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16. Abstract

The Crash Avoidance Metrics Partnership (CAMP) was formed between Ford and General Motors to accelerate the implementation of crash avoidance countermeasures in passenger cars to improve traffic safety. The CAMP partnership is engaged in cooperative research with the National Highway Traffic Safety Administration (NHTSA) to advance the safety research objectives of the Department's Intelligent Vehicle Initiative. This report describes the progress made in the first year of this three-year cooperative research program.

Progress in three projects is described in the report: Forward Crash Warning Requirements, Driver Workload Metrics, and Enhanced Digital Maps for Safety. The first project found that last-second steering occurred later than last-second braking in test track studies, thus raising concerns that using braking data alone to design a driver warning algorithm may lead to excessive nuisance alarms. The second project completed a literature review, analysis of potential metrics, and a draft experimental test design. The third project completed an identification of safety applications enabled or enhanced by advanced digital maps and determined application attribute requirements.

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PROGRAM OVERVIEW

Ford Motor Company and General Motors Corporation formed the Crash Avoidance Metrics Partnership (CAMP) in 1995. The objective of the partnership is to accelerate the implementation of crash avoidance countermeasures to improve traffic safety by defining and developing necessary pre-competitive enabling elements of future systems. CAMP provides a flexible mechanism to facilitate interaction among various participants executing specific cooperative projects. The CAMP Intelligent Vehicle Initiative (IVI) Light Vehicle Enabling Research Program brings together DaimlerChrysler Research and Technology, North America, Inc. (DaimlerChrysler RTNA), Ford Motor Company (Ford), General Motors Corporation (GM), Navigation Technologies Corporation, (NavTech) Nissan Technical Center North America, Inc. (NTCNA) and Toyota Technical Center Inc. USA (TTC) to work cooperatively with the United States Department of Transportation (USDOT) on a set of three separate pre-competitive projects addressing emerging crash avoidance and driver information systems. Each project involves a different subset of participants. A single cooperative agreement covering all three projects spans 42 months beginning April 1, 2001 for a total program cost of $20,960,846. Federal funding is provided at a 65 / 35 cost share. CAMP's role is to manage the agreement, coordinate overall activities and provide program administration support to each of the projects.

The **Driver Workload Metrics Project** brings together Ford, GM, NTCNA and TTC to develop performance metrics and test procedures for both visual, manual and cognitive aspects of driver workload from telematics systems. In the future, vehicle OEMs will be able to use these workload evaluation procedures to assess what in-vehicle tasks might be accessible to a driver while the vehicle is in motion. The research approach is investigating both 'driving performance measures' of driver workload taken under test track or on-road driving conditions as well as 'surrogate metrics' which include models, simulations or procedures that have been recently developed or proposed. The basic analysis approach will examine the ability of the driving performance measures and surrogate metrics to discriminate among the differing attentional demands of an array of cognitive, visual and manual secondary tasks. The final result of this project will be a set of correlated analysis, development, and validation procedures that will enable designers of future telematics systems to efficiently manage the driver workload implications of their designs during all stages of the design process.

During this program year, Task 1 – State of the Art Review was completed and a summary briefing given to the USDOT. The work performed under this task provides the foundation for the rest of the project and includes the following accomplishments:

- A review of US and Japanese crash data related to driver distraction / inattention identified typical situations associated with device oriented distraction and was used to define test scenarios for Task 2 testing. These include a test track car following scenario on a straight level roadway under dry, clear, daylight conditions at speeds of 45 mph or less and an on-road scenario involving way-finding in a naturalistic car-following condition with lane changes, intersections and junctions, etc.

- Driving performance measures and methods to assess driver workload were selected for use in Task 2 testing. This includes measures of visual allocation (glance duration, number of glances, glance sequence), vehicle control (lane keeping, car following, speed control), and object & event detection (situational awareness, car following, perceptual processes, way finding).

- Surrogate measures were identified by phase of system development for inclusion. These will be correlated with driving performance measures in Task 2 and include the numerous candidates to be used as analytic tools for pre-prototype evaluation, testing tools for interactive bench prototype evaluation, and testing tools for validation of full vehicle systems.

- Tests to characterize individual differences between drivers in their capacity for workload, multitasking, etc. were reviewed and a candidate set selected for use in Task 2 testing.

- A theoretical framework was developed as a basis for selecting a broad range of in-vehicle tasks (with respect to workload) for use in testing. Multiple Resource Theory was selected and a computational model was adapted and enhanced for application to multi-tasking during driving. The model predictions will be used to identify tasks likely to produce high, moderate, and low 'interference' with driving. This candidate set of tasks will then be balanced to ensure that it spans the types of interfaces and functions of interest.

The **Enhanced Digital Maps Project** brings together DaimlerChrysler RTNA, Ford, GM, NavTech and TTC. This effort is examining the feasibility of expanding the content and / or enhancing the resolution of present digital maps as an enabling technology for various collision avoidance systems. Digital map navigation may be able to act as an additional sensor for various driver assistance systems, providing information about the vehicle's relationship to the roadway infrastructure that is not feasible to obtain with other sensors such as radar or computer vision. It will not preclude the need for these other sensors, but may add a necessary component for successful implementation of future systems. The Enhanced Digital Maps project is developing a range of digital map database enhancements intended to enable or improve the performance of various driver assistance systems presently under development or consideration. The results of this effort will provide direction to map suppliers regarding enhancements needed to enable future driver assistance systems and establish the preliminary feasibility of generating and maintaining these enhancements.

During this program year, Task 1 – Identify Safety Applications, Task 2 – Application Attribute Requirements, Task 3 – Determine Final Demonstration and Task 8a – Deployment Analysis were completed. In addition, work was also performed under Task 4 – Data Collection / Maintainability and Task 6 – Demonstrator Vehicles. Two progress briefings were given to the USDOT. The results of this work include the following significant results / observations:

- Sixty-one potential safety related vehicle applications were identified which might be enabled or enhanced by improved digital maps. These applications were classified into categories of assistance, warning and control, and grouped by their potential deployment timeframe. Fifty-three instances of map-derived information (mapplets) were identified to support the set of safety related vehicle applications.

- A relational database was developed which resulted in the selection of the twelve highest safety potential applications based on crash scenario, harm, incremental effectiveness, market penetration, deployment timeframe and positioning accuracy requirements. A significant factor during this process was discovery that high accuracy / lower cost Inertial Measurement Units (IMUs) may be available in the mid rather than long term time frame as a result of military development programs.

- Demonstration applications were selected representing near and mid term high safety potential applications. Near term applications are supportable based on road-level mapping. Mid and long term applications require lane-level information. Differential GPS is required to support the selected mid-term applications.

- Test sites were selected in the metropolitan Detroit, Michigan and Palo Alto, California areas and candidate mapping techniques identified to generate the demonstration databases including mobile mapping, remote sensing and the use of probe vehicles.

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Ford and GM alone are conducting the Forward Collision Warning Requirements Project. This project extends the work completed in 1999 under a previous CAMP / NHTSA Cooperative Agreement. Utilizing the 'surrogate target' methodology developed in the first program, driver performance and alert function / interface requirements associated with rear-end crash scenarios are being examined in proving grounds testing of naive subjects under a wide variety of common conditions which include time of day, lead vehicle deceleration profile and last-second lane change maneuvers. In addition, testing is being conducted on the National Advanced Driving Simulator (NADS) to examine the correlation between driver's responses on a track and in the simulator, and to expand the scope of the database beyond that possible using controlled proving grounds testing. These results will expand the normative driver performance database created in the original project, and thereby expand the domain of validity of the resulting algorithm and interface recommendations.

During this program year, Task 1 – Last Second Maneuver was completed and a summary briefing given to the USDOT. Pilot testing was conducted on the NADS to establish the feasibility of conducting the last-second braking and last-second steering maneuvers required to replicate previous proving grounds testing. The results of this work to date including the following significant results / observations:

- Last-second braking results obtained from Task 1 testing at the Transportation Research Center in East Liberty, Ohio correspond well to the data from the previous program conducted at the General Motors Proving Grounds in Milford, Michigan. This indicates that the test methodology is robust across different test sites, and supports the validity of the 'too late' alert timing developed in the previous CAMP / NHTSA program. In addition, a new alert timing model was developed via logistic regression analysis that predicts the probability a driver is operating in a 'hard braking envelope'. This alternate method of interpreting the driver performance data has the advantage of requiring fewer input parameters.

- Last-second steering judgments obtained from Task 1 testing indicate that in high relative velocity conditions, last second steering can occur later than last-second braking. This suggests that under real world conditions some drivers may perceive alerts based solely on last-second braking considerations as nuisance alerts.

- Based on pilot testing conducted on the NADS, it appears that it will be feasible to execute the last-second braking and last-second steering trials already performed on the GM and TRC proving grounds. This work is scheduled to begin in the next program year.

CAMP Driver Workload Metrics Project

March 2001 – April 2002

PROJECT SCOPE

The objective of this project is to develop practical and repeatable driver workload performance metrics and test procedures that can be used to assess which in-vehicle tasks a driver might reasonably be allowed to access and perform while driving. Specifically, it will:

- Develop metrics for assessing driver workload that are meaningful, reliable, and practical for application within product development,
- Develop a set of procedures and measurement tools for workload assessment of in-vehicle tasks, and
- Examine the ability of these metrics to discriminate among the differing attentional demands of various in-vehicle tasks.

The project consists of a set of five closely interlocking tasks. The first task sets the stage by identifying the following: (1) criterion measures and methods with which to characterize driver workload; (2) candidate models, simulations and surrogate metrics and methods that might provide practical and meaningful substitutes for the criterion measures and methods; (3) a set of candidate in-vehicle device tasks that span the range of driver demand to which the to-be-developed metrics and methods should be responsive; and (4) test scenarios useful for assessment purposes. The second task takes the output of (1) and (2) above, together with a subset of in-vehicle tasks and test scenarios, to develop practical workload metrics and methods. Extensive human subject testing provides the empirical foundation used to assess the relative merits of candidate metrics and methods. The third task validates the practicality and repeatability of the proposed metrics and methods by use of a new test participant sample, a different set of in-vehicle devices or tasks, and device evaluators who have had no prior exposure to the project. This provides a final assessment of the reliability, validity, and usability of candidate metrics and methods. A fourth (reporting) task documents the workload metrics and methods for use by OEMs and others. A fifth (project management) task oversees the efforts, monitoring timing and deliverable status and revising the project plan as necessary.

CAMP Driver Workload Metrics Project

March 2001 – April 2002

PROJECT ACTIVITIES & ACCOMPLISHMENTS

TASK 1 – STATE OF ART REVIEW

Studies of U.S. crash data related to driver inattention were reviewed, along with a study of Japanese data on inattention-related crashes. The effort focused on understanding patterns associated with device-oriented distraction and identification of test scenarios for use in Task 2 testing. The scenarios identified include a test track scenario involving car following under daylight, level straightaway, dry pavement, clear weather conditions, at a speed $\leq$ 45 MPH and an on-road scenario involving way finding in a *naturalistic* car following condition with lane changes, intersections and junctions, etc.

The literature was reviewed with respect to methods and measures in two major categories: driving performance measures of driver workload and candidate surrogate measures for driver workload. This resulted in establishing taxonomy of measures, categorized in terms of the phase of the system development process at which they could be appropriately used. The taxonomy of driving performance measures included: Visual Allocation (Glance Duration, Number of Glances, Glance Sequence); Vehicle Control (Lane keeping, Car following, Speed control); Object & Event Detection (Situational awareness, Car following, Perceptual Processes, Way finding). Surrogate Measures identified by phase of system development included: Analytic Tools for the Pre-Prototype Phase (Count of Task Steps, IVIS DEMAND Model, GOMS Model, Modified MRT Model); Testing Tools for the Bench Interactive Prototype Phase (Static Single Task Method using task completion time, visual occlusion metrics, Static Multitask Method using concurrent tracking task metrics, peripheral detection task metrics, task completion time, rated situational awareness, rated workload, supervisory control metrics); and Testing Tools for the Confirmation / Validation Phase (Dynamic Drive Testing Methods using steering entropy, peripheral detection task, rated situational awareness, rated workload).

A survey of literature was undertaken to develop a taxonomy of tasks done concurrently while driving and a theoretical framework which could be used to guide selection of driving and secondary tasks to be studied. This review encompassed the recent literature on human attention and supervisory task management as it pertains to issues of driver workload and driver distraction. A theoretical framework was selected based on modified Multiple Resources Theory and a computational model was adapted for application to multitasking during driving to guide task selection. The model includes three enhancements based on recent findings: an explicit treatment of working memory, a way to capture demands of supervisory management activities on working memory and attention, and a 'global task difficulty' variable. It calculates "Total Interference Potential" (TIP) between tasks and enables tasks to be selected that span the range from low to moderate to high in their potential to interfere with driving. This model is being applied to the selection of several types of in-vehicle activities, including conventional and emerging device oriented tasks such as navigation, communication, electronic information and advanced entertainment, and selected non-device oriented tasks. The possibly of including artificial tasks (e.g., 'count backward by 3's') to serve as "known" levels and types of imposed demands is being considered as well. The resulting set of tasks will be refined so that it spans major interface types (visual-manual, hear-speak and mixed-mode) and functionalities and to ensure that testable hardware, software, or wizard-of-oz representations exist or can be created.

Driver Workload is a function of the task environment, the driver, and their interaction. Individual differences are a key concern. A review of methods to characterize individual differences between driver's capacity for managing workload, multitasking, etc. was performed. Selection of individual differences tests for use in Task 2 was driven by their safety relevance. Candidate individual tests include: Perceptual (dynamic visual acuity): Cognitive (useful field of view, grammatical reasoning, verbal memory span); Psychomotor (none); and Psychosocial (self-confidence in attention skills & driving (TBD)).

Task 1 – Review of Measures, Methods, Models and Metrics for Device Related Driver Workload Assessment was completed on schedule and a progress briefing was given to USDOT. This work identified several key items which will serve as the basis for the balance of the project including: driving scenarios to be used for test track or on-road data collection; a candidate set of driving performance measures and methods (formerly referred to as 'ground-truth' measures); candidate set of surrogate metrics (models, measures and methods) for use in the design process; a taxonomy of tasks in terms of demands on drivers along with a methodology for selection of in-vehicle tasks for use in Task 2; and a review and selection of tests to characterize individual differences between drivers in their capacity for workload, multitasking, etc.

TASK 2 – DEVELOP WORKLOAD METRICS

A revised test plan was developed which uses Ford's VIRTTEX driving simulator as an initial test stage (during poor weather) and then, as weather permits, the Ford Romeo Proving Grounds and surrounding area, public roads between CAMP's Farmington Hills location and Romeo, and a test center near the CAMP office in place of testing only on proving grounds roads as originally proposed. Program timing was revised accordingly.

Further testing of the Modified Multiple-Resource-Theory (MRT*) computational model developed by the CAMP team for use in task selection has been completed. Correlation between model predictions and on-road performance data from other studies appears promising. Approximately 40 additional tasks have been developed, added to the pool from which to select tasks for in-vehicle testing, and modeled using the MRT* model. These model predictions will be used to identify tasks likely to produce high, moderate, and low 'interference' with driving. Then, constraints will be applied to ensure that the tasks selected span the types of interfaces and functionalities for which the surrogate measures must work. The selected tasks will be executed using "off-the-shelf" devices that are available for after-market installation in vehicles.

The Task 2 experimental program was defined in more detail and a need for several pilot studies was identified. These studies are of two types: to pilot test the paradigm for assessing driver object and event detection to be used in on-road work, and to refine / select specific implementations of surrogate measures to be examined in the formal empirical work.

- An experimental design was formulated and pilot testing initiated on the VIRTTEX simulator at Ford to examine a paradigm for examining object and event detection (in addition to vehicle control) in on-road and test-track testing.
- Additional pilot studies are planned to examine Peripheral Detection Tasks, Visual Occlusion and Part Task Simulation Techniques (including concurrent tracking tasks) in various venues.

CAMP Driver Workload Metrics Project

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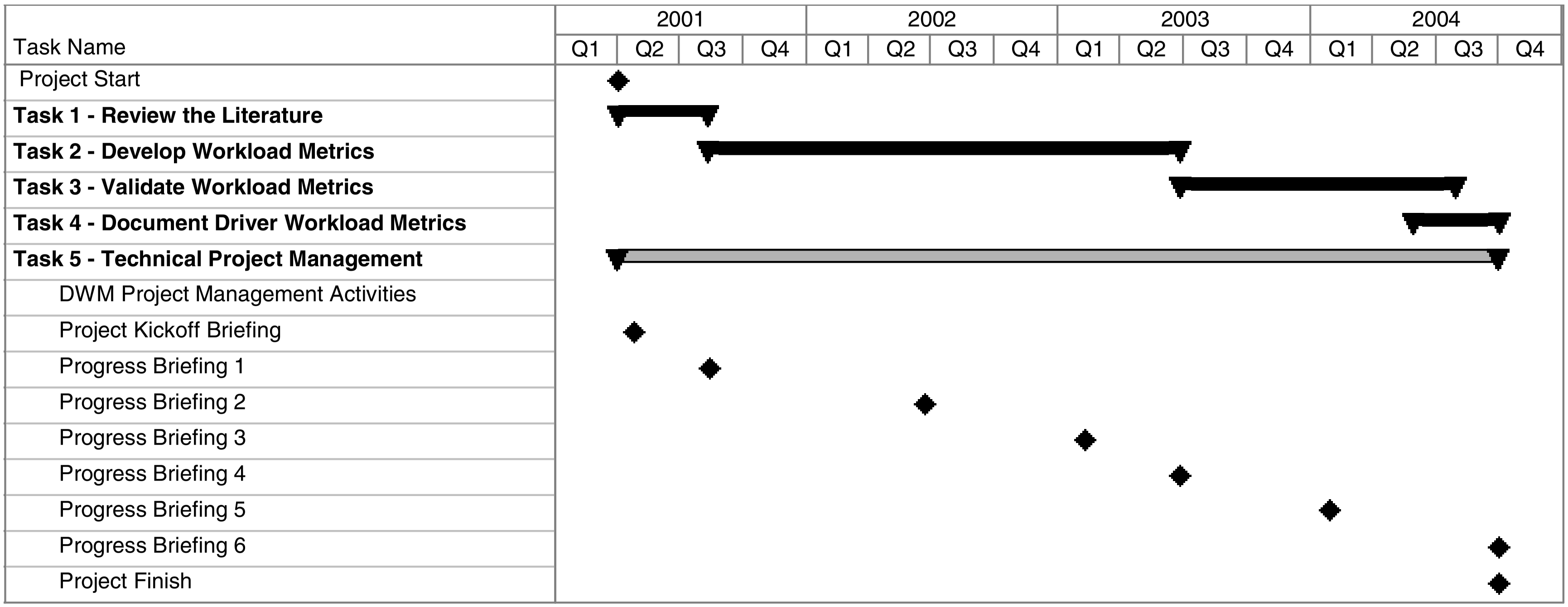

CAMP Enhanced Digital Maps Project

April 2001 – March 2002

PROJECT SCOPE

A digital map database and the associated navigation system are important to the development of certain advanced driver assistance systems (ADAS). Digital map navigation provides a connection between the vehicle and the roadway infrastructure that is not either possible or feasible with other ADAS sensors such as radar or computer vision. Digital map navigation does not obviate the need for these other sensors, but serves as a necessary component in the development of future driver assistance systems.

The Enhanced Digital Maps Project will provide avenues for implementing advanced digital map databases with a common set of attributes with sufficient related accuracy and reliability. The included attributes will be formed from a list of representative vehicle safety applications that are either enabled or improved through access to advanced digital maps. The safety-related applications will be distributed with respect to demands on attribute accuracy and reliability so as to provide a continuum of features enabled or improved by increasingly advanced stages of map capability.

The utility of the map database improvements will be tested on OEM demonstrator vehicles, each representing one or more map database ADAS applications. The tests will be conducted on two test sites that will be digitally mapped to meet the application specifications. The mapping techniques will include instrumented survey vehicles as well as the use of vehicles as probes, and will be investigated to understand the impact on database creation and maintainability.

Based on the demonstrator vehicle tests, a recommendation for attribute inclusion, and accuracy / reliability improvements, incremental or fundamental, will be made. The recommendation will trade off map measurement capability and maintainability against the level of accuracy needed to enable desired applications. The recommendation will provide a roadmap of applications enabled or improved with staged improvements in digital maps, and highlight potential benefits.

CAMP Enhanced Digital Maps Project

April 2001 – March 2002

PROJECT ACTIVITIES & ACCOMPLISHMENTS

TASK 1 – IDENTIFY SAFETY APPLICATIONS

The two main outputs of this task were an evaluation of potential map enabled / enhanced vehicle safety applications and a relational application database used in performing the analyses.

Sixty-one potential safety applications were identified that might be enabled or improved by enhanced digital map databases, which give rise to fifty-three possible ‘mapplets’. A mapplet is a collection of related information derived from a map database that is used by various applications. The mapplet serves as an application interface to a map database and is independent of a specific application.

Evaluation categories examined in down-selecting potential applications include incremental effectiveness, market penetration, deployment timeframe and positioning accuracy requirements. Deployment timeframe is broken into three time periods where ‘near-term’ corresponds to systems available to the customer one year after the end of the project, ‘mid-term’ five years, and ‘long-term’ ten years. The candidate list is stored in a relational database format, and has been associated with a crash scenario database to estimate the potential safety opportunities for each application.

Applications identified as having the highest potential for reducing the harm metric ‘functional years lost’ (as used in ‘44 Crashes’[1]) are as follows: near-term - curve speed assistant (warning), stop sign assistant (warning) and speed limit assistant (advisory); mid-term - forward collision warning, traffic signal assistant (warning), lane following assistant (warning), curve speed assistant (control) and stop sign assistant (control); long-term - lateral and longitudinal control, intersection collision warning (control), forward collision warning (control) and lane following assistant (control).

Task 1 was completed on schedule and a progress briefing given to USDOT.

TASK 2 – DETERMINE APPLICATION ATTRIBUTE REQUIREMENTS

Work in Task 2 refined the definition of the mapplets needed for the highest safety potential applications identified in Task 1. Mapplets were further developed based on an engineering analysis of the proposed applications, which captured application requirements based on kinematic and geometric calculations. This resulted in the formation of mapplet specifications and attribute definitions grouped by anticipated deployment time frame of the applications.

Data collection techniques identified in the first part of Task 4 were matched with the required mapplets and determination of the necessary attributes and precision needed for the near-term, mid-term, and long-term applications was finalized based on anticipated feasibility, cost, and effort to provide digital maps to the required specifications.

Current map database specifications were compared to the proposed specifications and gaps identified. Candidate mapping techniques to fill in the gaps were then determined based on timeframes and available technologies. Near-term mapplet requirements are a superset of currently planned map database enhancements. Mid-term mapplets specify lane level instead of road level geometry and attributes. This is a significant change over the near-term database. Long-term mapplets are similar to that of the mid-term, but have higher accuracy constraints.

Task 2 was completed on schedule and a progress briefing given to USDOT.

TASK 3 – DEFINE FINAL DEMONSTRATION

Two key deliverables were established in Task 3. The first was the selection of the specific applications that will be demonstrated. The applications come from near and mid-term time periods, and represent good coverage of applications that were identified as having high safety potential in Task 1. Demonstration applications include Stop Sign Assist (warning) and Curve Speed Assist (warning) from the near-term grouping and Stop Sign Assist (control), Curve Speed Assist (control), Traffic Signal Assist (warning), Lane Following Assist (warning) and Forward Collision Warning from the mid-term grouping. Several applications are in family form, i.e., both warning and control modes.

The second deliverable was the definition of the test site areas to be mapped, one located in southeast Michigan and one in Palo Alto, California. Test area statistics such as miles of road and percentage of varying levels of road curvature were generated. Details of the test areas to be mapped were selected that would provide suitable test scenarios for each of the selected demonstration applications and to explore the issues of Map database collection techniques and scalability.

Task 3 was completed on schedule and a progress briefing given to USDOT.

TASK 4 – DATA COLLECTION AND MAINTAINABILITY

Task 4 is active, examining data collection techniques to support the applications identified in Task 1. Ten 'Mobile Mapping', five 'Remote Sensing' and ten 'Third Party Sources' were identified for consideration. Map data collection methods for the near and mid-term map databases were selected based on their suitability for collecting the data required by the safety applications selected in Task 2.

The data collection techniques identified as potentially suitable to support the needs of the required mapplets for the demonstration applications were identified as Mobile Mapping, Remote Sensing and Probe Vehicles. Preliminary data representation modeling has begun. Development of the data collection and editing tools continues.

TASK 6 – DEMONSTRATOR VEHICLES

Work on Task 6 - Demonstrator Vehicles started ahead of schedule due to anticipated long product order lead-time on the inertial measurement units (IMUs) used for vehicle positioning. The team addressed positioning issues so that the demonstration vehicles can be equipped with term-appropriate hardware. At issue is the level or quality of IMU that can be expected to be available at pricing reasonable to support the proposed vehicle applications in the long-term, which was defined as 10 years to production implementation *after* the conclusion of the project. Current high-end (military grade) IMUs are very expensive, but are thought to be needed for high accuracy mapplets. The team discovered that the U.S. Army is funding a program to develop IMUs with cost and performance targets that could reasonably support OEM implementation of the proposed mapplets within the long-range time frame. The potential for low cost, high accuracy IMUs allows greater positioning opportunity.

High performance IMUs are a controlled defense technology item under section XII(d) of the U.S. Munitions List. CAMP has completed the registration process with the US Department of State as required under the International Traffic in Arms Regulations act. CAMP has also filed and received approval of it's application for the Technical Assistance Agreement required to conduct technical discussions of IMU technology with foreign nationals, as necessary to execute this project. Each individual Participant is responsible for any hardware licenses that may also be necessary. During the past year each project participant either produced evidence of an appropriate existing registration with the Office of Defense Controls, or is in the process of submitting an application for such registration, as required for execution of the CAMP's Technical Assistance Agreement. In conjunction with the Technology Transfer Control Plan, a training session regarding Defense Trade Controls Licensing and Compliance Issues was conducted for the project participants.

TASK 8 – DEPLOYMENT ANALYSIS

Due to significant contractual issues with the supplier originally selected to perform this task, alternative approaches to accomplishing the work were investigated. Several candidates to supply the positioning and communications parts of the deployment analysis were considered and an approach was identified using two suppliers. This approach provided equivalent or better technical performance for a lower financial cost. Task 8 timing was updated accordingly.

Task 8a analyses addressing communications and positioning technology was completed. These analyses examine issues involved in using various communications options to and from the vehicle and anticipated capabilities in positioning technology in support of the potential safety applications identified. The positioning work has brought to light information pointing toward significant potential to have high performance IMU capability available for production use in the mid-term, which would be five years ahead of what was anticipated. The team has adjusted project vehicle positioning expectations to include higher accuracy IMU capability in demonstrator vehicles (Task 6) as well as mapping equipment (Task 4). In order to make use of the increased positioning capability of the IMU, vehicles will need to have adequate differential GPS (DGPS) corrections available on a national scale.

The communications analysis indicated no significant roadblocks to deployment of potential applications. While the infrastructure is not yet in place, the study indicates that market forces will likely provide the necessary paths in the timeframe required for EDMap type applications. The top three high potential technologies were identified as dedicated short-range communication, advanced cellular, digital broadcast radio. It is unlikely that any one communications path will meet the needs of all EDMap applications- two or more will likely be required for the foreseeable future.

CAMP Enhanced Digital Maps Project

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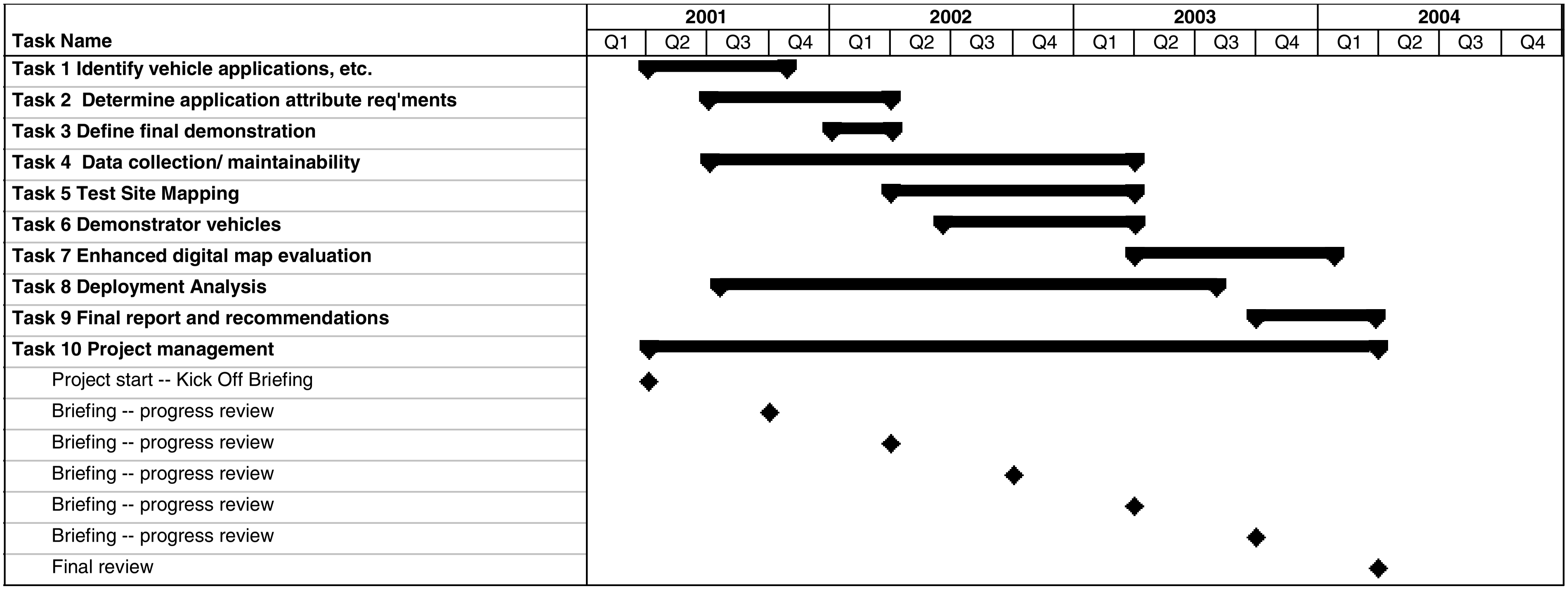

CAMP Forward Collision Warning Requirements Project

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PROJECT SCOPE

The Forward Collision Warning Requirements project contains two inter-related efforts which build off the work completed in 1999 under a previous CAMP / USDOT Cooperative Agreement on the same topic[2]. One focus is to obtain a substantial amount of additional "normative" driver performance data employing a surrogate target methodology in order to evaluate the previously developed crash alert timing under a broader range of conditions. This will involve obtaining driver performance data without FCW system support, which is used to further define 'too late' crash alert timing, and then evaluating driver performance with FCW system support. In the earlier program, all driver performance testing was conducted during clear weather daylight conditions on a straight, dry, level road in accordance with the predominate rear end crash scenario circumstances. The crash scenario evaluated was an in-lane approach to a stopped vehicle or a lead vehicle exhibiting constant deceleration levels. The current effort builds on this baseline by examining a wide variety of additional factors such as time of day, number of alert stages, approaches to a lead vehicle moving at a constant speed or decelerating with more typical non-constant lead vehicle deceleration profiles and "last second" lane-change (steering rather than braking) maneuvers.

A second focus is to better understand the relationship between data obtained employing the surrogate target methodology under closed-course conditions and data obtained using the National Advanced Driving Simulator (NADS). This effort will examine the relationship between last-second braking maneuvers and last-second lane-change maneuvers executed in the NADS with those executed on a closed-course. The last-second braking data are already available from the earlier CAMP / USDOT program, and the "last-second" lane-change data will be obtained during this project prior to executing the first of two NADS studies. If a reasonable correspondence (or "calibration") can be established between the closed-course and NADS findings, a second study will be conducted to examine additional crash alert timing and modality issues using the NADS. This second study will include scenarios that are difficult to replicate under closed-course conditions (e.g., a "surprise" unexpected braking scenario involving a stationary lead vehicle).

CAMP Forward Collision Warning Requirements Project

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PROJECT ACTIVITIES & ACCOMPLISHMENTS

TASK 1 – LAST SECOND MANEUVER

Task 1 employed the CAMP surrogate target methodology to examine driver's last-second braking and last-second steering behavior under a wide range of vehicle-to-vehicle kinematic testing conditions. These conditions included lead vehicle stationary, lead vehicle moving and braking, and lead vehicle moving at a slower constant speed and not braking (i.e., constant delta velocity). The analysis of results from closed-course testing at the Transportation Research Center in East Liberty, Ohio was completed. The data obtained were used to establish "normal" and "hard" braking and steering 'too late' envelopes that reflect the point beyond which a driver would typically have responded to the situation.

Last-second braking results from Task 1 corresponded well to those found in the earlier CAMP FCW project. Results also indicated that FCW alerts (based on assumptions surrounding the driver braking rather than steering) could occur during last-second lane changes under high velocity (60 MPH) conditions, and particularly under high relative velocity conditions. These results suggest that an FCW alert timing approach based only on last-second braking situations may result in alerts occurring before some drivers would execute normal (albeit aggressive) lane-change maneuvers

Two separate FCW timing models were developed and applied to the data. A model similar to the one developed in the first CAMP FCW project was examined and a new alternative timing model was created via logistic regression analysis. This new model has the advantage of operating very flexibly in a "probability of hard braking onset" domain, and may better represent the underlying mental process drivers use in deciding when to brake hard. Task 1 was completed on schedule and a summary briefing was given to.

TASK 4 – NADS LAST SECOND BRAKING / LANE CHANGE

A purchase order was issued to the NADS to conduct pilot testing and execute Task 4 testing. CAMP prepared a pilot test the methodology for the NADS team to execute in order to assess the feasibility of conducting last-second braking and last second steering judgments on the NADS. The results of the pilot testing conducted by CAMP, USDOT and NADS in November 2001 made it clear that the facility was not yet mature enough to perform the last-second steering and last-second braking maneuvers required for executing Task 4 and Task 6. However, the team felt that the issues identified will be addressed and that it would be feasible to conduct this testing on the NADS. Timing for the Task 4 and Task 6 studies was delayed approximately 6 months in order to allow the NADS facility to resolve start up issues and complete 100 hours of other customer testing prior to conducting the Task 4 closed course / simulator correlation study

CAMP Forward Collision Warning Requirements Project

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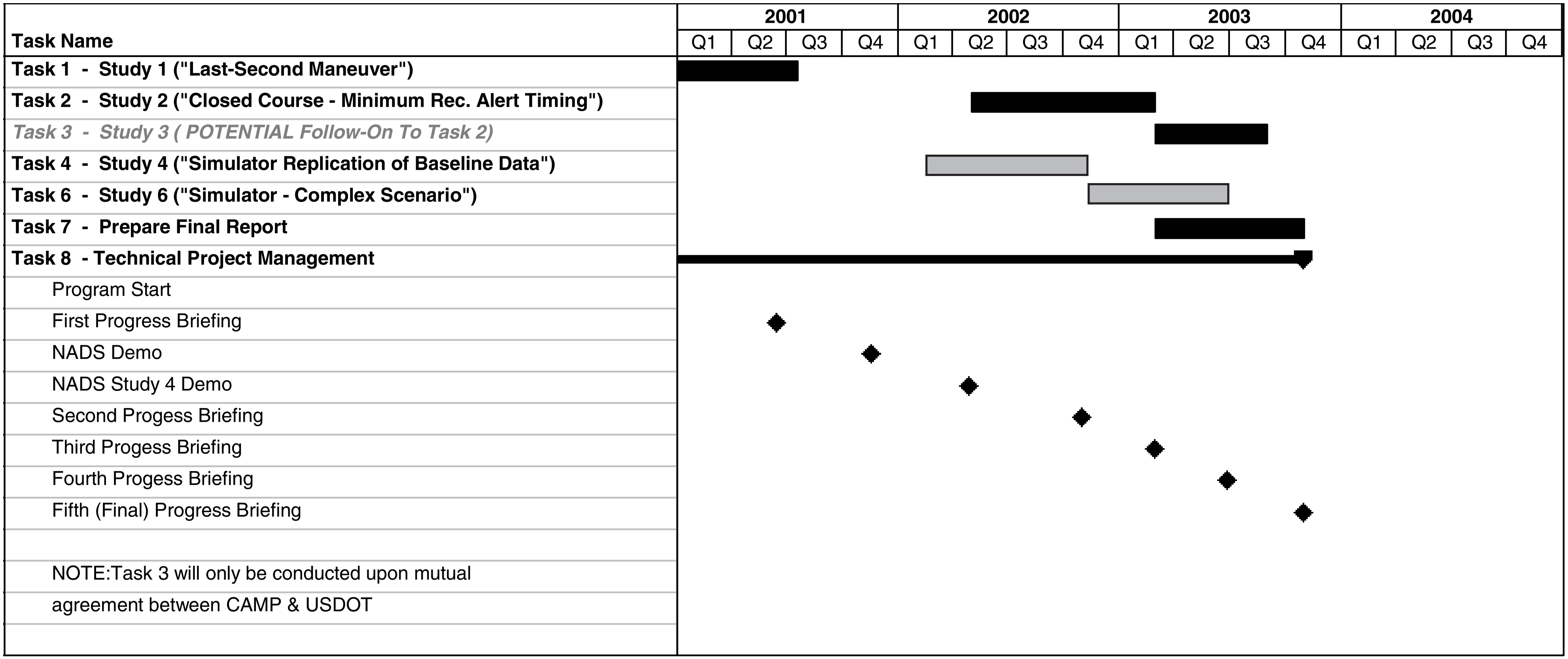

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