on the display map where no road or facilities are shown. A new road may have opened since the last time the map was updated. When a PSAP such as ADCOM receives a vehicle location near roads and landmarks that do not appear on the map, it is difficult for the dispatch center to direct emergency services to the accident site. This poses a potential liability issue for the PSAP and responder ADCOM's request for updates would ensure that the liability for any problems arising from outdated maps would be the responsibility of NAVSYS.

Frequent updates of digital maps can be prohibitively expensive. For a state like Colorado, quality maps can cost as much as \$50,000 per year per installation. In Colorado there are 63 counties. If each county needed a high quality digital map, the statewide cost would exceed \$3 million per year.

5.2.1.3 Staff training

ADCOM required that all of their dispatch staff be trained on the use of the Mayday dispatch station. This training would not include being able to maintain or repair it. It was intended to provide the ADCOM dispatchers all of the operational skills they would need to handle Mayday calls. Had ADCOM participated in Phase III, NAVSYS would have provided this training.

Currently, there are no national standards and protocols for dispatchers dealing with Mayday calls. Typically a dispatcher receives a narrative description of an incident and its location from the caller. They then relay this information to emergency response agencies. With a Mayday system, a variety of other potential systems may arise. Calls can either reach a PSAP directly from the caller, or they may be routed through a response center first, where an operator will determine the severity and type of the incident and to which emergency response agency it should be forwarded. A call may come into a dispatch center that provides only a location on the digital map but not other information and no voice contact with the caller. A call may reach the dispatch center where the caller identifies himself as being in a different site than the location reported by the system. A call may be made from a moving vehicle. The location that is reported is the point that the driver initiated the Mayday call process, but by the time the dispatcher speaks with the driver he has moved farther along the road. Or, a Good Samaritan may call in an accident that he or she observes but was not directly involved in.

5.2.2 Cross Country Group

Cross Country Motor Club (CCMC), a division of CCG, is the leading provider of automotive customer service programs in North America. They have over twenty million motorists subscribed to their various programs. Their expertise is in roadside assistance programs and enhancements. Their service is usually provided to customers under other brand names, often included as a roadside assistance package with the purchase of a new vehicle. CCMC's operates Association of Public-Safety Communications Officials (APCO) trained call centers with locations across North America.

Through CCMC, CCG offers Enhanced Call Center capabilities for in-vehicle and personal cellular GPS and ITS. They can provide enhanced services available for GPS and ITS which include:

- Mayday Processing Center, using APCO certified 911 personnel;
- GPS location Roadside Assistance and Towing;
- Vehicle security, tracking and theft recovery;
- Vehicle remote control – Lock, Unlock, Open Trunk;
- Trip routing; and
- Custom travel concierge services and information services.

Each of the above features was identified as a potential value-added service of the Mayday project.

From the institutional perspective, the Colorado Mayday project had two distinct features that separated it from other programs that offered Mayday-type services. The first was that it would directly connect the caller with a PSAP. The second was that it was intended strictly as a Mayday device, with other value-added services being considered at a later time. The involvement of CCG meant that both of these features would be eliminated, altering the goals and objectives of the project.

CCG, along with other traveler assistance programs such as the Automobile Association of America (AAA), has its own set of dispatchers that will speak with travelers and then determine whether or not the requestor requires emergency response. Additionally, the location information would be reported to the CCG call center, and not directly to a PSAP.

CCG's interest in the Mayday technology revolved around its ability to drive a suite of services, of which Mayday was one. These value-added functions would create a desirable package for travelers, who would be willing to pay for the complete set. This was not in agreement with the Mayday project's original plan of developing and assessing the marketability a Mayday specific device. This issue was not a major concern for the project, however, because other value-added systems such as OnStar and Rescu had changed the public's expectations, and the project recognized that it would have to be capable of providing value-added services in order to be competitive.

5.2.2.1 System coordination with existing dispatch system

During the Mayday project, there were three opportunities to integrate the Mayday system into PSAPs or dispatch stations. For the purposes of the Colorado Mayday Operational Test, ADCOM and CSP would have installed the processing and dispatch stations as a stand-alone system that would have required no integration of existing hardware or software. The dispatchers would have used the Mayday station as an additional resource. When a Mayday request came in, a dispatcher would have to either move to the station where the Mayday system calls came into, or there would be a person assigned to responding to Mayday calls full-time.

CCG is developing its own Mayday response system, and required that NAVSYS deliver the

emergency information to their existing dispatch stations. At CCG, a Mayday call would have been transmitted to a central location. From there, a router would have been required to determine which dispatcher was available to respond. It would then send the vehicle location data to that dispatch station, as well as direct the voice connection to that station. CCG was not willing to supply the equipment necessary to do this routing, and the \$250,000 cost was not within the project budget for NAVSYS.

5.2.3 Colorado State Patrol

When arrangements with the other two potential PSAPs fell through, CSP was contacted to become reinitiated with the Mayday. By this time a variety of issues had surfaced that posed as obstacles to their participation.

5.2.3.1 Project support

An MOU was drafted at project inception and it included the option for any of the project partners to leave the project at any time. CSP was initially one of the project partners. However, during the project's life, the CSP employee that was most enthusiastic about the Mayday concept changed jobs and left the project to individuals who were not as familiar with it, or as receptive to the technology.

Under new direction at CSP, support decreased and at one point CSP encouraged the rest of the project team to move to another PSAP or service provider. Under the new direction, CSP requested additional resources to support their effort. These included a full-time dispatcher stationed at the Mayday station and paid for by the Mayday project, ownership of all Mayday software and hardware, and direct interface between the Mayday system and their existing computer aided dispatch (CAD) stations. These were not part of the original MOU and were not allocated in the project budget.

5.2.3.2 Staffing

Before the Colorado Mayday project, the CSP PSAP was responsible for responding to all wireless 911 calls through the state. Their dispatch area consisted of several CAD stations that did not have the capability to display graphical maps of caller locations. The Colorado Mayday system would only route emergency calls to the PSAP. It would not have offered participants any value-added services. However, CSP was concerned that there would be a significant increase in wireless 911 calls due to Mayday, and required that the project provide a full-time dispatcher to monitor the Mayday system throughout Phase III.

On average, there are 130,000 911 calls in the United States every day. This is a rate of less than one call per U.S. resident every five years for both landline and wireless uses. If this rate held true for the up to 2000 participants that would have took part in Phase III for eighteen

months, the PSAP would have received less than one call per day from Mayday participants. However, CSP believed that the call rate for Mayday users would have been higher than that of other users. They felt that they did not have to resources to supply the additional staffing that Mayday may require.

5.2.3.3 Dispatcher resistance

A simulation dispatcher workstation was operated by Colorado State Patrol dispatchers for approximately two weeks. After this period, the dispatchers responded to surveys that queried them on the effectiveness of the system. In whole, the dispatchers were impressed with the capability of the system, but felt it was slow and not user friendly. Improvements were made to the system, but they were completed after the demonstration period and were not explicitly shown to the dispatchers.

Additionally, the Mayday workstation was located away from the dispatchers workstations. This made it difficult for them to use since their responsibilities required them to stay near their stations.

5.3 SELECTION AND RECRUITMENT OF PARTICIPANTS

NAVSYS was initially obligated by the project to recruit 2000 participants for Phase III. This was reduced to 1000 because of cost constraints. Recruitment involved identifying a representative cross-section of drivers 'within the test area and soliciting their participation. NAVSYS was to be assisted in this effort by the cellular service providers, who had access to new and existing cellular phone users. The cellular providers terminated their partnership in the project after Phase I, however, and did not provide any support for attracting Phase III participants. Others that were to be recruited include local fleet operators, commercial vehicle and large- and small-scale transit operators. State vehicles were to be outfitted with in-vehicle equipment as would have been various other people connected to project team members.

Marketing materials were to be produced. They would serve as promotional information as well as prepare participants for their responsibilities and the liabilities of the system. They would explain the test nature of the project and what participants could expect.

Because Phase III was delayed by the lack of a participating PSAP, marketing and recruitment efforts did not move beyond the planning stage. No marketing materials were produced or distributed. However, there were several issues and obstacles encountered during the planning stage that affected the potential recruitment of participants.

5.3.1 Equipment Limitations

As discussed earlier, the Colorado Mayday IVU worked most reliably with the Nokia C-15 and C-16 series phones. Other phones were tested, including Motorola mobile phones, and they could work with considerable and costly modifications. Only the Nokia phones provided a cost-effective cellular solution. Further, NAVSYS determined that only the C-16 series phones should be used since they had the capabilities required by the IVU. This meant that Phase III participants could only use a single type of phone. Prior to Phase III, Nokia discontinued manufacturing the C-16 phone series, meaning that it could not be easily purchased by potential participants.

The potential for attracting 1000 participants in the metropolitan Denver area willing to purchase a cellular phone that was vehicle-based and not portable was daunting. Adding the requirement that it be a particular type of phone that was no longer manufactured made it appear unlikely. The solution proposed by CDOT was to purchase the phones for the participants, taking the funds from the project budget. NAVSYS successfully tracked down a large quantity of the phones on the east coast that could have been purchased.

While participants would have been given the phones, they still would have had to pay their own cellular service costs. Many cellular providers give customers cellular phones when they subscribe for service. Therefore, it is likely that the offer of a free cellular phone would not have provided a significant incentive to potential participants.

The recruitment process was also hampered by the lack of a marketing strategy. Many issues that had to be defined before recruitment began were not. NAVSYS was responsible for installing and testing the 1000 units in participants' vehicles, but they did not develop a clear, workable strategy for doing this. Additionally, a customer support network was necessary to address participants' questions, and to update them on the project's process. NAVSYS failed to develop a satisfactory customer service strategy, and this hindered interest in a Phase III from cellular phone retail outlets, which could have served as recruitment and installation centers.

5.3.2 The Mayday Market

In 1994, the Colorado Mayday project's target was an after-market product that would sell for less than \$500 per unit, not including the phone, and then sell Mayday service for approximately \$20 a month. Two focus groups were conducted during Phase I and most of the participants indicated that they would be willing to pay these fees. In fact, many focus group participants felt that the price offered a good value. Since that time, the market for Mayday devices has been impacted by the commercial introduction of GM's OnStar and Lincoln's Rescu. These systems are built into vehicles and provide Mayday as one of a suite of value-added services. They cost the customer about \$1000 for the equipment, including

cellular phone, and then \$20 per month for service, not including cellular service. From a marketing perspective, the primary differences between the GM and Lincoln systems and Colorado Mayday as originally envisioned were:

- Colorado Mayday would be less expensive to purchase;
- Colorado Mayday was intended as an after-market device that could be installed in any car equipped with a three watt cellular phone, and the GM and Lincoln systems came in new cars only;
- Colorado Mayday would connect callers directly with a PSAP, and OnStar and Rescu would connect to a service center which would assess the situation before connecting the caller with the appropriate PSAP;
- Rescu and OnStar provided a suite of services such as roadside assistance, and vehicle tracking, which were not part of the original Colorado Mayday plan; and
- Rescu and OnStar were supported by major corporations with long histories of customer relations.

No focus groups were conducted after Phase I, and no actual pricing structure was developed for Colorado Mayday. While the market differences between the systems are clear, it was not learned during this project whether the Colorado Mayday system had commercially viable niche in its initial form.

5.4 OTHER PLANNED PHASE III EFFORTS

Other efforts that were planned under Phase III, such as installation of in-vehicle equipment and operation of the Mayday processing and dispatch stations, were contingent upon Phase III moving forward. Because the obstacles encountered proved insurmountable in sum, the remainder of activities were non-existent.

Evaluation efforts in Phase III were intended to evaluate the functionality and performance of the system, as well its potential to be commercially sustained beyond the operational test. These efforts were redirected to develop this document.

6. COLORADO MAYDAY LESSONS LEARNED

6.1 INTRODUCTION

Because the Colorado Mayday Operational Test was one of the first deployments of a Mayday type device, it could not be prepared for the range of barriers and issues that arose. While these barriers ultimately prevented the project from full-scale testing, a number of valuable lessons were learned that can benefit other field operational tests and Mayday projects. This section describes the lessons learned from Colorado Mayday, and they are separated into the following sections:

- technical lessons learned;
- marketing lessons learned;
- institutional lessons learned; and
- legal lessons learned.

6.2 COLORADO MAYDAY TECHNICAL LESSONS LEARNED

As with any new technology, its true technical performance is fully assessed through real-world application. In the Colorado Mayday project, the real-world application was the testing in Phases I and II, where the in-vehicle equipment and communications medium were tested. During testing, the TIDGET7-based system revealed limitations and strengths that were unanticipated or had a greater impact on the test results than expected. Additionally, as the project progressed, its fit within the National ITS Architecture and standards efforts were identified.

6.2.1 TIDGET and GPS Receiver

The Colorado Mayday system has a unique and proprietary application for determining locations using GPS. Most Mayday systems use GPS receivers that track satellites and calculate a latitude and longitude on-site. The Colorado Mayday TIDGET7 collects raw satellite data and transmits it to the processing center where the vehicle location is determined. The advantages of the TIDGET7 are:

- lower power needs because of the absence of a microprocessor;
- fewer satellites needed to be seen by vehicle to determine a location;
- lower cost because of device simplicity;
- quicker Time to First Fix (TTFF), five seconds for a GPS sensor as opposed to up to

- one minute for a GPS receiver; and
- simplicity results in a more reliable system.⁴

The quicker TTFF is crucial for the Mayday application. When a driver is in distress, a few seconds may be the difference between life and death. The TIDGET7 when well-tuned, can provide this time advantage over GPS receiver based systems. The advantages that a GPS receiver has over the TIDGET7 are mostly due to its ability to determine vehicle location on-site. New in-vehicle ITS technologies such as vehicle navigation systems require that the location be determined entirely at the vehicle. Additionally, the on-site processing systems do not need to communicate with a processing center in order to generate a solution, and therefore rely on one less communication link.

The TIDGET7 whose target cost was less than \$150 per unit, is significantly lower than the \$1000 cost of Ford Rescu and GM OnStar. This cost savings is the most compelling benefit of the Colorado Mayday technology: it is affordable to a much wider range of people. It can also be purchased and installed as an aftermarket device, which is not possible with the GM and Lincoln systems.

6.2.2 Colorado Mayday' s 150 Kilometer Range Limitation

One serious drawback to the Colorado Mayday system was its limitation to a range of 150 kilometers from the location of the antenna used by the processing station. The location accuracy of the system was erratic beyond 150 kilometers. Every time a location is generated the TIDGET7 collects GPS codes that are transmitted from at least four different satellites. The codes (called gold codes) imbedded in the signal are unique to each satellite so that a GPS sensor will not confuse two signals. The determination of a position is done by taking all of the signals received and determining the number of whole gold codes and partial gold codes that reside in the space between the TIDGET7 and the satellites.

Because the raw data is only collected by the TIDGET7 and not processed, the number of whole codes received must be interpolated. It can only be interpolated exactly if the following information is known:

- the average height above the earth of the satellites; and
- the average radius of the earth

Both of these pieces of information are known by the processing computer. The amount of partial code is determined by shifting the gold code until it matches the whole codes received.

⁴LocaterNet System Overview. NAVSYS Corporation, 1997

One-hundred-fifty kilometers represents the amount of time it takes to transmit one-half of a whole gold code at the speed of light. When the difference between the gold code received at the antenna at the processing station is within one-half gold code of the one received at a vehicle's sensor, the processing station can always correctly shift the code and determine the total number of whole codes. If the distance between caller and processing station is more than one-half of a code (more than 150 km), then the processing station cannot reliably determine the number of whole codes, and therefore cannot accurately determine the vehicle's location.

NAVSYS has developed more advanced devices than the technology used in the Mayday IVU, which report the cell tower that a call is sent from. In this way, the processing station can determine the latitude and longitude of that cellular tower and determine the most likely number of whole gold codes. Thus, newer NAVSYS devices can cover more than 150 kilometers. However, the improved technology was not used in Colorado Mayday because it was not developed until after the project had begun. The 150 kilometer limitation was a significant barrier to the range of the testing area, and the location that the project could select participants from. CSP was in a central location, near Denver, for the testing. And when the processing station and GPS antenna were at their building, the entire test area was within the 150 kilometer range. However, when it was decided that they would no longer serve as the dispatch center and the system moved to Colorado Springs, the suitable testing area shifted 115 kilometers south. The test area was no longer completely covered.

6.2.3 Colorado Mayday System Limitations

Because Phase III did not occur, and the marketing plan was never fully implemented, it is not known how successful the project team would have been at attracting 1000 participants. However, as discussed in section 5.3.1, the availability and desirability to customers of the Nokia C-16 series phone would have been a major hindrance to the recruitment of 1000 participants. Many technical constraints led to the use of a single phone type, but the system might have been developed to accommodate other phones had this result been foreseen.

An IVU that could be used with a wide variety of phone types would have made recruitment significantly easier, and allowed participants to simply add the Mayday MJ to their existing cellular phone equipment. In hindsight, it is clear that, prior to the manufacture of 1000 IVUs, a stronger emphasis should have been made by the steering committee to ensure system compatibility with many phone types.

6.2.4 National ITS Architecture

The Colorado Mayday project began while the National Architecture effort had not defined a structure for systems of its type. In light of this, it is valuable to discuss the Mayday

project's fit into the Architecture. The Architecture first identifies market packages for the development of various ITS technologies. The Mayday package, as defined by the National Architecture is shown in figure 6.2.1.

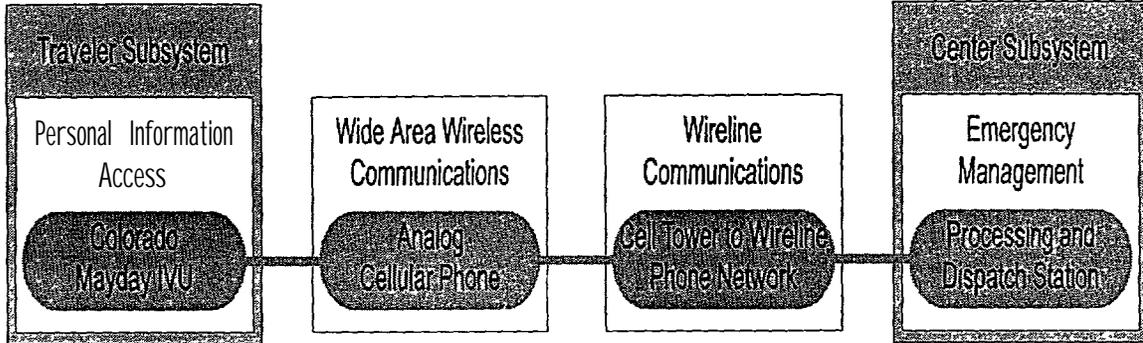


Figure 6.27 Mayday National Architecture Market Package

The Colorado Mayday system occupies a portion of the entire Mayday market package defined in the National Architecture. The IVU is a vehicle-based Mayday system. The notification and acknowledgment functions would be carried over cellular phone, and the Emergency management agency would be a PSAP such as CSP. The role of a customer service center, such as CCG, is not explicitly shown in the market package, but would most likely occupy the space between the vehicle and the PSAP. They would have the role of providing notification of emergencies to PSAPs and it would return acknowledgment to its customers.

Additionally, in Colorado Mayday the processing station and dispatch station do not have to be in the same location. The processing station could be in any geographic location, but it would fit into the market package structure between the vehicle-based Mayday and the emergency management system. The dispatch station may be at a customer service center or a PSAP.

According to the National Architecture, Mayday support requires a portable traveler interface and interactive, wide area wireless communications between the traveler and the infrastructure. The same portable traveler interface and interactive communications capabilities can be leveraged to support other traveler information capabilities. These other capabilities, as defined by the Architecture, are included in the value-added functions identified for Mayday systems. A diagram of the conceptual structure of the architecture is shown in Figure 6.2.2.

The Architecture defines the structure of each ITS technology in terms of the center, roadside, vehicle and traveler subsystems. Center subsystems will perform functions of the public/private sector such as administrative, management or planning. This includes management of traffic, transit and emergency information, CVO credential and safety

administration and traffic data management. The role of information service provider (ISP), that collects, formats and disseminates information to travelers is also part of the center subsystem. For CoLoRado Mayday, the center subsystem is the emergency management systems to which Mayday will provide vehicle and driver location information. Roadside subsystems include the roadside equipment identified in the transportation layer. It is the physical roadway, signs, communication beacons, electronic CVO pre-clearance, etc. The Colorado Mayday system did not employ any roadside equipment. Vehicle subsystems are systems installed in the vehicle. They are in-vehicle systems that may receive information that is later passed on to the driver, make automated decisions based on vehicle- and location-specific data, or automatically transmit data about the vehicle to other subsystems. Vehicle subsystems include ITS communication and operation equipment in transit, commercial, emergency and personal vehicles. The Colorado Mayday in-vehicle equipment is considered a vehicle subsystem. Traveler subsystems include both travelers en-route and those doing pre-trip planning. The traveler subsystems are systems that directly communicate with travelers such as information kiosks, in-vehicle displays and radios. In the case of Colorado Mayday, the traveler subsystem is the button box and the cellular phone.

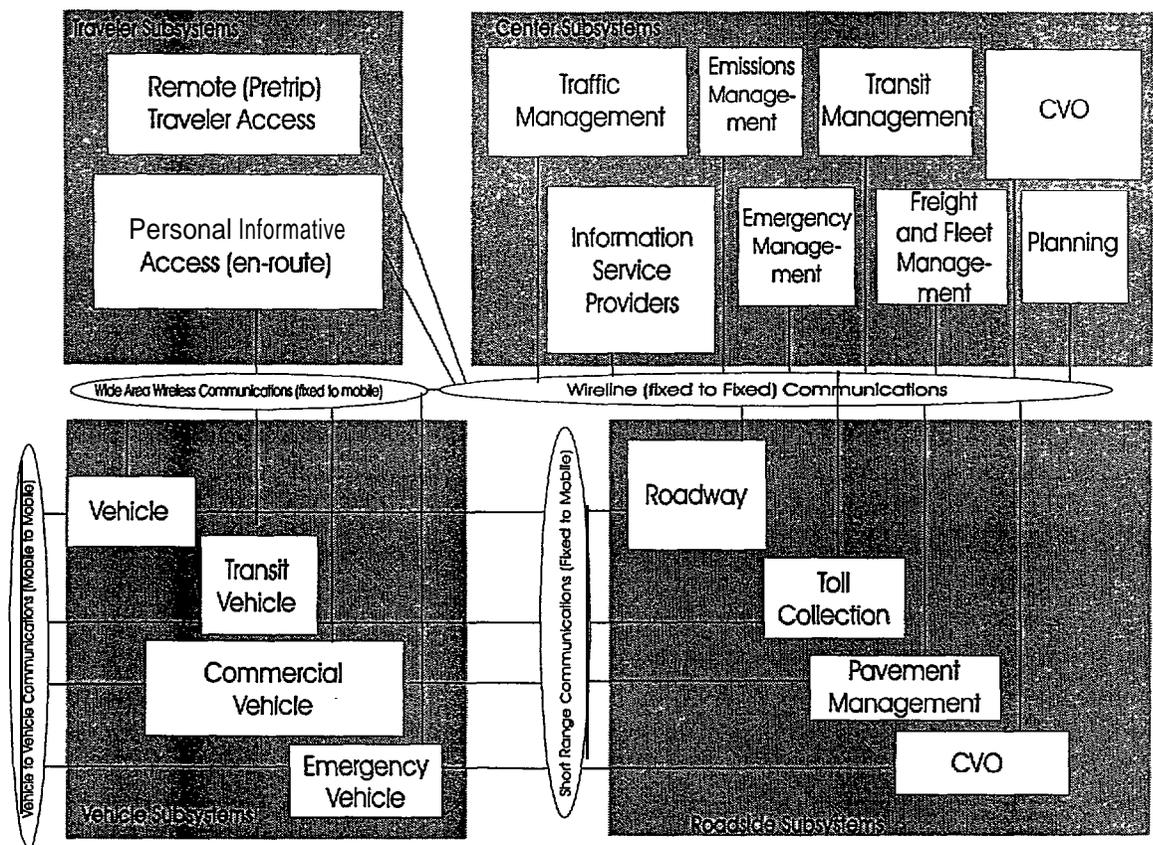


Figure 6.2.2 Conceptual diagram of the National Architecture

6.2.5 National Mayday Standards

When the Colorado Mayday project began there was no national standards effort underway. In early 1996, the FHWA identified five organizations that would develop ITS standards. These organizations follow the priorities and other standards needs identified in the National Architecture. Mayday standards were identified as a need for national compatibility, so that travelers would be able to effectively use their in-vehicle device across jurisdictions.

The Society of Automotive Engineers (SAE) was designated by the FHWA to identify a set of Mayday standards. The Architecture identified Mayday as an area with no standards available to be advanced or promoted. Rather, it indicated that it would be necessary to develop new standards. This development was listed as a priority because of the proliferation of Mayday type systems. In fact, there was a set of open, non-proprietary standards developed by ENTERPRISE, and in use in Colorado Mayday, but SAE and FHWA selected to not use these as a foundation for further Mayday standards development.

The Colorado Mayday system is proprietary, and it uses a proprietary system for transmitting raw GPS data from the vehicle to the processing station. The format of the raw GPS data in Colorado Mayday is owned by NAVSYS and is unique to the TIDGET7 method. The raw GPS data captured by the TIDGET7 at the vehicle's site does not define a location without the processing performed by the processing station. Only after it reaches the processing center and a location is determined is the data complete. Only then can a PSAP display the vehicle location and the unit owner's record.

From the processing station to the PSAP is where an open, non-proprietary standard would be beneficial. With a universally used standard, the information could be sent to any Mayday-ready PSAP. Similarly, all Mayday system equipped vehicles would be able to request assistance from any PSAP.

From the processing center, Colorado Mayday used the TRADIN EDIFACT traveler information message packet to transmit Mayday incident information over landline from the processing center to the PSAPs or customer service centers. The TRADIN message may include the following information:

- caller identification;
- system type identification;
- cell site identification;
- data request;
- device control;
- location solution;
- location raw data;
- assistance type request;
- assistance request details;

- vehicle occupant data;
- seat belt usage data;
- air bag deployment data;
- speed before collision;
- direction before collision;
- collisions data; and
- fire detection⁵

Clearly not all fields were used during Colorado Mayday. However, the standard was developed to suit several types of assistance request systems with varying capabilities. The TRADIN message type is intended to allow for further development in sensors and the types of information a vehicle can send back. It is intended almost exclusively for Mayday information exchange, and not the potential value-added services.

One strength of the processing station approach to Mayday systems is that a single software change can make the system compatible with any standards. While Colorado Mayday chose to transmit emergency requests using TRADIN, simple adjustments could have been made to allow for the transmission of request information in any preferred format. No changes would have been required for transmission between the vehicles and the processing center, which would have involved altering every IVU.

SAE continues to develop a Mayday standard to meet the needs of the ITS community. Colorado is a member of the ENTERPRISE MJM Committee which is also identifying the needs and requirements of standards. However, there is currently no consensus or accepted standard available. It should be noted that the standards apply only to the data transmission, as voice communication would occur separately.

6.3 COLORADO MAYDAY MARKETING LESSONS LEARNED

There were two elements to the marketing plans for Colorado Mayday. The first part was to attract participants to the operational test. Beyond that, there were the market factors that would determine the viability of Colorado Mayday as a commercially sustainable venture.

6.3.1 Mayday Market

The Ford Rescu and GM OnStar Mayday-type systems impacted the market potential of the Mayday system. Both systems offered Mayday as one part of a suite of traveler services and

⁵ Mayday System Specifications, ENTERPRISE ITIS Committee, 1995

both were heavily promoted to consumers. During negotiations with ADCOM and CCG, the Colorado Mayday system was discussed as providing a similar suite of services. This was anticipated by NAVSYS, which had placed buttons on the button box that were not yet assigned functions. CCG, which has developed their own Mayday response system within their call centers, believes that Mayday is commercially feasible as one of many Automated Location Information (ALI)-based functions. ADCOM was also interested in the potential revenue that could be generated by offering additional services. The potential revenue generation through traveler assistance may help to offset the cost of equipping PSAPs for receiving Mayday requests and information.

6.3.2 Participant Recruitment

Recruitment of 1000 participants would have taken a much more intensive effort than was originally anticipated. It was assumed at the project inception that enthusiasm in the new technology would help drive recruitment efforts through media attention and word of mouth. Commercially available Mayday devices meant that many people that would have volunteered due to their interest in the technology were able to purchase a Mayday type system. NAVSYS had committed to the recruitment of 1000 participants. However, they did not develop a clear strategy for the recruitment and did not recruit any of the 1000 needed participants. A stronger commitment to recruitment with goals established throughout the project life would have helped the project team understand what effort levels were required to reach project goals. It was also a mistake for the project team to assume that recruitment could be done as needed. Efforts must be made at all times with the long-term goals in mind.

The MJM technical committee, of which CDOT is a member, has developed a series of recommendations for participant recruitment during a Mayday operational test. The recommendations are designed to ensure the successful recruitment of a suitable test participants and allow the program to collect a significant amount of data for evaluation purposes. Documenting the recommendations occurred after all recruitment efforts of Colorado Mayday were complete, and the project was not able to incorporate them. However, they are relevant in light of the experience of the Colorado experience.

6.4 COLORADO MAYDAY INSTITUTIONAL LESSONS LEARNED

The Colorado Mayday Operational Test experienced a wide range of institutional issues during its two phases and planning for the third phase. During the project, the development team was in contact with three potential response centers. Through the interaction with these three potential partners with distinct issues, the Mayday team was exposed to both public and private sector concerns. In this section, the institutional issues that were encountered are

discussed in detail.

6.4.1 Project Partner Commitments

Several partners, including the cellular companies and CSP, left the project because the Memorandum of Understanding (MOU) permitted it. Stronger, more binding agreements between the various partners would particularly benefit operational tests, which are often prone to delays, technical glitches and setbacks. Additionally, outreach to the executive level of the partnering members is crucial during project development. In the case of CSP, it appeared that Mayday was most strongly supported by one individual. When she left her position, the remaining CSP staff was not well-educated about or supportive of the Mayday system, and that may have contributed to their reluctance to remain a project partner.

6.4.2 Mayday Funding

In the commercial deployment of Colorado Mayday that would have followed Phase III, users would pay a fee for the Mayday service, and that fee would go entirely to the processing agency and/or a commercial call center. The processing agency would receive the raw data, determine the vehicle location, and pass this on to the CSP dispatch center, with other information such as vehicle owner's name, vehicle type, and possibly medical information.

Many states, including Colorado, have established excise taxes for cellular users. These fees are intended to serve in addressing the issues specific to cellular 911 calls. The primary issue is determining the location of the caller. From fixed locations, most 911 systems can identify the address and position of the caller. However, cellular callers often cannot identify their location or move from the locations they report to dispatchers. Additionally, states such as California had such a large number of callers abusing 911 by calling for non-emergencies that they considered not accepting emergency calls from cellular phones. The excise tax is intended to help in determining the area the caller comes from by identifying the cellular phone owner and the cellular towers through which the call is transmitted. It allows the call to be sent to the nearest PSAP. It does not help dispatchers identify the exact location, but gives them an idea of which jurisdiction the caller is in. Colorado resident cellular phone owners pay \$0.75 per month in excise fees.

The excise fee does not cover the cost of additional hardware and training required to deal with Mayday type calls. During the Mayday Operational Test, CSP had more than \$150,000 worth of hardware and software installed in their dispatch center. This equipment was intended to serve 2000 test participants, with the system expanding to cover far more users once it reached commercial deployment. For the project, no additional staffing was originally planned at CSP, but in a full commercial deployment, additional dispatch station would most

likely be needed, along with frequent system maintenance. It is not possible to estimate the additional staffing required since the impacts of the system on CSP staffing were not investigated during the project. However, it should be noted that Colorado did not have any funding mechanism in place for expanding the Mayday system from operational test to commercial deployment through a public dispatch agency.

Eventually, even calls such as those going through private response centers may provide location data to emergency dispatch centers. This data will require new equipment that can accept location data and translate it into graphical location displays, or textual location descriptions. The additional cost should be identified and planned for through excise or user fees that directly target the segment of the cellular community that will benefit from it.

6.4.3 Dispatch Station Design

Surveys were distributed to dispatchers at CSP to assess their acceptance of the dispatch station that was installed in the CSP dispatch center. The dispatchers indicated how the display should look and what information should be displayed to help them speed response to emergency callers. However, this exercise forced the dispatchers to consider a predetermined dispatch station. This station was a stand-alone and could not be integrated into their existing CAD stations. CCG later was interested in serving as the Mayday call service center, but required that the Mayday data be integrated into their existing workstations.

The Colorado Mayday effort would have benefitted from an integrated approach that worked with existing systems rather than introducing a new system into the dispatch environment. More potential response services would have been interested in participating in the project if it could have been integrated so that Mayday calls would have been routed directly to existing dispatch stations. By integrating the Mayday display into existing workstations, dispatchers would have most likely had a higher level of acceptance. It would reduce the level of complexity for them and would allow all dispatchers to share the responsibility of Mayday, rather than assigning one individual to the Mayday station.

6.4.4 125 Meter Rule

According to the FCC,

“The continuing growth of mobile radio service customers will increase the number of 911 calls that are placed from mobile telephones. As currently configured, however, wireless 911 services are inferior to the wireline 911 services that telephone users have come to expect. Specifically, 911 calls originated by mobile radio users generally do not provide PSAP attendants with the caller’s precise

location. Because the callers may not know their location, the ability of emergency service personnel to respond is hindered."⁶

FCC developed a plan that would force cellular manufacturers and service providers to develop a system for locating callers within 125 meters of their actual location.

6.4.4.1 Implementing the 125 meter rule

The FCC is considering the several systems for ALI, including GPS based systems. The FCC's primary concern with GPS is that it does not work well if a caller is inside a building or amid obstructions that attenuate or block the satellite radio signals. Due to the concerns about technical and financial feasibility expressed by manufacturers and communications service providers, the FCC has tentatively concluded that compliance with any ALI requirement should be implemented in three steps. These three steps are:

1. Wireless service providers would be required to design their systems so that the location of the base station or cell site receiving a 911 call from a mobile unit is relayed to the PSAP. The FCC has targeted that wireless base stations be capable, within one year after adopting rules (or by 1999, if rules are enacted immediately), to route 911 calls with sufficient location information to permit connection of the mobile station to the PSAP closest to the mobile caller.
2. In the second stage, the associated base station or cell site should be capable of relaying more precise information. This stage was to take effect three years after the effective date of the order adopting rules. The ALI information provided to the PSAP will include an estimate of the approximate location and the distance of the caller from the receiving base station or cell site, calculated on the basis of the received signal strength or by some other method.
3. In the third phase, the mobile station will be located in a 3-dimensional environment within a radius of no more than 125 meters. This will be five years after adoption of the rules (as early as 2003). This information will enable the PSAP to assist emergency services personnel by providing a relatively precise location for a 911 caller using a wireless service. The FCC notes that even greater accuracy could be necessary in urban environments to determine the precise location of a caller within a multi-story structure.

These rules will drive development of ALI technology. The Colorado Mayday system was designed for this test as a three watt, vehicle-based system. The proposed FCC rules apply to all wireless phones, not just vehicle based. It is not clear from the proposed FCC rules at this time whether a uniform system will be required of all phones, or whether each

⁶ FCC Petition for Comments on Cellular Phone Location, Federal Communication Commission, 1997

manufacturer and provider can achieve the 125 meter rule by its own means.

6.4.4.2 The potential impact of the 125 meter rule on technology

Because of advances in the miniaturization of cellular technology, three watt, vehicle-based phones are not as popular as they once were. In 1984, they were virtually the only type of phone available to the public. In 1997, however, Over 80% of the cellular phones that were sold were 0.6 watt phones that could be carried in a pocket or on a person. The 125 meter rule applies to both vehicle-based and hand-held cellular phones. To this extent, NAVSYS is developing the GPS Phone, which is a hand held unit that will be able to gather raw GPS data from satellites and transmit it to a processing center. The processing center will then transmit the data to a PSAP or other response center. Other strategies are being developed that triangulate a caller's location from the strength of the cellular signal at nearby cellular towers.

The FCC rule also does not address how the location information will be provided to PSAPs. If it will be provided in coordinates, it will do little for PSAPs that have no system for converting that into an understandable location description, such as cross streets or an address, that can be relayed to en-route emergency response teams. If it will be provided to responders in terms of landmarks and street names, there is no provision in the rule as to how and when the translation from coordinates will be made. Also, it is not clear how location descriptions will be standardized so that they are clear to all dispatchers.

While the Colorado Mayday system provided a complete system from a driver pushing a button to a response team knowing an exact incident location, it may be superseded by the mandates of the FCC, which may result in a system, or systems, that are incompatible with Colorado Mayday. The equipment purchased and installed by PSAPs to handle the locating of wireless 911 calls will be dictated by the FCC's 125 meter rule and how most providers and manufacturers address it. If the way that location information is provided to PSAPs under the proposed rule is not compatible with the way information was provided by Colorado Mayday it will result in one of two scenarios. The first scenario is that after-market systems such as Colorado Mayday will be driven to third party responders who will receive calls and forward the information on to PSAPs. The second scenario is that systems like Colorado Mayday will have to be drastically revised to be compatible with PSAP equipment.

6.4.5 Implications of Public Sector Technology Development

One significant lesson learned by the project team was the impact of public sector involvement in technology development. Between the inception of Colorado Mayday and when Phase III was in the planning stages, several other commercially funded Mayday type projects had achieved a higher level of public awareness and commercial success. While the technology that drove the commercial deployments was different and had its own set of

advantages and disadvantages, the private sector was more able to promote and support their systems. Additionally, because the commercial systems had no public funding, they were conceived entirely as commercially sustainable systems and had to respond more quickly to shifts in the market.

Colorado Mayday had a scope of work it was committed to from the outset. The funding sources that the project team members relied on the project team accomplishing the scope. Over time the relevance of the scope shifted, but the project remained committed because funding was contingent on reaching milestones identified in it. Additionally, adjusting the project scope would have been a slow process because of the number of agencies which would have to approve the adjustment. Commercial systems also had preliminary goals and objectives, but those could more easily change. The programs had to adapt based on the market potential because their overriding goal was to be profitable and commercially sustainable.

Public sector funded operational tests of evolving technologies are at a disadvantage if they are attempting to develop commercially sustainable systems. When the original project scope is no longer the best strategy for developing a commercial system, the project team is faced with a dilemma. The project team relies on funding that is contingent upon achieving the milestones identified in the work scope, and may pursue the milestones in order to keep the project progressing, rather than stop and identify a better approach. In this way, public sector support may actually drive an operational test away from commercial sustainability.

One example of the project direction that is taken with public sector support is the issue of the cellular phones in Colorado Mayday. The project ended up only being able to use a single, discontinued model of phone. The project team was able to continue with the project despite this limitation, however, the commercial potential for a system tied to an obsolete phone was low. Had the system been market driven from the outset, the project would have identified and addressed the equipment limitation much earlier.

6.4.6 Colorado Mayday Equipment Ownership and Maintenance

For Phase III, NAVSYS would have installed its Mayday workstation at the ADCOM PSAP. As part of this arrangement, ADCOM wanted ownership of the hardware and software, not only for the duration of the operational test, but also permanently. This issue is indicative of the scenario facing many rural PSAPs: they cannot afford the equipment required to handle Mayday calls. Most PSAPs operate text-based CAD systems that will need to be upgraded to graphic-based systems in order to optimally use Mayday system data. ADCOM was seeking a means for avoiding the tremendous costs of becoming Mayday capable. One potential solution that was considered by NAVSYS, but never formally explored, was revenue sharing with the PSAPs to allow them to adequately deal with Mayday calls.

6.5 COLORADO MAYDAY LEGAL LESSONS LEARNED

As one of the first Mayday operational tests, the Colorado Mayday project included the opportunity to address legal issues and their relationship to the implementation of Mayday type technologies. The legal exposure of the project partners through Mayday was explored by the law firm of Miller & Welch during Phase I. They summarized the anticipated legal issues that would evolve from the Mayday technology, for responders, equipment manufacturers and processors. The summary can be found in Appendix B. While that document is a valid summary, additional lessons were learned through real-world application. Many of the issues that affected the Colorado Mayday system were unanticipated and the Colorado experience can be used to better prepare other Mayday system developers.

6.5.1 Liability

According to the legal research, liability for dispatchers and the information processors is limited to their negligence or malicious activity. However, the ability to identify locations and respond to a new type of emergency call may result in “special service” that widens the amount of liability and damages that the dispatcher and processor can be responsible for.

As discussed in section 5.2, both ADCOM and CSP required at least one million dollars of liability insurance coverage provided by NAVSYS in order to participate. This insurance would have been available to the PSAPs for all legal disputes arising from the Mayday system. This cost was not anticipated by the Mayday project team and was a major barrier to full-scale deployment.

6.5.2 Technical Performance

Operational tests have performance specifications that indicate the reliability and accuracy expected from the system. In the case of Colorado Mayday, the performance of the system was below expectations at many points. This is common for operational tests where systems are being modified and improved throughout the project.

If a system underachieves the specifications and this leads to misinformation or a delay in emergency response, the project team could be liable for providing sub-specification performance to the users. The Colorado Mayday project notified all users of the testing nature of the system. No performance levels were promised to participants.

7. RECOMMENDATIONS

7.1 INTRODUCTION

One purpose of operational tests is to document the experiences and provide a history that future projects can build from in order to improve and expand. Many of the issues and barriers encountered by the Colorado Mayday Operational Test could have been avoided had it been possible to foresee them. The recommendations provided here are intended to help future Mayday projects and operational tests prepare for the potential obstacles and opportunities between project inception and successful deployment. The project recommendations are divided into four areas:

- technical;
- marketing;
- institutional; and
- legal.

7.2 COLORADO MAYDAY TECHNICAL RECOMMENDATIONS

Operational tests are constantly changing. During the Colorado Mayday Operational Test, the project was delayed several times while modifications and improvements were made to the hardware and software. This is to be expected from a project of this-nature. However, while the changes were in the best interest of the project at the time, some later became disadvantages.

7.2.1 Avoid Equipment Limitations

Colorado Mayday Phase II was, and most likely Phase III would have been, limited in its deployment because the IW worked well with only one brand and model of cellular phone. By allowing the Mayday system to be built around a single cellular phone, the project team was unable to take advantage of the improvements in analog cellular, and ended up with an in-vehicle device built around an obsolete phone. While one technology may result in a system that achieves the projects goals and accomplishes the work scope, it may not prove to support a commercial deployment. Operational tests with the goal of commercial sustainability should be planned from the outset to be adaptable to the foreseeable changes in technology. It is recommended at each phase of an operational test that the commercial viability of the technology decisions are considered.

7.2.2 Build System to Fit Current Operations

The Colorado Mayday system was built to display information to dispatchers on a single workstation. Because most PSAPs have multiple dispatch stations with a dispatcher assigned to each station, the Mayday display did not integrate well into the existing office organization. One potential dispatch group withdrew from the project because the information could not be provided to the existing dispatch workstations. The Colorado Mayday project presented a dispatch station to the PSAPs before assessing their needs and therefore produced dispatch equipment that met resistance and required significant changes in the way the dispatch stations work.

Future Mayday type systems should be able to determine the criteria of the PSAP environment. Similarly, operational tests should ascertain the requirements of the test participants before significant investment is made in equipment that does not meet the partners' needs.

7.3 COLORADO MAYDAY MARKETING RECOMMENDATIONS

An operational test often combines several technical organizations that are adept at developing technology, but are not necessarily qualified to market the resulting product. The technical groups can become so involved in developing a high-quality product that the marketing aspect becomes secondary. In order for the technology to reach its target, marketing efforts must be undertaken to raise awareness.

In the Colorado Mayday Operational Test, the project team focused heavily on technical development. As technical issues threatened the continuation of the project, they were addressed at the expense of preparation of a marketing plan. As a result, the project developed a technically competent device with significantly reduced commercial appeal, due to the lack of aggressive marketing and the equipment limitations.

7.3.1 Utilize the MJM Mayday Recruitment Recommendations

There are four MJM recommendations which are provided in detail in Appendix C. The recommendations are::

Recommendation #1 - Identify the types of participants necessary for the project before beginning recruitment.

The number of potential participants identified should be considerably larger than the number ultimately required. This larger pool should be assessed, either through interview or

survey, to identify the participants that meet the needs of the project, and are willing and eager to contribute. In Colorado, the lack of a strategic recruitment plan could have had deleterious effects on the quality of data collected. For example, it would have been easier and less expensive for the project team to distribute the phones in a small urban region where participant support would have been simplified. However, that distribution would have skewed data to a small, geographically similar urban area. No requirement was set that specifically identified where and to whom phones should be distributed.

Recommendation #2 - Prepare the necessary tools for recruitment before beginning.

In Colorado Mayday Phase III, a concern was expressed as to how to make sure that all 1000 units in the field were working all of the time. A participant could have the unit installed in his car, but it might not work, or may have been installed incorrectly and the participant would not know. Additionally, there was a question of how the units would be installed in vehicles and by whom.

It is important to have consistent information available to potential participants before they are recruited. If they fully understand what is asked of them, it is more likely that only those that are interested and enthusiastic about the technology and the test will participate.

Recommendation #3 - Use as many resources as possible to recruit participants.

NAVSYS marketing plan for Phase III provided a recruitment plan that included the use of the local media., brochures and industry specific journals and magazines. Their plan provided a good strategy for providing a suitable amount of information to the public. A creative recruitment strategy used in New York's Mayday operational test has local fire departments distributing test equipment. Various fire departments were given a large number of testing units. One testing unit, if deployed through a tire station, would result in a \$500 prize for the station that distributed it.

Recommendation #4 - Remain in close contact with participants during the course of the project.

The MJM committee recognizes that test participants are often enthusiastic at the beginning of a project, but over time the enthusiasm and interest wanes. Participants can drop out if they are not actively courted throughout the project. In other Mayday operational tests, incentives were used to keep participants involved. Gift certificates for free gas and coffee were given to participants when they returned their data logs or completed other milestones of their participation. This reminded the testers of their value to the project.

In Washington State, keeping the participants active in the testing for the entire testing period was difficult. Generally, after the novelty of the equipment wore off in two or three weeks, the participants tested infrequently and kept less exact logs. Washington's experience was

that only half of the total possible number of tests should be expected during testing. Washington said that if it were to do its testing over, it would offer incremental incentives to keep participants interested for the duration.

7.3.2 Commit to Marketing Roles and Responsibilities

It is recommended that operational test project teams specifically identify the level of effort each project team member's roles and responsibilities in the recruitment process. The project manager should insure that all efforts are made at the committed levels. Additionally, if it is determined early on that there is no qualified project partner to perform the marketing tasks, an organization with strong marketing skills should be added. Operational tests are often multi-million dollar exercises, and their positive results should be advertised and promoted in order to place them in the public domain where they will serve the public, industry and the public sector.

7.4 COLORADO MAYDAY INSTITUTIONAL RECOMMENDATIONS

While there were technical issues that slowed the progress of the Colorado Mayday project, it was institutional issues that were most responsible for stopping the operational test before it achieved its goals. The institutional issues could have been avoided if they had been anticipated. The recommendations are intended to help other operational tests better prepare during project conception.

7.4.1 Develop Strong Project Partner Commitments

The primary recommendation resulting from this project is that the MOU developed at the project's beginning be binding and specifically identify the roles and responsibilities of each project partner. With evolving technologies, there are a variety of issues that can discourage particular project partner. A strong MOU and contract will keep members involved and participating until they can see the benefits of their efforts.

One key element to stronger relationships with project partners is to clearly define each partner's needs at the outset of the project. Each partner will have an individual set of goals and objectives if these needs are defined from the beginning. Additionally, by clearly understanding all needs at the project's inception, the project team can show the partners how those needs will be filled and during what part of the project results can be expected.

7.4.2 Involve the Project Partners

Outreach is also essential at all stages of project development. Team members must be involved and aware of the project's progress at all times. Project resistance or support can arise from members within the partner organizations, but who are not directly involved in the project. An example of this is CSP's change of attitude toward the Colorado Mayday project once a key employee left her position. The other CSP employees had not been kept involved in the project and therefore were not as aware of the project as the rest of the team. They did not recognize the potential benefits of the system, neither did they understand their commitments. Information should therefore be spread beyond just those that are directly involved in the project and to the entire organizations.

The Colorado Mayday team also learned that a team effort is crucial. When NAVSYS did not lead the project marketing, CDOT attempted to recruit Phase II participants. The CDOT personnel involved were already burdened with full workloads and could not achieve the needed levels of effort. The result was low participant enrollment. It is essential for project partners to work as a team, with each member performing its committed role, to ensure that each goal and objective is fully met.

Whenever possible, outreach should also be performed to the public. Their support of a project can provide project partners with a mandate to research new technologies. Public support will help the public sector partner to define the value that their customers place on a project. It can help shape the level to which the partners will participate.

7.4.3 Identify Funding for Full-Scale Mayday Deployment

Rural PSAPs will not equip themselves for Mayday response until there is funding in place that supplements their limited budgets. A strategy for educating PSAPs about Mayday and the equipment they require should precede any national, or wide scale, deployments in order to ensure that PSAPs have plans in place for maintaining, upkeeping and repairing the PSAP-located equipment. Current cellular 911 funding in Colorado and other states does not support the purchase and deployment of Mayday type equipment in the state's PSAPs and these will be necessary for a fully deployed Mayday system with the same objectives as Colorado Mayday.

7.4.4 Determine the Legislative Implications of the FCC's 125 Meter Rule

The FCC's 125 meter legislation will require additional legislation at the local level that deals directly with its impacts. Primarily, a call may be placed in a different jurisdiction than where it is located by the location system. This applies not only to GPS based systems such as Colorado Mayday, but also all other ALI schemes that are being proposed. If a caller's

location is mistakenly identified as being within the incorrect jurisdiction, his call may be responded to by a PSAP that cannot help him. Legislative measures, or inter-jurisdictional agreements, will be required to address potential incidents. In most areas, there are inter-jurisdictional agreements in place that can be amended.

7.4.5 Develop an Approach for Dispatchers Handling Mayday Calls

There are no standard approaches that define how a dispatcher should handle situations unique to Mayday systems. These include how dispatchers:

- interact with Mayday callers;
- relay Mayday information to emergency response agencies;
- interpret and react to incomplete messages from Mayday callers; and
- decide the appropriate response when there is no voice communication.

These are all issues that should not be addressed at the local level because a nationally uniform approach is needed, similar to the 911 training already conducted by APCO. A national effort, through an organization such as APCO or National Emergency Number Association (NENA) that addresses the way that dispatchers respond to Mayday calls would be of significant benefit to the dispatchers that will participate in future Mayday exercises.

Before a national approach for handling Mayday calls is established Mayday project teams should develop agreements at project inception that identify which organization will train the Mayday dispatchers. This organization should have the authority to train dispatchers and the Mayday training should be integrated into their existing training.

7.5 COLORADO MAYDAY LEGAL RECOMMENDATIONS

As this project attempted to switch the partner PSAP, a different set of legal concerns became barriers. Because one goal of this project was to determine the feasibility of a national Mayday system, a variety of PSAPs would ultimately have to be involved. Operational tests should explore not only the legal issues facing the project partners but also those of any potential participants once the project is fully-deployed.

RELATED DOCUMENTS

The following table contains a chronological list of relevant documents that were produced during the Colorado Mayday Field Operational Test. These documents are available to anyone seeking more detailed information than that provided in the Project Summary Report.

Date	Title
January 1994	Mayday operational Test Proposal
June 1994	Draft Specifications for a Mayday System
July 1994	Revised Memorandum of Understanding, Scope of Work, Budget, Schedule
September 1994	Project Objectives, Budget, Schedule
January 1995	Revised Memorandum of Understanding, Scope of Work, Budget, Schedule
February 1995	Phase I Evaluation Plan
May 1995	Phase I Interim Evaluation Summary
July 1995	Legal Evaluation of Mayday (found in Appendix B)
July 1995	Phase II Evaluation Activities
September 1995	Revised NAVSYS Task Descriptions
September 1995	Evaluation of a Mayday System: Phase I Results
September 1995	Detailed Phase II Acceptance Testing
September 1995	Detailed Phase II Acceptance Testing Activity Summary
October 1995	International Traveler Information Interchange Standard Mayday System Specifications
October 1995	Mayday Project Focus Group Report
October 1995	Colorado Mayday Revised NAVSYS Task Descriptions for Phases II and III
October 1995	Mayday in the Rockies - Article in GPS World (found in Appendix D)
November 1995	Phase I Evaluation Summary Report
January 1996	MJ Test Procedures, including modem board and button box test procedures
February 1996	Revised Operational Test Evaluation Plan
January 1997	Revised Operational Test Evaluation Plan
March 1997	Mayday Phase II Activity Status Report

April 1997	Mayday Phase II Activity Status Report
July 1997	Summary Report of Exclusive Nokia C- 16 Testing
July 1997	Mayday Phase III Marketing Plan
October 1997	LocatorNet system Overview

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APPENDIX A - VALUE ADDED

POTENTIAL VALUE-ADDED SERVICES FOR THE MAYDAY SYSTEM

June 1996

Castle Rock Consultants

POTENTIAL VALUE-ADDED SERVICES FOR THE MAYDAY SYSTEM

A Mayday system consists of three linked components: a TIDGET7 or GPS sensor, a communications medium, and a processing center. A TIDGET7 is a cost-effective type of GPS sensor that does not determine its position, but collects data and requires a communication link to allow the position to be calculated at the dispatch center. The conventional GPS sensor is capable of collecting data from Global Positioning Satellites and directly calculating the vehicle coordinates from it. The Mayday unit using a conventional GPS sensor transmits the coordinates to the dispatch center. Currently, the communications medium in the Colorado MAYDAY project and the Minnesota Mayday Plus project are cellular phones, however, other methods such as pagers technology are feasible.

With the installation of a Mayday system, vehicles will be able to utilize the GPS and communications capabilities for many other potential traveler services. These services can be classified in two categories. The first category is services that can use the GPS sensor but do not require the communications link to provide the traveler with useful information. Because the TIDGET7 requires the communication link to determine location, TIDGET7 based Mayday systems cannot offer these services. The second category is services that require both the GPS function and the communication link. Since the communication link is required for these, both the TIDGET7 and conventional GPS sensor can offer all of these services.

1. SERVICES REQUIRING NO COMMUNICATIONS LINK

In a conventional GPS sensor, the longitude and latitude of its position are calculated within the unit when it has four or more satellites in its view. For Mayday, the location data is transmitted to the dispatch center which uses GIS map databases to find the relative position of the vehicle. However, the locational information provided by the sensor can be integrated into other functions that operate entirely without two-way communication.

1.1 Traveler Information Radio

There are several projects underway in the United States and worldwide that will broadcast information regarding road and weather conditions, services available and transit and parking to vehicles. The information is broadcast in digital format and is converted to messages by an in-vehicle unit.

Radio stations with powerful radiated signals that cover a wide range are selected to broadcast the signal on their subcarrier. The wide area allows travelers to receive a steady stream of information without having to change stations and also allows the broadcast signal to reach into areas that are generally harder to reach such as canyons, valleys and across mountain ranges. The traveler information, then, must include messages that will cover traffic, weather and road conditions for the

entire range. The majority of messages may be irrelevant to the individual who is probably only traveling through a fraction of the broadcast area. The traveler may become confused about which messages concern his trip when bombarded with so many messages. In addition, because so much of the information is not useful to the individual, that person might choose not to use the messages rather than sort through them.

The conventional GPS sensor can provide a filtering function when integrated with the traveler information system. Messages displayed by the traveler information system will include a location reference code. By integrating the GPS sensor into the traveler information system, the coordinates can be read and the a location reference code can be assigned to the vehicle. By comparing the codes of the vehicle and the incoming messages, all messages applying to reconditions outside the vehicle's area can be filtered out.

By filtering out messages that do not apply, the traveler information broadcasts become more effective. The frequency of messages is decreased preventing an overload of information on the traveler. With directly applicable information, the traveler can more easily and effectively make trip decisions.

Both of the technologies required for this additional function are becoming increasingly common. The Minnesota TRILOGY project uses RBDS technology to broadcast traveler information to vehicles. Soon, Minnesota will be testing a Mayday system based on conventional GPS sensors. Colorado is testing an AM subcarrier for traveler information in the HERALD project and is also testing Mayday technology. By utilizing the GPS sensor from the Mayday system and the traveler information technology from TRILOGY and HERALD, vehicles will have the major components of this system. The only additional requirement of this system would be an interface between the GPS sensor and the TRILOGY receiver.

1.2 Tourist Services

Personal computer programs and hand-held devices that inform travelers of services and facilities available along their travel route are becoming increasingly popular. They can be a very effective tool in planning a trip, because they inform the traveler of the stops that will provide the desired services. A major drawback of these travel planning systems is that they require the traveler to plan ahead and know in advance the route and destination in order to provide a list of services available. They also do not offer a solution to the immediate needs of a driver such as hunger, exhaustion or illness.

By knowing a vehicle's location, a simple in-vehicle system will be able to identify the most convenient services and facilities. The system will be able to interface the vehicle's GPS sensor with a directory of services stored on compact disc by type and location. A single compact disc can hold more service information than several books of yellow pages. The system will then display information about the requested services or facilities within the desired proximity of the vehicle's

location. In addition, the system will be capable of identifying services and facilities at user-specified locations.

The hardware required by this system are becoming more popular with travelers for other functions that they provide. A complete system can be built by combining the GPS sensor from the Mayday system with a CD-ROM drive, simple processor and display unit. The compact disc service and facility directories have the potential to be self-sustaining and be funded similar to commercial telephone directories. Simple descriptions could be available for all services that choose to list with them, but more detailed, advertisement-style notices could be purchased, financing the directory development and maintenance.

1.3 Route Guidance

Similar in hardware requirements to the tourist service system is a system that will provide a traveler with directions and trip information. Many packages for the home computer will give a recommended path between any origin and destination for travel planning. However this information is only useful to the traveler that has time to plan ahead and if the traveler does not take side-trips or leave the pre-planned trip route. Additionally, these trip planning systems are useless in the cases where travelers are most likely to need directions: when they are lost.

Map databases at varying levels of detail can be stored on compact disc. Using an in-vehicle CD-ROM drive and in-vehicle display, these databases can be viewed or utilized for route guidance. The GPS sensor can be interfaced with the map databases and processor to determine the vehicle's relative location on the map. Route guidance to the selected destination can be determined from any point regardless of whether the traveler knows his location or not.

This system offers the driver the freedom to deviate from his planned route without fear of being lost. It also allows the traveler the ability to change plans or destination when already traveling. With this system, a driver will never feel truly lost because the GPS sensor and map databases will be able to locate the vehicle and offer guidance to the destination.

Route guidance systems are increasingly popular with several commercial manufacturers and rental agencies offering in-vehicle navigation systems as a value-added option on their rental cars. The advantage to the owner of a Mayday system with a conventional GPS sensor is that the GPS function is already present in the vehicle. By utilizing the existing hardware, a traveler would only need to add the CD-ROM drive, processor and in-vehicle display unit, if the person did not already own any of these.

2. SERVICES REQUIRING COMMUNICATIONS LINKS

Installing a Mayday system provides a vehicle-owner with the combination of a GPS receiver and an integrated communication link. The combination has the potential to offer a variety of services beyond the Mayday function. There are services that directly and indirectly benefit drivers based on a vehicle's ability to broadcast its position and receive information back from a centralized processing center. Because these potential services require two-way communication, both the TIDGET and the conventional GPS sensor are capable of offering the following features.

2.1 Vehicle Tracking

With a GPS sensor in a vehicle, its location can be determined at any time when the sensor is in view of enough satellites. The cellular communication link used in Mayday allows this location to be broadcast to a dispatch center or other facility it contacts. In Mayday type incidents, contact with the dispatch center is initiated from the vehicle. For a stolen vehicle, however, the initial contact must be made remotely, either from the dispatch center or through a system that triggers the Mayday system.

If a vehicle is reported to the processing center, a communication link will be established with the reported vehicle's Mayday unit. This phone call will initiate the system to gather the information needed to determine the vehicle's location and transmit that back to the center. Similar to the way a Mayday case will be treated, this information will then be passed on to the appropriate authorities who will then track the car down at the given location. The system will operate regardless of whether the actual coordinates are calculated on board the vehicle or whether they are determined at the processing center.

Vehicle tracking systems are very popular despite their still relatively high prices and periodical operation fees. They offer vehicle owners an added sense of security in the knowledge that their stolen vehicle can be quickly recovered. The main advantage of a Mayday-based tracking system to the owner of a Mayday unit is that no additional hardware is required. The communication link and GPS sensor will already be in place. Only slight modification will be required to allow calls to be initiated by the control center as well as from the Mayday unit.

In order for this application of the Mayday system to be effective the GPS receiver and communications hardware should be integrated into a single unit. If a car is stolen, it may be quickly dismantled and the cellular phone will be disconnected. Once disconnected from the cellular phone, the GPS unit will be unable to transmit its location. A simple communications link that offers no voice transmission capability but acts only as a simple modem for data could be built into the Mayday unit inexpensively. This integrated unit, with an inconspicuous antenna, would provide an inaudible, invisible device for tracking purposes.

2.2 Vehicle Probes

Of little direct use to the traveler, but of enormous use to planners and traffic management agencies, is the use of the mayday system as a vehicle probe. A probe is a vehicle in traffic that can transmit road, weather and traffic conditions back to a processing center. With a suitable number of probes in the traffic stream, a traffic management team can determine traffic conditions for an entire area. Recent reports on the effectiveness of several probe systems for incident detection have been very encouraging. This is particularly important as incidents cause over 65% of the total traffic congestion in urban areas. It is possible that a vehicle probe system may prove to be more cost effective than other types of surveillance systems in collecting information to support ATMS projects.

Vehicles equipped with Mayday units will have the hardware to both determine the vehicle's location and send traffic information back to a management center. By integrating the system into speed gauges, anti-lock brakes, vehicle-mounted temperature gauges and a variety of other sensors, the GPS sensor and communication link can be used to transmit a host of valuable transportation data to traffic management centers.

This additional function of the Mayday system can be implemented with very little hardware in addition to the Mayday components. Depending on the level of detail and amount of information desired by the traffic management centers, however, it may require significantly more equipment. The most rudimentary implementation will only require the existing GPS sensor, communication links and a means for measuring vehicle speed. Vehicles with anti-lock-brakes would also be able to report conditions regarding icy or wet roads. Further installation in probe-vehicles can include temperature gauges to determine road and weather temperature, video cameras for traffic conditions and congestion levels, and ultra sound systems to determine the condition of the road surface.

2.3 Tourist Services

A directory of tourist services provided for the area a vehicle is in can be provided without an in-vehicle CD-ROM drive and processor when the communication link is utilized. If a traveler needs service and facility information, that person will be able to use their Mayday unit to report their location to a processing center via the communications link. The processing center will be able to use the directories it holds to search for services and facilities based on the reported location. This system will be more flexible than the CD-ROM based system because it will more capable of providing up-to-date information and information regarding which services are currently opened and closed for the day or season. Additionally, the only hardware required besides the Mayday components is an in-vehicle display unit.

2.4 Route Guidance

Route guidance utilizing both the GPS sensor and the communication link will provide similar services to the traveler as the system not using the communication link. With the link, however, the vehicle will not need a CD-ROM or processor. Instead, specific route directions may be determined at a central location that is provided with the vehicle location and desired destination of the traveler. Additionally, updated road conditions can be factored into the route guidance. The incorporation of current road conditions cannot be done when information is taken from an archival compact disc. The most effective use of this system would have an in-vehicle display unit. However, travelers will also be able to contact a processing center that can locate the vehicles and then guide the drivers to their destinations using voice communication.

APPENDIX B - LEGAL ISSUES

**EVALUATION OF LEGAL EXPOSURE OF
MAYDAY SYSTEM**

I. Scope of Project

Castle Rock Consultants has requested Miller & Welch, L.L.C. to do an analysis of the potential legal exposure of the manufacturer/retailer and monitor of the "Mayday" system -- an emergency communication device that is being developed for installation in motor vehicles to enable the occupants to summon assistance in the event of an emergency. The device is intended to permit communication between the occupants of the car and the monitoring facility and to enable the monitoring facility to pinpoint the location of the vehicle for purposes of sending appropriate assistance.

Castle Rock Consultants wishes to have an analysis of the possible liability issues that could arise in conjunction with the installation and operation of such a system and to what extent those associated with such a system could protect themselves from and/or limit their exposure for such liability.

II. Operative Assumptions

For purposes of this analysis, Miller & Welch, L.L.C. has assumed the following facts:

A. The device will consist of a unit (separate from the motorist's cellular phone) with a push button on it. When the button is depressed, the cellular phone is activated and the monitoring station automatically called. Ultimately, it is possible that the design will call for "automatic deployment," like an air bag. It is unclear to us whether activation of the cellular phone enables two-way voice communication between the occupants of the car and the monitoring station or whether the device activates the phone solely to "transmit" the locating signal.

B. No final decision has yet been made with regard to the power source for the system. We believe serious liability problems are posed in the event the system is designed to run off the vehicle's power supply/the car's engine. It is eminently foreseeable that an accident which might trigger the need for resort to the system would render the engine non-operational. In our opinion, a power source independent of the vehicle's engine (i.e., one which would permit the system to operate even if the car's engine stopped) is essential.

C. Although the device will be installed only in state-owned vehicles for an initial trial period, for purposes of this report, Miller & Welch, L.L.C. has been asked to assume that the device will ultimately be available to members of the general public, presumably upon payment of a subscription or monitoring fee. Monitoring of

signals emitted by the device will be by the State Highway Patrol. Due to issues of a "special relationship" (see below) and governmental immunity, monitoring of the system by a private entity could raise additional liability considerations.

D. The device/system will, at least for purposes of this memorandum, only be sold in and operational within the State of Colorado.

III. Identification and Evaluation of Liability Issues

The purpose and, indeed, "selling point" of a device such as the Mayday System is to offer comfort or assurance to a motorist that, in the event of an automobile accident, someone in a position to come to the motorist's aid or rescue will be notified and the location of the vehicle pinpointed to facilitate prompt assistance of whatever type is needed. While receipt of and response to the signal may be particularly important when the accident occurs on a remote, relatively untraveled road (because of the unlikelihood that there will be passing motorists to provide assistance), it can be equally important in an urban area, where good intentions of the would be "Samaritan" cannot be taken for granted. Any malfunction of the system (whether in the sending or receipt of the signal or the response of the monitoring personnel) thus poses a potential liability claim.

The possibilities for such a "glitch" are numerous and include the following:

- The cellular phone is disabled as a result of the accident;
- Because of the physical location of the vehicle (e.g., a remote valley in the mountains), the signal is not transmitted to or received by the monitoring station;
- The monitoring station's response is delayed due to manpower limitations;
- The monitoring station's response is delayed due to prioritization (e.g., a multi-car accident at another location which the monitoring personnel deem of greater severity);
- A malfunction of the device which fails to transmit the location of the vehicle or transmits an erroneous location or the monitoring personnel advise the rescue units of an erroneous location.

A. Product Liability Issues -- Manufacturer/Retailer

There are numerous legal theories available to one claiming to have suffered an injury as a result of a defect in or a failure to

warn about a product. The most commonly asserted (in ascending order) are: breach of the contract for sale or lease of the product, breach of express or implied warranties of the product's condition or performance, negligence in the design or manufacture of the product, and strict liability in tort. Depending upon the availability of proof of the required elements (e.g., that the manufacturer or the retailer in fact extended express warranties or did not disclaim implied warranties, that the retailer was involved in the manufacture or design of the product, etc.), either the manufacturer or the retailer or both could be held liable for the resulting damages. The exception to this general rule applies to claims of strict liability in tort--a theory that has been developed to facilitate recovery from a product manufacturer even without identification of the "negligent act" that resulted in creation of the product defect. In Colorado, the retailer cannot be held liable for damages in claims of strict liability in tort IF the retailer was not involved in the design or manufacturing process and IF the manufacturer is subject to the jurisdiction of courts of this state. Under those circumstances, the product manufacturer is the only proper defendant. Note, however, that the retailer is a proper defendant as to the other claims identified--breach of contract, breach of warranties, and negligence. C.R.S. § 13-21-402, attached.

It is now well-established in Colorado and most other jurisdictions that the manufacturer of an automobile or devices designed to be installed in automobiles is chargeable with the knowledge that the vehicles are likely to be involved in accidents. That knowledge raises a corresponding duty on such manufacturers to design a vehicle and the component parts of that vehicle in such a fashion as to offer reasonable protection to the occupants in the event of a collision (the crashworthiness doctrine) and to limit, to the extent practical, injuries from the occupant's colliding with the interior of the vehicle (the second collision doctrine). Claims such as those arising from Pinto fuel tank fires have been premised on the crashworthiness doctrine. Development and improvement of restraint systems such as seat belts and air bags represent the auto industry's response to the second collision types of issues.

These doctrines interface with the proposed Mayday system in two respects: It is general recognition of the fact that automobile accidents occur, often disabling both the vehicle and its occupants and "creating" the need for emergency assistance, that presumably will be a significant point in the marketing of this system. Since the primary intent of the system is to enable location of the vehicle in the event of a disabling accident, the design, operation and manufacture of such a system must take into account the almost limitless ways in which an accident can cause damage to a vehicle and protect the component parts of the Mayday system, to the greatest extent possible, from damage which would disable it. (In addition to the concern about preventing damage to the unit/push button mechanism in the event of an accident, this is also the

reason for concern about a power supply which will not be disabled or "cut off" in the event of an accident.)

The second design issue relates to the form of the device and its location within the vehicle. It is eminently foreseeable that, in the course of automobile accidents, the occupants and/or "things" in the interior of the car will be thrown around and moved from their normal or intended positions. (Unfortunately, notwithstanding the seat belt law in Colorado, it is probably also foreseeable, as a matter of law, that some people do not use seat belts.)

In the event the device is permanently affixed to the interior of the car (the dashboard, the windshield, etc.), determination of the location of the attachment must take into account the possibility that occupants of the car will be "ricocheting" off various portions of the interior of the car. Thus, both the design of the device and its location within the car should be such as to minimize, to the greatest extent practical, the likelihood that an occupant of the vehicle will come in contact with the device and, as a result, sustain injuries that would not otherwise have been sustained or greater injuries than would otherwise have been suffered. The location of the signaling device must also take into account the car's structure. It should be affixed to that portion of the vehicle that will offer protection from physical damage to the device that could render it nonfunctional.

If the device is not to be permanently affixed to the interior of the car, consideration must be given to its weight, shape, and the materials from which it is to be manufactured, again with an eye toward eliminating or minimizing, to the greatest extent possible, both the injuries that an occupant would suffer in the event he or she were struck by the device when the car was rolling over, for example, and the likelihood that, by "rattling around" the interior of the car, the device would be damaged to the point where it would no longer perform its intended function. By way of example, in Southwestern Bell Tel Co V Griffith 575 S.W.2d 92 (Tex.Civ.App. 1978) a verdict of \$420,371.68 was returned in favor of a person who claimed that a negligently or defectively installed mobile phone in his truck came loose, striking his leg and causing an accident. The alleged defect was installation of the unit on the transmission hump instead of a flat surface on which all four corners of the unit could be fastened down.

Yet another design consideration relates to the method of activating the device. It is foreseeable that occupants of a vehicle are likely to suffer injuries of various types in an accident. Thus, in order for the device to be suitable for its intended purpose (to summon aid in the event of an accident), if it is not "automatically" activated, the method of activating the device should be sufficiently simple and straight-forward that one who had suffered physical injuries or was somewhat disoriented from a blow to the head, for example, could take such action as would be

required to activate the device. The more complex the system (e.g., requiring the injured person to remember a lengthy number or sequence of buttons to be depressed), the more likely it is that the manufacturer would be held liable for injuries resulting from the person's inability to summon assistance. Again, assuming the device is to be permanently attached to the vehicle, it should be located in a position that will allow an injured occupant to activate it. Given the fact that a vehicle may or may not have passengers, but will have a driver, one of the primary considerations in terms of the accessibility of the device should be that the driver can reach it from his or her position in the car--belted in behind the steering wheel.

B. Liability for Failure to Respond--State Patrol and Private Monitoring Agency

1. Liability -- State Patrol

The liability of a governmental entity (such as the Colorado State Highway Patrol) for negligence in responding to "911" calls for emergency assistance could, in theory, provide some guidance on assessing the liability of a governmental entity for negligence in monitoring or responding to Mayday system signals. Unfortunately, however, the case law among (and sometime within) the jurisdictions is not consistent and is highly fact specific. Many jurisdictions accept the general rule that the duty to provide police or law-enforcement assistance is owed to the general public, not to an individual person, and that breach or negligent performance of the duty is only retraceable in a public context, not in a tort action. These jurisdictions also recognize an exception to that general rule where there is a "special relationship" between the law enforcement agency and the victim or where the agency has accepted or created a "special duty" to an individual citizen. Resolution of the issue of whether that "special relationship" or "special duty" exists, however, is totally dependent on the facts of the case, and a general statement that "x" is sufficient to demonstrate that relationship cannot accurately be made.

Colorado has rejected the notion that there is a distinction between the "enforceability" of duties owed by a governmental entity or employee to the general public and duties owed to a particular individual. As of its decision in Leake v. Cain u720 P.2d 152 (Colo. 1986), the Colorado Supreme Court abandoned the "public duty" exception to governmental liability and held that the duty of a public entity or its employees would be determined in the same manner as the duty owed by a private party.

In Leake, police officers were called to a teen party because of noise. When they attempted to break up the party, one of the teens (who was drunk), became boisterous, whereupon the officers placed him in handcuffs until he had calmed down. The teen's younger brother (who appeared sober and had a driver's license) then

told the officers that he would drive his brother home. After leaving the party, they made a stop and the drunken brother got behind the wheel of the car. He drove into a crowd of people, injuring 4 and killing 2. The heirs of the deceased filed suit against the officers and their employer, the city, claiming that, having had the drunken teenager in their custody, the officers owed a duty to the deceased persons to hold him in custody so as to prevent an accident of this type.

The Colorado Supreme Court rejected the notion (upon which the trial court had granted summary judgment for the officers and the city) that the officers' duty was owed to the general public and that its breach, if any, could not therefore be remedied by a private action for damages. According to the opinion, the officers did owe a duty to prevent the teenager from injuring anyone else while he was handcuffed and in the officers' custody, but that duty was discharged by restraining the young man until he had calmed down and then releasing him to his sober brother. "The officers did not assume a duty to respondents' decedents, induce reliance, or create a peril or charge the nature of an already existing risk." (P. 161) Accordingly, the Court found there was no liability on the officers or the city as a matter of law.

An issue was also raised in Leake concerning the "discretionary acts" exception to the doctrine of governmental immunity. Under that exception, a public official who is performing discretionary acts within the scope of his or her office is not liable for damages or injuries suffered by another unless his/her conduct was willful, malicious, or intended to cause harm. The Court of Appeals had ruled that the officers' decision not to take the drunken teenager into custody was not a discretionary act, and the exception thus did not apply. The Supreme Court disagreed. While the Court indicated that a decision not to take into custody a person who was operating a vehicle at the time of the stop and was under the influence of alcohol may not be a discretionary act, those were not the facts in Leake. The teen was not driving, and there were affirmative indications by his sober brother that he would not drive. The only statutory authority for the officers to take the teen into custody was the emergency confinement statute, which requires a determination that the individual was dangerous to himself or others--clearly a discretionary decision. Since the officers were public officials performing a discretionary function, they were immune from liability even if it had been determined that they owed a duty to the decedents and had breached that duty.

Even under Leake, the notion of a "special relationship" still comes into play in determining whether the actor/defendant owed a duty to prevent the harm to the victim. In two "joint" post-Leake decisions from the Supreme Court, the Court elaborated on the "duty" question. See, Jefferson County Sch. Dist. R v. Stus, 725 P.2d 767 (Colo. 1986) and Jefferson county Sch. Dist. R-1 v. Gilbert, 725 P. 2d774 (Colo. 1986). The Court's analysis begins with the premise

that, as a general rule, a person (whether public official or private citizen) does not owe a duty to another to protect the other from harm. However, when the actor has represented to that other person, by words or action, that he (the actor) has done or will do something to protect the other and other relies on his performance, there is liability for expectable harm if the representations were negligently or intentionally false or the actor fails to perform without an excuse.

The Court approved the language from the Restatement (Second) of Torts § 323 (1965):

One who undertakes, gratuitously or for consideration, to render services to another which he should recognize as necessary for the protection of the other's person or things, is subject to liability to the other for physical harm resulting from his failure to exercise reasonable care to perform his undertaking, if

- (a) his failure to exercise such care increases the risk of harm, or
- (b) the harm is suffered because of the other's reliance upon the undertaking.

The issue is a mixed one of the fact and law. Finding that a duty was undertaken requires a showing that the defendant, through his acts or promises, undertook to render a service reasonably calculated to prevent the harm that befell the plaintiff, and that the plaintiff relied on the defendant to perform that service.

Under the rationale of Leake and the Jefferson District cases, it is highly probable that a court would find that the Colorado State Highway Patrol (or a private monitoring agency) owes a duty to the motorists whose vehicles are equipped with the Mayday system to take reasonably necessary action to protect those motorists from the additional physical harm that may be caused by a failure to respond or a delay in responding to the Mayday signal. Whether there is a fee charged for the monitoring service is irrelevant. The Colorado State Highway Patrol should clearly recognize that the monitoring and response services which it is providing are "necessary for the protection of the [motorist's] person or things." The highway patrol would therefore be subject to liability to the motorist for any harm resulting from the Patrol's failure to exercise reasonable care to perform [the monitoring and response services]."

The literal language from the Leake decision and from § 323 of the Restatement. (using the disjunctive "or" to describe the circumstances under which a duty would arise) would appear to eliminate the requirement of reliance as a condition to liability. In the Leake decision, the Colorado Supreme Court indicates that liability can arise if the actor/defendant assumes a duty

(presumably by virtue of an agreement or verbal promise), induces reliance (by action, as opposed to an express written or verbal agreement) or creates a peril or changes the nature of an already existing risk. Similarly, the Restatement indicates that liability can attach if the failure to perform the undertaking increases the risk of harm or causes or permits the harm to be suffered because of the other person's reliance upon the undertaking. It would seem, therefore, that at such time as the device may be automatically deployed by virtue of the occurrence of an accident, the fact that the driver or an occupant of the vehicle was not aware that the vehicle was equipped with the Mayday system would not prevent the monitoring agency from being held liable in the event the system malfunctioned. This result is contrary to the result in other jurisdictions (see discussion below), but in the absence of further clarification of this question from the Colorado Supreme Court, one ought to assume that reliance is not a necessary element.

A determination that a duty was owed is not, however, the end of the liability analysis. The monitoring and/or responding entity can be held liable for the failure to respond or the failure to respond in a timely fashion only if the failure was as a result of the entity's failure to exercise reasonable care - the standard definition of "negligence". Assume, for example, that at a approximately the same time as the Mayday signal is received by the monitoring station, there is a major multi-car collision on an interstate highway within the same jurisdiction as the location of the accident involving the car with the Mayday-system. Further assuming that the Mayday system permits to a voice communication, assume also that the individual monitoring the Mayday system speaks with the vehicle's occupant who informs the monitoring person that the car is not drivable and, due to an apparent broken leg, for example, the motorist is not able to go for help. However, the motorist also informs the monitoring personnel that he or she is not otherwise seriously injured. Based upon that communication the monitoring person assigns a lower priority to the Mayday car and directs all available personnel first to assist with the multi-car accident. As soon as an individual responding to that emergency has been freed up, appropriate emergency assistance is sent to the car emitting the Mayday signal. In the interim, as a result of the delay, the motorist lapsed into a coma as a result of head injuries which the motorist did not realize he or she had sustained at the time of the exchange with the monitoring person. In that scenario, the judge might well find that the assigning of a priority to the Mayday call was a "discretionary act" for which the state highway patrol employee is entitled to immunity. The issue of whether an act is a discretionary one is most likely a question of law, which means the trial judge will be making the determination, not a jury. In the event the trial judge can be persuaded that the act was a discretionary one and that immunity therefore attaches, the claims should be dismissed at that point, without the necessity for a trial,

Given the continued vitality of the "special relationship" issue in Colorado, a review of case law from other jurisdictions addressing this question is still of benefit, even though not all of the cases are directly applicable.

The consequence of errors in responding to a request for assistance once received is demonstrated in DeLong v. County of Erie, 457 N.E.2d 717 (N.Y. 1983). A woman whose home was in the process of being burglarized called "911" to request assistance. The call was directed to the Center for Emergency Services, which was to have notified the appropriate law enforcement agency of the nature of the assistance required and the address. The individual receiving the call erroneously noted the address as "219 Victoria St." instead of 319 and mistakenly assumed that the address was in the City of Buffalo, instead of the neighboring village of Kenmore. (In fact, the victim's home was located 1,300 feet from the Kenmore Police Department.) The City of Buffalo officers who attempted to respond to the call informed the dispatcher that there was no such street address; the highest number on Victoria St. was 195. The dispatcher took no further action. The woman died from loss of blood resulting from numerous stab wounds inflicted by the burglar, and her husband successfully sued the City of Buffalo and the County of Erie for their negligence in responding to the request for emergency assistance. While the Court acknowledged that a governmental entity may enjoy immunity for negligent performance of a governmental function, when that entity has affirmatively undertaken a "special duty" (a finding of which is dependent upon the circumstances of the particular case), the governmental entity may be held liable for negligence in performing that duty. The Court found that creation of the 911 system in this case was sufficient evidence of the entity's having undertaken a "special duty."

The seeming inconsistency of the application of these "rules," even within the same jurisdiction, is demonstrated in New York State. Seven years after the DeLong decision, the New York Court of Appeals declined to hold the entity liable for its failure to respond to a request for emergency assistance where the caller was the victim's neighbor, not the victim herself. Merced v. City of New York, 551N.E.2d 589 (N.Y. 1990). Where "there was no evidence that the decedent contacted the municipality's agents or relied on any assurances of assistance, . . . we cannot conclude that the municipality's conduct deprived decedent of assistance that reasonably could have been expected from another source." (P. 589-90.1 As previously noted, reliance may not be required in Colorado.

In Chambers-Castanes v. King County 669 P. 2d 451 (Wash. 1983), the court held that privity or a "special relationship" creating a "duty of protection" existed where the dispatcher received 11 telephone calls in the course of 1 hour and 20 minutes following an assault on two motorists by occupants of the following vehicle. Governmental immunity (which attaches to discretionary acts at a

basic policy level) did not shield the police department from liability for discretionary acts at an operational level--such as whether to dispatch an officer to the scene of the crime or to investigate a crime. Additionally, the fact that the dispatchers had assured the wife/victim that officers were on the way (when they were not) and that she relied on those assurances was sufficient to create the "privity" which constituted an exception to the general rule of governmental immunity.

Opinions with similar facts but contrary results are Doe v. Hendricks, 590 P.2d 647 (N.M. 1979) and Warren v. District of Columbia 444 A.2d 1 (D.C. 1981), both involving cases in which the police failed to respond or delayed their response to calls for help, as a result of which a young boy (Doe) and three women (Warren) were sexually assaulted. These two courts applied the general rule that the duty owed by law enforcement agencies to protect against or investigate criminal activity was one owed to the public at large, declining to allow the receipt of 911 calls or other calls for emergency assistance to create a "special relationship" between the agency and the victim(s) such as would constitute an exception to that general rule.

The variability of the law in this area is further demonstrated by Trezzi v. City of Detroit 328 N.W.2d 70 (Mich. 1982). By statute in Michigan, a governmental agency is immune from tort liability wherever the agency is engaged in the exercise or discharge of a governmental function, unless the agency's actions resulting in the injury were "intentionally tortious acts," which would not be within the exercise or discharge of a governmental function. Hoping to avoid the immunity bar, the plaintiff claimed that the 911 operators' assignment of an "unjustifiably low priority rating" to several 911 calls for emergency assistance at the deceased's home and the police dispatcher's failure to dispatch patrol cars for approximately 1-1/2 hours after receipt of the first call was an intentional tort. Two of the three Court of Appeals judges held that the bar applied and the city could not be held liable. The third agreed that the acts were not intentional torts, but "gross negligence," but disagreed with the majority's characterization of the operation of the 911 emergency system as a "governmental function," particularly since it was staffed by private citizens, not police department personnel. Among other factors, the dissenter noted that "[h]ad there been no 911 system, the decedents here could have directly phoned a police dispatcher, and the senseless tragedy . . . might well have been averted." (p. 74.)

The "special relationship" which is required between a governmental agency and a private citizen in order to avoid the governmental immunity bar (and the inconsistent application of that test by the various jurisdictions) is further demonstrated by Mastberaen v. City of Sheldon 515 N.W.2d 3 (Ia. 1994). The court held that investigation of crimes is a duty owed to the general

public, not specific individuals, notwithstanding the fact that the jewelry store owner had paid \$5/month for the previous 11 years to the police department to monitor his silent alarm--a system which he installed at the suggestion of the city's police chief. Thus, the owner was not permitted to recover the value of the property stolen. One of the two responding officers started to enter the store but was knocked down by one of the robbers. The other officer went to the rear entrance, but the second robber had escaped with the stolen goods before he got to the rear entrance. The owner claimed that the police department was negligent in failing to prepare a plan for responding to merchants' silent alarms and that the officers should have set up covert positions around the building.

Further evidence of the unsettled state of the law in this area is provided by a comparison of two California Court of Appeals decisions--*Harzler v. San Jose*, 120 Cal. Rptr. 5 (Cal. App. 1975) and ~~*Whitcombe v. County of Yolo*~~ 141 Cal. Rptr. 189 (Cal. App. 1975). While both opinions came down on the side of "no liability," the *Harzler* court struggled with the issue of whether an abused spouse's earlier telephone call on the evening of her death and 20 calls prior to that evening complaining of threats of violence by her husband were sufficient to create the "special relationship" different from that relationship existing between the police and citizens generally. The ~~*Whitcombe*~~ court concluded that the California statute providing that public entities are not liable for failure to provide sufficient police protection service did not contain any exception for "special relationships," and that there was therefore no need to determine whether calls for emergency assistance were sufficient to create such a relationship.

As a practical matter, it appears that in some of the cases, the "special relationship" question turns on the issue of whether the communications between the victim and the law enforcement agency were such as to engender a reasonable and justifiable reliance on forthcoming police assistance on the part of the victim. Related to this question (although not always explicitly stated) is the issue of whether the victim did forego or may have foregone seeking alternative sources of assistance or methods of obtaining assistance in reliance on assurances that the entity that was contacted would respond. Thus, no special relationship was found and recovery was denied in *Rome v. Jordan* 426 S.E.2d 861 (Ga. 1993), where it was the victim's sister-in-law who telephoned the police asking for assistance and where the evidence indicated that the victim was not aware that the police had made any assurance of assistance (if they in fact did) and any reliance on her part was based on her assumption that the police would come if called. Also, compare *Merced*, *infra*, (no liability where there was no evidence that decedent relied on assurances that the police would come) with *DeLong* *infra*, (liability where the victim was assured that help would be there right away). Even this "rule", however, is not always observed, as indicated by the result in *Warren*, *infra*, in

which the court refused to recognize that a "special duty" was created by a second telephone call seeking assistance, despite the fact that a police officer assured the victims that help was on the way yet failed to dispatch any officers.

A jurisdictional limitation, in addition to the lack of reliance on the part of the victim, precluded imposition of liability in one reported case--Sawicki v. Ottawa Hills, 525 N.E.2d 468 (Ohio 1988). Where the crime occurred in a neighboring city 300 yards from the police station to which the call for assistance was placed, and where legislation forbade the police department from responding to calls for assistance originating beyond its jurisdictional boundaries, the Ohio Supreme Court held that the "special duty" exception to the public duty rule did not apply and the police department could not be held liable for the death of the crime victim.

The jurisdictional limitation is not likely to come into play, particularly so long as the monitoring is being done by the Colorado State Highway Patrol. The Attorney General's Office has issued an opinion in which it indicated that [t]he powers and duties of the Colorado State Patrol with regard to the investigation and reporting of vehicular accidents 'elsewhere through out the state' do not differ from its powers and duties with regard to the investigation and reporting of vehicular accidents 'upon the streets and highways' of the state. In other words, the Colorado State Highway Patrol clearly has jurisdictional authority to investigate vehicular accidents anywhere in the state without regard to whether the accident occurs on a county road, an unimproved road, etc. Additionally, since the state highway patrol monitoring personnel will presumably be in a position to contact other law enforcement agencies (city police, county sheriff, etc.) and/or appropriate emergency aid providers (private ambulance company), the issue of jurisdictional restraints, even assuming they exist, is presumably not a factor.

2. Liability--Private Monitoring Companies

Case law relating to the liability (or limitations thereon) of privately operated burglar or fire alarm systems (the application of which is not "confounded" by the rules relating to jurisdictional questions and governmental immunity) provides a bit more consistent guidance as to the potential exposure of private companies involved in the Mayday system. Generally speaking, the defendant's liability in this context can be controlled by the provisions of the contract pursuant to which the security or alarm service is provided. It should be noted, however, that, until recently, the vast majority of these cases presented questions of liability for personal or real property that has been stolen or damaged (not for personal injuries) as a result of failure of the system to generate an alarm or failure of the monitoring company's employees properly to respond to the alarm. As expressly noted by Lobianco v. Property Protection, Inc.

437 A.2d 417 (Pa. Super. 1981), the validity of contractual clauses limiting the installer's or monitor's liability to the cost of repairs or to specified liquidated damages may be more questionable where personal injuries are alleged to have been caused by the system's failure.

Contracts for the provision of burglar or fire alarm services typically contain liquidated damages or limitation of damage clauses (imposing limitations on the damages for which the company providing the services can be held liable) or exculpatory clauses (eliminating any damage liability whatsoever). The extent of the company's liability is often described as a flat dollar amount (\$25 or \$50) or as the greater or lesser of a specified percentage of the monthly or annual service fee or a flat dollar amount--e.g., "10% of the annual service fee or \$250, whichever is greater." Where the damages sought to be recovered resulted from the theft or destruction of personal property, not personal injuries inflicted by the burglar or suffered in the fire, such clauses are enforced in the majority of jurisdictions. A frequently stated rationale is the fact that such companies are simply providing a service; they are not insurers charging a premium for theft or fire insurance coverage; and the purchaser of the service has the option of obtaining such insurance coverage from other sources, should he so desire.

Exceptions to this rule are generally limited to cases in which the installer has misrepresented the system's features or capacity [Mankap Enterprises, Inc. v. Wells Fargo Alarm Service, 427 So.2d 332 (Fla. App. 1983)] or has been guilty of gross or willful and wanton negligence [Douglas W. Randall, Inc. v. AFA Protective Systems, Inc. 516 F.Supp. 1122 (E-D-Pa.), aff'd. 688 F.2d 820 (3rd Cir. 1981)]. "Gross" or "willful and wanton" negligence has been predicated upon findings that an alarm company employee turned the sensitivity level of a detector system "all the way down" to prevent false alarms [Douglas W. Randall, Inc.] and that tags identifying various wires servicing the alarm system (one reading "3 M Alarm Service--Holdup alarm, do not cut") had been left on the wires which had been by-passed prior to the burglary. [Morgan Co. v. Minnesota Mining & Mfg. Co., 246 N.W.2d 443 (Minn. 1976).]

Notwithstanding the Lobianco court's "caution" about contrary results in the event personal injuries, not property damage, resulted from the failure of the burglar or fire alarm systems, some courts have nevertheless denied recovery to personal injury plaintiffs. It is very dubious, however, that the rationales used by such courts would offer any "protection" to a private monitoring company, due to the differences between the nature and purposes of the burglar alarm systems and the Mayday system.

In the majority of these cases, the courts have concluded that the injured party was not a third-party beneficiary of the contract, generally based on the fact that the systems or security guards were

intended and designed to provide security for business premises during other than normal business hours--i-e., when it was anticipated that no one (including employees) would be in the store. See, e.g., Nieves v. Holmes Protection, Inc., 382 N.Y.S.2d 769 (N.Y. Sup. Ct. 1982); Paradiso v. Apex Inc. Investigations & Sec. Co., 458 N.Y.S.2d 234 (N.Y. Sup. Ct. 1983); and Hill v. Sonitrol of Southwestern Ohio 521 N.E.2d 780 (Ohio 1988) The fact that the Mayday system is specifically designed for the protection of human life is a significant distinguishing factor.

Lobianco's caution that exculpatory clauses or clauses purporting to limit liability to specified liquidated damages in personal injury claims may not be effective has, in fact, been "implemented" in other decisions. Thus, in cases in which smoke or heat detectors failed to raise alarms in the presence of fire, resulting in death or personal injuries, the manufacturers and, in some cases, the sellers of those alarms have been held liable. Interstate Engineering, Inc. v. Burnette, 474 So.2d 624 (Ala. 1985); Laaperi v. Sears, Roebuck, & Co., 787 F.2d 726 (1st Cir. 1986); Butler v. Pittway Corp. 770 F.2d 7 (2nd Cir. 1985) and Pearshall Emhart Industries, Inc. 599 F.Supp. 207 (E-D. Pa. 1984). (The Butler court cautioned, however, that the defendant's liability was limited to the injuries which were enhanced or aggravated by the failure of the smoke detector timely to sound the alarm, not for those injuries which would have been sustained in the fire even if the alarm had functioned properly.)

Notwithstanding the "cautionary" dicta in Lobianco and the more recent case law holding fire and burglar alarm service providers liable for the full extent of personal injuries, even with contractual provisions limiting such liability, it is highly recommended that the owner of each vehicle in which the Mayday system is installed be required to sign a contract containing appropriate exculpatory and liquidated damages provisions. While inclusion of such clauses is not a guarantee of non- or limited liability, their absence deprives defendants in a claim arising from an allegedly defective transmitting system or negligent response to a signal from the system from even arguing their validity! Recommended provisions for such a contract are discussed on an attachment to this document.

C. Damages

Without regard to whether the "malfunction" in any particular situation was due to the failure of the device to transmit the signal, an erroneous transmission of the location of the vehicle, a failure of the monitoring personnel to "pick up on" the signal, or an erroneous assigning of priority to the need for assistance, assuming there is liability, recoverable damages should be limited to those which probably would have been avoided, had the signal been sent, received, and responded to "properly". (Of course, the nature of the malfunction will likely be highly relevant to a determination

of the identity of the defendant(s) who will have to pay those damages.)

Furthermore, without regard to the legal theory upon which the claim is based (e.g., negligence, strict liability in tort, etc.), the "fault" or responsibility of the injured person, as well as the "fault" or responsibility of others who may not have been named in the lawsuit is to be assessed by the jury, and the defendant is responsible for only that percentage of the ultimate damage award that corresponds to the percentage of negligence assigned by the jury to that defendant. C.R.S. § 13-21-406.

Application of the assessment of "fault" can be a fairly complicated process which is perhaps best explained by an example. Assume that, as a result of the driver's negligent operation of the vehicle, there is a single car accident involving a vehicle equipped with the Mayday device. A passenger in the vehicle suffers a broken arm and a crushing injury to his leg. Had the passenger received prompt medical attention, the leg injury could have been treated and the leg saved. However, the Mayday device malfunctioned (or the monitoring agency did not respond to the distress signal), and the resulting delay in medical attention caused amputation of the leg. The driver whose negligence caused the accident should be held solely liable for the damages (cost of medical care, pain and suffering, etc.) flowing from the broken arm. The jury should be asked to apportion the damages flowing from the crushed leg, assigning a certain percentage of responsibility or "fault" to the driver and a separate percentage to the manufacturer/retailer (or the monitoring agency) of the Mayday device. (In practice, the verdict form would not call for separate damage awards for the broken arm and the crushed/amputated leg, but rather for a single damage award for all damages with separate percentages assigned to the driver and the manufacturer/retailer or the monitoring agency. Specific "instructions" on how to assess those separate percentages would probably be handled by counsel for the parties in closing argument.)

In the preceding example, therefore, if the jury determined that the total amount of damages suffered by the passenger was \$500,000, the driver was responsible for 75% of the damages, and the manufacturer/retailer (or monitoring agency) was responsible for 25% the ultimate verdict against the driver would be in the amount of \$375,000 (75% of \$500,000) and the ultimate verdict against the manufacturer/retailer (or monitoring agency) would be \$125,000. Even if the driver of the vehicle were judgment proof and had minimal insurance coverage (\$50,000), the passenger could not collect more than \$125,000 from the defendant(s) other than the driver.

Recognizing that there are few, if any, products that can be truly "foolproof or damage-proof, it is appropriate to address the damages that might ensue from a finding that the device was

improperly designed, installed, or the signal was not "properly" responded to. In the event the device caused or added to the occupant's injuries, liability of the manufacturer/retailer should be limited to compensation for the "new" or additional injuries. If, for example, the occupant sustained a broken leg in the accident, but, as a result of striking the Mayday device attached to the windshield, he also suffered a severe cut and scarring to his head or face, the manufacturer could be held liable for the cut and associated pain, suffering and scarring, but not for the broken leg or the associated pain and suffering or disabilities. (The burden of proving that the device was improperly designed or installed and that those injuries -would not have been suffered but for the improper placement or design of the Mayday device is on the plaintiff; as a practical matter, most manufacturers attempt to prove that their product did not cause the injury and/or that the injury would likely have been sustained even if the product had not been installed in the vehicle.)

The potential exposure to the manufacturer/retailer in the event the device malfunctioned or was rendered non-functional as a result of the accident is probably greater, subject to the same caveat regarding the plaintiff's burden of proof. There are in Colorado many miles of relatively isolated roads; during the winter months, there is a very significant risk that a car would slide off the road and roll, causing injuries to the occupant, or simply become stuck, miles from any potential source of help. In a "worst possible case" scenario, it is highly foreseeable that the failure of the device to operate could lead to the death of the vehicle's occupant(s)--either by freezing or the absence of appropriate first aid/medical assistance for injuries sustained in the accident. Should a plaintiff be able to prove that (a) the device was not designed or constructed to withstand the foreseeable forces of an accident or malfunctioned due to a defect in the device; and (b) but for the damage to or malfunctioning of the device, appropriate assistance could have been summoned and would have responded; (c) because of the lack of any assistance (or delay in the providing of assistance), the occupant(s) of the car died; and (d) they would not have died had the device functioned properly, the manufacturer would be facing those types and amounts of damages that are awarded in any other wrongful death case.

Because the Mayday system is designed to respond in the event of an accident, it is doubtful that the manufacturer could take full advantage of some tort defenses, most especially that of comparative negligence or fault, at least insofar as the occurrence of the accident is concerned. The fact that the driver of the car/plaintiff was himself negligent, causing the accident, may be deemed of no or only minimal relevance to a system which is designed to operate only in the event of an accident. On the other hand, to the extent it could be shown that the malfunction of the device was due to the plaintiff's failure properly to maintain the device, that form of comparative negligence should serve to eliminate or reduce

the manufacturer's liability. (In light of the fact that the devices are initially going to be installed only in state-owned vehicles, not vehicles owned by individual persons who would also have the duty to maintain them, the damage reduction that would occur would be in the form of the negligence of non-parties, which would have the same ultimate effect on the manufacturer's liability as a finding of comparative negligence.)

It is our understanding that the distress signal will likely be relayed to the monitoring entity/the State Patrol via satellite and that it is possible that there are certain areas (in the mountains, for example) in which the signal may not be transmitted. To the extent that relay system may not work because of the remote location of the vehicle at the time the distress signal is emitted, in order to avoid liability for false or misleading claims as to the system's capabilities and/or for "failure to warn" types of claims, it is critical that users of the device be forewarned of that potential limitation. Even in the event of a claim under such circumstances, however, a liability analysis should turn on whether the individual did something he would not have done or failed to do something he would otherwise have done had he realized the Mayday device was incapable of transmitting a signal or that the signal was not being received by a monitoring station.

In other words, if the individual had no choice but to be traveling on that remote road at that time (i.e., he was not relying on the availability and functioning of the device in choosing that route or in proceeding notwithstanding adverse weather conditions), and if the car became disabled miles away from any source of assistance, it cannot be said that the failure of the device to operate or the manufacturer's failure to warn the user that the device may not transmit signals under certain circumstances was the cause of the occupant's injuries, and there should thus be no liability.

In this vein, attention is directed to the discussion of the potential liability of the State Patrol in Section B.2, where it is noted that there is some question about the state of Colorado law with regard to the necessity for reliance on the availability of help or assistance in order to establish liability on the part of the person who "encouraged" or whose actions fostered that reliance. While that analysis has some application to this aspect of a manufacturer/retailer's liability as well, if adequate notice of limitations on the system's ability to function has been given, the manufacturer/retailer would have available as a defense the notion that, having received such notice, the motorist's reliance on the system's ability to function in that remote location was not reasonable--a position which could, if accepted by the jury, defeat liability.

Another factor which will impact potential damages in the event the device malfunctions or is damaged as a result of the accident

is the ability of the units that would otherwise have responded physically to get to the scene of the accident. If, for example, there was a single car accident in a remote mountain canyon during a major blizzard, and the device failed to operate, either because of the inaccessible location of the vehicle or because the device was damaged during the course of the accident, a defense to any claim for damages would be the fact (assuming it can be proved) that the blizzard conditions were such that no rescue or aid units could have physically gotten to the scene of the accident in time to render appropriate aid. Under those circumstances, it cannot be said that the device's failure to activate was a cause of the greater injuries suffered by the vehicle's occupants due to delayed rescue efforts, as the storm conditions would have prevented those efforts even if the signal had been transmitted.

The injuries and resulting liability will not necessarily be limited to the aggravation of physical injuries sustained in the accident or injuries "inflicted" by the device itself (the "second collision" concept). Suppose the occupant suffered injuries which did not disable her--a severely fractured arm. Realizing that the signaling device had been damaged and was not emitting a signal, she leaves the vehicle to go for help. A motorist who passes her on the road, picks her up, but instead of taking her to a hospital, he physically assaults and rapes her. If the plaintiff can show that a "properly designed or installed device would not have been damaged in the accident, the manufacturer/retailer may be facing a substantial personal 'injury award. While the manufacturer and/or installer of the phone should not be liable for the broken arm, they could be held liable for the -additional injuries suffered in the assault, for the damages flowing from the rape, and, if appropriate expert testimony were introduced, any aggravation of physical injuries flowing from the fracture, which injuries would not have been sustained had the vehicle occupant received prompt medical attention.

While the foregoing damage analysis has focused on the consequences of the device's malfunction (i.e., the manufacturer/retailer's liability), the same general principles would apply to the damage exposure of the State Highway Patrol or a private monitoring entity. To the extent the plaintiff can prove that the State Patrol's or monitoring entity's failure to respond to a distress signal or delay in responding either aggravated the severity of injuries suffered in the accident or caused "new" injuries (e.g., the physical assault and rape example noted above), the monitoring entity could be held liable for the aggravated or new damages, but not for the damages suffered in the accident itself. As noted in Section B--Liability, however, the State Highway Patrol may have defenses available to it that would not be available to a private entity--e.g., the qualified immunity for discretionary acts.

D. Privacy Concerns/Unauthorized Disclosure -- State Patrol and/or Private Monitoring Companies

It is well known that various tow truck companies and/or their employees monitor police band transmissions, hoping to be the first on the scene of an accident and thereby obtain a towing contract. One must assume that the possibility exists that various entities with a financial interest in providing assistance to stranded motorists or accident victims may also devise a method (if one does not already exist) to monitor Mayday system calls as well.

Federal legislation prohibiting the intentional disclosure of the contents of wire communications also applies to cellular telecommunications. 18 U.S.C. §§ 2511(h) (3) (a) and 2520; Shubert v. Metrophone, Inc., 898 F.2d 401 (3rd Cir. 1990). The criminal and civil penalties or damages that are recoverable from one violating these statutes would also thus apply to anyone who "intentionally disclosed" Mayday communications to an unauthorized recipient. The Third Circuit Court of Appeals has held, however, that the mere recognition that cellular transmissions are vulnerable to interception and failure to scramble or encrypt those transmissions does not constitute "intentional disclosure." Shubert, supra.

While neither the State Patrol nor a private monitoring company need be concerned that the fact that another entity may intercept Mayday calls will subject it to criminal or civil liability, it is critical that the--monitoring entity adopt appropriate personnel rules and regulations informing its personnel that they may not and must not divulge the content of the communications to anyone other than those persons or entities who are to respond to the request for assistance. Those regulations should also provide for appropriate discipline of an employee who violates the prohibition.

IV. Avoidance of Limitation of Liability

There are a variety of steps that the manufacturer/retailer and monitor of the Mayday system can take in an attempt to limit or avoid their liability. Some of these have been commented on in the text of this memorandum; for convenience, they will be repeated in this section.

1. Obviously, the manufacturer and/or retailer of the Mayday system is in a position to limit the exposure of its or their assets by the purchase of an appropriate comprehensive general liability policy. The Colorado State Highway Patrol, as a governmental entity, is entitled to the defense of governmental immunity.
2. The provisions of the Colorado Governmental Immunity Act offer additional protection to the state highway

patrol and its employees. C.R.S. § 24-10-106 specifies the conditions under which the immunity of a public entity is waived and the public entity can therefore be liable for damages resulting from its negligence or the negligence of its employees. The monitoring of and/or response to requests for emergency assistance are not among those claims as to which immunity had been waived. Furthermore, even assuming that a creative attorney could somehow place this function within the category of acts for which immunity has been waived, subsection two of this statute indicates that if the injury arises from the act, or failure to act, of a public employee where the act is the type of act for which the public employee would be or here to for has been personally immune from liability (i.e., a discretionary act), both the employee and the entity retain that immunity. In other words, so long as the claim for damages arises out of the employee's performance of a discretionary act, both the public employee and the public entity are immune from any claim for damages.

3. We strongly recommend that any person subscribing to the service be required to sign a contract, containing provision such as those addressed in the attachment.
4. It is essential that the monitoring station (whether public or private) create personnel rules governing the conduct of those persons whose duties include monitoring requests for emergency assistance. The rules should address the privacy interests of persons participating in cellular telephone communications, and the need for any and all employees to maintain the confidence of these types of communications, with a corresponding "warning" of appropriate disciplinary action in the event the rules are violated.
5. Informational brochures and decals of some sort should be prepared and distributed to persons subscribing to the service and/or in whose vehicles the system is to be installed. The brochure should contain a summary of the same type of information that is included in the recommended contract. The cover of the brochure should contain a recommendation that the brochure be kept in the glove box or some accessible place within the vehicle, so that persons who are not signers of the contract will still have access to the information.

It is recommended that a decal also be designed and affixed to the unit containing the push button for activating the system. The decal should inform the reader that there are various restrictions and/or limitations on the system's capacity and that the reader ought to familiarize himself or herself with the brochure which accompanies the unit. In the event the system is designed for use with a fully portable cellular phone (i.e., one that can be carried in a pocket and is not required to be connected to the car), the decal should also contain cautionary language indicating that a cellular phone is required in order for the system to function.

6. To the greatest extent possible and practical, the manufacturer/retailer of the system ought to attempt to "transfer" responsibility for some of the decisions or considerations involved in the "crashworthiness" and "second collision" issues to other sources. For example, the manufacturer/retailer may wish to suggest to purchasers/subscribers that they contact the vehicle manufacturer or dealer to seek advice with respect to mounting the unit containing the push button activating device (or indeed to have the device actually installed) in a location within the vehicle which will offer the greatest protection from damage but still be accessible to occupants of the vehicle. The manufacturer or dealer should know the design of the car well enough to know where the device can best be affixed to meet those objectives. If the car owner does that, it lessens the likelihood that the Mayday system manufacturer/retailer can be held liable on a "crashworthiness" or "second collision" theory. If the owner chooses not to do that, a defense of contributory fault would be available to the manufacturer/retailer in the event of a lawsuit.

7. The manufacturer/retailer of the system should negotiate a indemnification agreement with the Highway Patrol/monitoring entity, in which the monitoring entity acknowledges that it is the sole entity with responsibility for monitoring of the distress signal and responding thereto (including determination of the priority to be assigned to the signal), and if the manufacturer/retailer is subject to a claim for damages due to failure to monitor, erroneous transmission of information to the responding entity (e.g., an ambulance service) concerning the vehicle's location, and/or negligent assigning of a response priority, the monitoring

entity agrees to indemnify the manufacturer/retailer for any and all liability and costs incurred as a result of any such claims.

RECOMMENDED CONTRACTUAL PROVISIONS -- MAYDAY CONTRACT

1 - Language describing how the system is designed to work and any conditions which could adversely affect the transmission or receipt of the distress signal (e.g., remote location of the vehicle in need of assistance, physical damage to the cellular telephone before or as a result of the accident generating the need for assistance, conditions which cause the car's engine to stop [if the phone is reliant upon the car's battery as a power supply], etc.). The subscriber/occupants of the car should also be informed about how they can confirm that the distress signal has been received. If two-way voice communication is contemplated, do they need to "turn on" the cellular phone in order to enable that communication or does the emission of the signal activate the phone? If there is no two-way voice communication, is there a signal (audible or visible) that will confirm receipt of the distress signal?

2 - A complete and accurate statement of the required maintenance of the cellular phone/Mayday system, including any special maintenance or testing that is recommended after the vehicle/phone has been damaged to ensure that the system is still operational.

3 - Language suggesting that the subscriber consult with the vehicle manufacturer's representative concerning location of the push button device inside the vehicle (or for the actual installation of the push button device) with due regard for (a) the need to prevent physical damage to the device in the event of an accident, -and (b) the need for the driver/occupant of the vehicle to have access to the distress signal button in the event of an accident.

4 - A recommended periodic test interval (every 6 months? annually?) to ensure that the system is operational and the procedures for conducting the test. As to the testing procedures, if operation of the Mayday system does not include two way voice communication in conjunction with or in addition to emission of the distress signal, some established procedure should be created and defined in the contract to enable the vehicle owner to confirm the system is functioning without triggering a response by the State Patrol. If two-way voice communication is an integral part of the system, the owner could be instructed to call a "system check" telephone number; when the call is answered, inform the person answering that the owner is doing a system check; the caller would then depress the button activating the distress signal; the monitoring person would then confirm that the signal had been received and indicated that the vehicle was at "x" location.

5 - Language indicating that the purpose of the system is to enable the vehicle driver or occupant to summon aid in the event of an accident disabling the vehicle and/or its occupants or in the event of a health (life-threatening?) emergency. The contract should specifically recite that the subscriber acknowledges that the monitoring company is not an insurer of the vehicle or its contents or of the health and safety of the vehicle's occupants. The

contract should also recite that the subscriber acknowledges that the Mayday system is not designed to provide services such as those provided by an automobile club (repair of a flat tire, charging of a battery, towing services, etc.) and if the subscriber wishes that type of protection, he/she should purchase appropriate insurance and/or join an automobile club. Castle Rock Consultants/the manufacturer or monitor of the system may wish to include a damages clause calling for payment of 'a set "penalty" or reimbursing costs of responding to a "false alarm."

6 - In large, bold print prominently placed in the text of the contract, a disclaimer of all warranties, express or implied, and of liability for losses or injuries due to the negligent performance or non-performance of any contractual obligation. Remedies available to the subscriber in the event of malfunction of the system should be limited to repair of the system and/or the lesser (or greater) of a flat dollar amount or a percentage of the annual subscription charges for the service.

7 - Depending on how the distress signal button is to be integrated into the cellular phone system, language referring the vehicle driver to maintenance requirements, warranties, trouble shooting provisions, etc. as extended by the cellular phone manufacturer may be appropriate, Particularly in the event the subscriber is going to provide his/her own cellular phone, separate and apart from the push button device, the contract should also reiterate that a functioning cellular phone in the vehicle is required for the device to be operational.

8 - The contract should specify what, if anything, the subscriber needs to do if the vehicle in which the system is initially installed is thereafter sold (or totalled) and replaced by a new vehicle, into which the subscriber wishes the service installed. If the system is going to operate from a "totally portable" cellular phone (i.e., one that is not affixed in any way to the interior of the vehicle), presumably the protection provided by the system "follows the phone" and the subscriber need do nothing, so long as the activation button or mechanism is transferred to the new vehicle. Does Castle Rock Consultants/the system manufacturer or monitor wish to be informed of the change in vehicles? Is the identification of the vehicle in which the phone is located at the time of the emission of the distress signal of any consequence to Castle Rock Consultants or the monitor of the system? If the push button mechanism is not permanently attached to the vehicle, does the service "follow" the push button device? the car? the subscriber?

9 - Language indicating that the Colorado State Highway Patrol is the entity that will be providing monitoring and response services, that the manufacturer/retailer has no control or influence in the Patrol's hiring or assignment of employees performing this function, and. identifying the extent of the manufacturer/seller's responsibility post-sale (presumably solely to repair and replace malfunctioning equipment).

FURTHER RECOMMENDATION/OBSERVATIONS

A. In recognition of the fact that, during the initial trial period, the Mayday system is to be installed only in state-owned vehicles, it is recommended that the contract with the State of Colorado also include language to the effect that (a) the State agrees and acknowledges that it is critical that each operator of a vehicle equipped with the Mayday system be fully informed as to the provisions of the contract for provision of the service, including, by way of example and not by way of limitation, the conditions which may affect the system's operation and the limitations of liability; (b) due to changes in employment status and/or any particular employee's access to vehicles equipped with this system, it is an absolute impossibility for Castle Rock Consultants and/or the manufacturer of the system to ensure that each operator of a vehicle equipped with the system is informed as to the contractual provisions; and (c) the State warrants and promises that it will not permit any employee or agent to operate a vehicle equipped with the Mayday system without requiring that employee or agent read and review the contract.

To further "extend" the protection which is intended to be offered by the contractual provisions, and in recognition of the fact that, once the system is offered to the general public, it is highly probable that subscribers to the system will allow others to operate vehicles equipped with the Mayday system, it is further recommended that a brief brochure accompany installation of the system, reiterating the relevant-contractual provisions (including, at a minimum, those conditions which may adversely affect the system's operation and the limitations on liability). The cover of the brochure should contain an instruction or recommendation that it be placed in the vehicle's glove box or some other place within the vehicle where it will be accessible to the occupants. Additionally, a decal (to be affixed either to the interior of the vehicle or to the push button device by the "installer" of the system, not left up to the vehicle owner) should be developed advising the driver and occupants of the vehicle that certain conditions may adversely affect the system's operation, that a cellular phone is required in order for the device to be operational, that there are limitations on the monitor's liability, and that they should consult the brochure for further details.

The above provisions (Section A, Further Recommendations/Observations) assume that the cellular phone is connected to the car and that the "protection" is intended primarily to attach to the car, via the phone. To the extent the protection attaches and can be activated via a "pocket" phone (one which is or can be carried by the subscriber or any other person and is not dependent on the vehicle's power supply), the decal and brochure are not only irrelevant, they could be "misleading" in the sense of implying protection even if the phone used to activate the distress signal is not in the car. In that event, the decal may more appropriately be affixed to the phone, not the car, and the language will have to

be modified to direct the cellular phone "user" (who may or may not be the owner of the unit) to another source of the conditions which may affect transmission or receipt of the signal and the limitations of liability.

B. Once the system is extended to members of the general public, Castle Rock Consultants (or the company or entity that assumes marketing responsibility for the system) must ensure that its sales and marketing personnel are fully trained on the operation, capacities, and limitations of the system and that representations made in advertising materials and/or by sales personnel do not overstate the capacity or play down the limitations. Contractual provisions that might otherwise be effective in limiting liability may be rendered null and void by misrepresentations or fraud!

C. Particularly if there is not two-way verbal communication between the occupants of the vehicle in need of assistance and the monitoring personnel, the manufacturer of the device may wish to design in an audible tone that will confirm to the vehicle occupants that the signal has been received. If the occupants have no method of confirming that, they may leave the vehicle if assistance has not arrived within a certain period of time (believing the signal was not received) and expose themselves to greater danger and the manufacturer to greater liability.

RE-CAP OF OPEN QUESTIONS AND "CONSEQUENCES"

1 - Does the system require a particular cellular phone which is to be purchased or leased through the manufacturer, or can it use ANY type of cellular phone now on the market? To the extent selection of the phone can be left up to the subscriber, there is less risk of liability on the part of the manufacturer for a malfunction of the phone (as opposed to the push button device) and/or for liability problems related to the design, manufacture or installation of the phone. However, in the event a particular type of cellular phone is required (e.g., one that is to be permanently affixed to the vehicle, with the push button signaling device attached or connected to the phone), those requirements either need to be spelled out in written detail to the user/subscriber and/or the manufacturer/retailer should insist upon installing the system to ensure that an appropriate phone is selected and appropriate connections between the signaling device and the phone are made.

2 - What is the relationship of the cellular phone to the functioning of the Mayday system?

a. If two-way voice communication is not necessarily an integral part of the system, some method of informing the motorist that the signal has been sent and received should be designed and implemented.

b. If two-way communication via the cellular phone is an integral part of the system, the following issues are presented:

1) The cellular -phone should not be dependent upon the vehicle's power supply (e.g.,...- a running engine) and the subscriber/occupants of the vehicle should be so informed;

2) The subscriber and the vehicle's occupants must be notified that the system will not operate without a functional cellular phone, that it is their sole responsibility to assure that the phone is in the vehicle, that the battery is charged, and that the phone is "on" (if that is a requirement);

3) Does activation of the push button signaling device automatically activate the cellular phone/two-way voice communication or do the occupants of the vehicle need to do something else to establish voice communication? Is sending of the distress signal dependent on the phone being turned on? (All of these types of questions should be addressed in the brochure and contract.)

3 - Does the service attach to or follow the individual subscriber and his or her family, the vehicle, or the cellular phone? This impacts the extent to which notice of restrictions on operation, for example, must be displayed or available in the vehicle itself and issues concerning what notification and process is required if the vehicle equipped with the system is totalled or sold.

Citation
CRSA Sec. 13-21-402. Strict liability

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C.R.S.A. Sec. 13-21-402

WEST'S COLORADO REVISED STATUTES ANNOTATED
TITLE 13. COURTS AND COURT PROCEDURE
DAMAGES
DAMAGES
ARTICLE 21. DAMAGES
PART 4. PRODUCT LIABILITY ACTIONS-GENERAL -PROVISIONS

Current through ail 1994 Second Regular Session laws

Sec. 13-21402. Strict liability

(1) No product liability action based on the doctrine of strict liability in tort shall be commenced or maintained against any seller of a product which is alleged to contain or possess a defective condition unreasonably dangerous to the buyer, user, or consumer unless said seller is also the manufacturer of said product or the manufacturer of the part thereof claimed to be defective. Nothing in this part 4 shall be construed to limit any other action from being brought against any seller of a product.

(2) If jurisdiction cannot be obtained over a particular manufacturer of a product or a part of a product alleged to be defective, then that manufacturer's principal distributor or seller over whom jurisdiction can be obtained shall be deemed, for the purposes of this section, the manufacturer of the product.

CREDIT(S)

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(Laws 1977, H.B.1536, Sec. 2.)

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Citation
CRSA Sec. 13-21-406, Comparative fault as measure of damages

C.R.S.A. Sec. 13-21-406

WEST'S COLORADO REVISED STATUTES ANNOTATED
TITLE 13. COURTS AND COURT PROCEDURE
DAMAGES
DAMAGES
ARTICLE 21. DAMAGES
PART 4. PRODUCT LIABILITY ACTIONS-GENERAL PROVISIONS

Current through all 1994 Second Regular Session laws

Sec. 13-21-406. Comparative fault as measure of damages

(1) In any product liability action, the fault of the person suffering the harm, as well as the fault of all others who are parties to the action for causing the harm, shall be compared by the trier of fact in accordance with this section. The fault of the person suffering the harm shall not bar such person. *or* a party bringing an action on behalf of such a person, or his estate, or his heirs from recovering damages, but the award of damages to such person or the party bringing the action shall be diminished in proportion to the amount of causal fault attributed to the person suffering the harm. If any party is claiming damages for a decedent's wrongful death, the fault of the decedent, if any, shall be imputed to such party.

(2) Where comparative fault in any such action is an issue, the jury shall return special verdicts, or, in the absence of a jury, the court shall make special findings determining the percentage of fault attributable to each of the persons to whom some fault is attributed and determining the total amount of damages sustained by each of the claimants. The entry of judgment shall be made by the court, and no general verdict shall be returned by the jury.

(3) Repealed by Laws 1986, S-B-70, Sec. 6.

(4) The provisions of section 13-21-11 do not apply to any product liability action.

CREDIT(S)

1989 Main Volume

(Laws 1981, S.B.63, Sec. 1; Laws 1981, S.B.418, Sec. 42; Laws 1986, S.B.70, Sec. 6.)

HISTORICAL NOTES

HISTORICAL AND STATUTORY NOTES

1989 Main Volume

Laws 1981, S.B. 418, Sec. 42, made a technical correction in subset. (3)(repealed in 1986).

Laws 1986, S.B.70, Sec. 6, repealed subset. (3) which read:

“(3).Where comparative fault in any product liability action is an issue and recovery is allowed against more than

CRSA Sec. 13-21-406, Comparative fault as measure of damages

one party, each such party shall be liable for only that portion of the total dollar amount awarded as damages to any claimant in the proportion that the amount of his causal fault bears to the amount of the causal fault attributed to all parties against whom such recovery is allowed, unless the causal fault of a party is equal to or greater than the causal fault of a claimant making claim against that party, in which case that party shall be jointly and severally liable to that claimant.”

APPENDIX C - MJM RECRUITMENT RECOMMENDATIONS

MAYDAY TEST PARTICIPANT RECRUITMENT

**Prepared by:
The ENTERPRISE MJM Committee
March, 1997**

1. INTRODUCTION

The ENTERPRISE Multi-jurisdictional Mayday (MJM) group links together representatives from four Federally-funded Mayday operational tests for interactive discussion and project update sessions. The states actively involved in MJM include Washington State, Colorado, Minnesota, New York and Virginia. The integration of the separate tests allows for greater information sharing, a steeper learning curve and added value for all participants.

The MJM Group was created because it was recognized that while each operational test exists as a stand-alone project, the ultimate success of a nationwide Mayday system requires communication and interaction among the different projects. As such, the primary goal of this group is to ease the entry of emergency response providers (both public and private) into the Mayday arena, by facilitating working discussions among public and private sector participants.

This white paper is the result of a meeting of MJM members and invited guests to discuss the issues surrounding participant recruitment for Mayday Field Operational Tests. The paper presents lessons learned and recommendations for recruitment of participants, and is intended to serve as a source document for newcomers to the Mayday industry to garner knowledge from previous experiences. This document will also serve as a reference to private sector organizations interested in marketing eventual Mayday products and services.

2. IMPORTANCE OF RECRUITMENT

The challenge to meet the Federal, State and private partner objectives for operational tests can be met through strategic recruitment and proper involvement of test participants. With the efforts involved in system development and integration, recruitment is often overshadowed, when in effect it ultimately is one of the most important aspect of an operational test.

Proper recruitment can benefit the operational test partners in the following ways:

- Assembling a statistically valid sample. Among other things, the operational test evaluation team is responsible for reaching conclusions about equipment performance and the potential for real-world implementation. Statistical analyses assist in making recommendations based on quantitative decisions. For those projects where test participant involvement is key to the data gathering and collection process, the participant population must be conducive to collecting a statistically valid data sample. Most importantly, the population sample must be significantly large, demographically and geographically diverse, and represent as much as

possible the eventual market for the products and services.

- Ensuring data quality. Participants in the operational test are responsible for either directly or indirectly collecting data. Directly, participants make keep data logs, record messages or complete surveys/interviews. Indirectly, the participants may use equipment or infrastructure that automatically records information.
- For participants directly recording data, it is imperative that their activities generate data that is reliable, accurate and representative of the actual activities. Proper participant recruitment will assemble a group of individuals both capable and willing to perform these data collection activities in a reliable fashion.

3. RECOMMENDED RECRUITMENT PRACTICES

Presentations by the Minnesota Department of Transportation, the Booz Allen National Evaluation Team, the Washington State PuSHME Project, and the New York ACN Project representatives highlighted lessons learned from several operational tests. This section summarizes the groups recommendations based on these experiences.

Recommendation Number 1: Identify the types of participants necessary for the project before beginning recruitment.

As indicated previously, the proper group of participants will ensure representative data that is effective in meeting the needs of project partners. Before recruitment can begin a profile of the desired participants should be completed. This description should be based upon the goals and objectives of the operational test as well as those of the project evaluation. Participants should be those people able and willing to perform the necessary activities for the duration of the test. Consideration should be given to the length of the operational test. For example, if the operational test involves equipment mounted in vehicles, and is scheduled to last longer than one year, participants should be selected who are likely not to sell their vehicle over the course of the project. Participant selection shall be representative of the potential market for the products or services. Including such aspects as demographics and driving habits.

Recommendation Number 2: Prepare the necessary tools for recruitment before beginning

The process for recruiting participants should begin with a well defined recruitment package that includes the following items:

- a profile of desired participants;
- a strategy for attracting potential participants;
- a description of the responsibilities and benefits of being a participant;
- an orientation package for the participants; and
- a plan for maintaining the active involvement of participants throughout the project.

This recruitment package will provide the tools necessary to solicit and orient the participants for each test. Once participants are brought on board it is important to maintain their interest and belief in the project. To ensure this, the necessary acceptance testing should be performed to ensure that the equipment, when distributed to participants, performs as designed.

Further, efforts should be spent researching and investigating the potential for any liability issues that may arise from participants' involvement in the projects. Legal waivers may need to be drafted and reviewed by the private partners as well as the public agencies' legal representatives.

Recommendation Number 3: Use as many resources as possible to recruit participants

Various operational tests have used a variety of approaches to soliciting participants. Announcements in local media devices such as newspapers, television and radio commercials can complement project specific announcements such as brochures and booth displays at local events (ie. County fairs). It is also important to involve as large a group of recruiters as possible. Existing agencies such as fire departments or emergency service volunteers may assist in promoting the project and announcing the call for participants. If a large force of participant recruiters are involved, it is important that a recruitment package be available such that the information disseminated is consistent and accurate. Also, a variety of incentives are effective at attracting participants. Such incentives must be sufficiently attractive to participants and must be convenient to redeem.

One proven method for recruitment is a staged process where potential participants are asked to answer a very small number of questions. Only those who meet the preliminary requirements are solicited further. This mechanism can avoid wasted time familiarizing individuals who will not qualify as participants. The actual methods for recruitment may involve a variety of medium and strategies. Some examples can include direct mailings, supplements to existing mailings, brochures, direct calling, general advertising, telephone hotlines and the use of the Internet or email.

Recommendation Number 4: Remain in close contact with participants during the course of the project.

While the idea of participating in an operational test and using experimental equipment is often appealing to the general public. The data needs of such projects often mandate that the collection period last for several months or years. Test participants tend to lose interest if they are not kept informed of the project status and advised on the overall activities. Previous tests have had positive experience using hard copy newsletters to communicate with participants throughout the test. Also, a help-line telephone number, or pre-arranged meetings with participants to share any early data analysis results will maintain communication and potentially support interest in the activities.

While it is not a direct activity of the recruiters, each participant will need the appropriate training before commencing testing. Follow-up communications during the test will reveal if such training was adequate or if more is required. Communication with participants is also important to relay any feedback to participants about the data being collected. This should be performed in conjunction with preliminary data analyses to ensure that the data collected and the manner it is collected is appropriate.

5. CONCLUSIONS

The experiences shared in the participant recruitment discussion for Mayday operational tests have resulted in four recommendations that apply not only to Mayday activities, but to any ITS activity that demands that participants assist in data collection

The experiences and lessons learned in performing participant recruitment for several operational tests have provided an excellent baseline for future projects. The recommendations presented in this paper are intended to assist future operational tests as well as sales for actual products and services.