286500-6-T

Project Implementation Plan

Variable Dynamic Testbed Vehicle

D.R. McLellan, T.J. Blessing, J.L. Nyman

FEBRUARY 1997

Prepared for:

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P.O. Number: 718752
Contract Number: 959915

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16. Abstract

This document is the project implementation plan for the Variable Dynamic Testbed Vehicle (VDTV) program, sponsored by the Jet Propulsion Laboratory for the Office of Crash Avoidance Research (OCAR) programs in support of Thrust One of the National Highway Traffic Safety Administration's (NHTSA's) five-thrust program toward the Intelligent Vehicle Highway System (IVHS).

The project implementation plan lays out the process by which we will provide NHTSA the capability to methodically vary vehicle control and handling characteristics, which are needed for research associated with the Automated Highway Systems (AHS) and other IVHS programs, including crash avoidance countermeasures and human factors research, and in support of the National Advanced Driving Simulator (NADS).

In developing our plan, we followed the project statement of work for work breakdown. We also include program schedules and our process for program management.

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CONTENTS

FIGURES AND TABLE

ACRONYMS

COTR	Contracting Officer's Technical Representative
COTS	Commercial-Off-the-Shelf
DOE	Design of Experiments
ECU	Electronic Control Unit
ICD	Interface Control Document
IF	Interface
I/O	Input/output
MDI	Mechanical Dynamics Inc.
MRA	Millken Research Associates, Inc.
MPM	Master Processing Module
M S/S	Measurement Subsystem
OEM	Original Equipment Manufacturer
PPG	Policy, Procedure, and Guidance
SAE	Society of Automotive Engineers
SIL	Systems Integration Laboratory
VDTV	Variable Dynamic Testbed Vehicle

1. TASK SCOPE

1.1 TASK 1 — VDTV Design Concept Definition

1.1.1 Perform Trade Studies

Subcontractors Milliken Research Associates, Inc., (MRA) and Mechanical Dynamics Inc. (MDI) are conducting this task. The task involves summarizing metric handling response data from the Department of Transportation and characterizing the U.S. fleet of passenger cars, based on fleet data provided by OEMs.

1.1.2 Conduct Dynamics Analysis of the Selected Design Concept

The VDTV will represent the dynamic characteristics of a wide range of vehicles, from small cars to large luxury vehicles. The simulation model will be used to determine how closely the VDTV can match key parameters used to characterize the handling characteristics of the fleet. Subcontractors MRA and MDI are conducting this task. MRA will develop the dynamics characteristics of the VDTV that will be required to emulate the fleet and achieve state-of-the-art emergency maneuver performance. MDI will develop the detailed characterization of the VDTV that will allow us to integrate the subsystems into the vehicle and achieve the required performance.

MRA will recommend handling performance goals for the VDTV based on maxima and minima obtained during their review of data on the U.S. fleet. The rationale for selection of these goals will be provided in detail, along with any reservations about their practicality. Generally, MRA expects to recommend metrics that are 25 percent higher than the maxima and 75 percent of the minima.

MRA will update an existing simplified simulation, a computer program called SVDM, of vehicle dynamics and employ it to simulate the VDTV. SVDM has already been used to emulate a VDTV with hydraulic control subsystems for steer and active suspension. It will be modified to add models of an electric steering control system (front and rear) and active anti-roll bars (front and rear).

With the revised computer program, MRA will run exploratory cases with nominal subsystem and tire dynamic parameters to determine which feedback variables and gains are effective in causing the VDTV to achieve the extremes of handling metrics. Lateral accelerations will be below about 0.6g. Experience gained in writing the Calspan-Lotus-MRA VDTV proposal will be useful in performing this task Sets of runs will then be performed to demonstrate the effect of varying feedback gains on the handling response metrics (e.g., side slip gradient, roll gradient, steering sensitivity, understeer gradient, etc.). In addition, MRA will determine sensitivities to the following:

- Control subsystem frequency and damping (bandwidth, etc.);
- Tire friction coefficient, aligning torque (pneumatic trail), cornering stiffness, and relaxation length (tire dynamics);
- Shock absorber force-velocity characteristics.

Based on the above sets, MRA will recommend to ERIM/MDI appropriate feedback variables and gains, subsystem bandwidths, and tire characteristics.

MDI has received an ADAMS model of the production Taurus SHO from Ford and will manually convert this model to a fully parameterized model so that both sensitivity studies and design changes are easily facilitated. They will then modify the model to reflect the baseline VDTV configuration, which includes rear steer, front and rear steer-by-wire, front and rear dynamic anti-roll bars, and high-performance tires.

MDI will add rear-steer capability to the baseline Taurus model. This will include both a rear steering rack, as well as modifications to the rear suspension required for accommodating a rear-steer system.

MDI will implement steer-by-wire to both the front and rear wheels. This will be achieved through the use of a linear coupling modeling element between the steering wheel input and the rack travel to front and rear (no actual linkage between steering wheel and the racks). Appropriate steering feel will be modeled modifying the coupling ratio between steering wheel and front and rear racks. The model will be capable of introducing a fixed-time delay between front and rear steering inputs if required.

The baseline Taurus model will be modified by MDI to include front and rear dynamic anti-roll bars. These will have the capability to separately vary, using electro-hydraulic struts, the front and rear roll moments during a simulation.

MDI will add high-performance tires to the baseline Taurus model. Tire data for these tires, such as Pacjecka coefficients, will be provided by Goodyear in a format compatible with MDI's available tire models.

MDI will add a simple brake controller to the baseline Taurus model. This will apply a torque at the wheels to decelerate the vehicle.

MDI will add a simple velocity controller to the baseline Taurus model. This will apply a torque to the wheels to maintain constant vehicle velocity and will be capable of accelerating the vehicle to a given speed.

For the passenger car fleet performance modeling portion of its work, MDI will perform several simulation suites as follows.

Modeling of Maximum and Minimum Performance Requirements

Using the ADAMS full vehicle models of selected cars representative of the range of vehicles to be emulated by the VDTV, MDI will run simulations with these models to investigate the lateral response characteristics of each type of vehicle. For any vehicle models that lack ADAMS models, MDI will use provided full geometric and vehicle data, such as mass, inertia, linear or non-linear stiffness and damping coefficients, and vehicle handling characteristics.

VDTV Performance Relative to Performance Requirements

MDI will run several simulations of the VDTV in which the parameterized variables in the vehicle are varied throughout their reasonable range, using the automatic Design of Experiments (DOE) algorithms built into ADAMS. The parameters to be varied will include but not be limited to linear spring and damper rates, suspension mounting points, dynamic anti-roll bar length, and steering feel (coupler factor).

Vehicle Test Simulations for Performance Characterization

MDI will run the following vehicle test simulations:

J-Turn Maneuver

This will involve a linearly ramped steering input of 360 deg/s at a constant forward speed of 80 km/h being applied until steady-state turning conditions are established. This simulation will be used to determine steering effort (calculated from tie rod loads), understeer gradient, roll gradient, side slip gradient, steering sensitivity, lateral acceleration response time (90% rise time), and yaw velocity response time.

Maximum Lateral Acceleration Test

This simulation will involve driving the VDTV model on a fixed radius circle at the maximum speed possible to maintain that circular course. Vehicle speed and yaw rate will be measured during the simulation and will be used to calculate the maximum controllable steady-state lateral acceleration of the vehicle. This simulation may be run in both directions if the mass effect of the driver is considered important.

Frequency Response Test

The simulation for this test will be run at constant speed using a swept sinusoidal angular displacement input to the steering system. The frequency characteristics of the vehicle yaw velocity, lateral acceleration, and roll angle responses to the steering system excitation will be obtained for lateral acceleration bandwidth, yaw velocity bandwidth, roll response, and roll-yaw velocity coupling effects.

Obstacle Avoidance Maneuver
This simulation will be performed at approximately 55 km/h with no braking. The maximum speed at which the VDTV can successfully complete this double lane-change maneuver will be recorded.

Safety: Rollover Analysis
The envelope of safe operation of the VDTV will be assessed using simulations such as braking-in-a-turn, a reverse J-turn maneuver, and a road-holding test involving the vehicle traversing a bump while performing the Maximum Lateral Acceleration Test. Any simulations that would cause the VDTV to fail will be flagged, and the combination of parameters used will be recorded. Failure criteria will include, but not be limited to, two-wheel liftoff.

1.1.3 Address Backup to Dynamic Subsystems

Failure modes and any required backups to the dynamic subsystems will be evaluated with the MDI ADAMS model.

1.1.4 Establish ERIM Software Development Process

The ERIM software development, as adapted to the VDTV program, is composed of these steps:

1. Estimate total effort based on program requirements (already performed).
2. Establish requirements for entire software suite.
3. Establish architectural approach, including hardware/software partition.
4. Flow down requirements to individual software modules.
5. Develop interface control documents (ICD) for software modules.
6. Develop data dictionary of passable parameters.
7. Review software approach before coding begins (verify requirements coverage).
8. Code individual software modules.
9. Integrate and test individual software modules incrementally in the systems integration laboratory (SIL).
10. Verify (as much as possible) that requirements are met before transfer to the SIL.
11. Transfer software to vehicle – verify functionality.
12. Verify that requirements are met in vehicle.
13. Establish formal version control.

The SIL will be at ERIM in a laboratory adjacent to our high-bay facility. In this way testing can move from the lab bench to the vehicle (and back) with a minimum of disruption.

Software version control will be handled in three phases as the project progresses. Until the computer subsystem is installed in the VDTV, informal version control will **be** maintained. At this level, the software tools will prevent more than one programmer from "checking out" a piece of software simultaneously. This will help preserve the incremental completeness of the software and prevent "backtracking." This level of version control should be suitable until vehicle testing begins, due to the small size of the programming team (1 to 2 people).

Once vehicle testing begins, version control will be tightened. Until the end of the acceptance tests, the lead software engineer must approve all code changes (in consultation with the safety engineer when appropriate). This partial version control, an ERIM3 milestone, will be implemented by September 1, 1997. Once acceptance tests have been completed, full version control will be implemented. Under full version control, any modifications must be approved by the sponsor before installation on the VDTV. Full version control, an ERIM3 milestone, will be implemented by April 1, 1998.

Specifically during Task 1, we will establish the architecture, shown in Figure 1. This will cover the establishment of the architectural approach, including hardware/software partition. In addition, the interface strategy to the measurement subsystem will be developed.

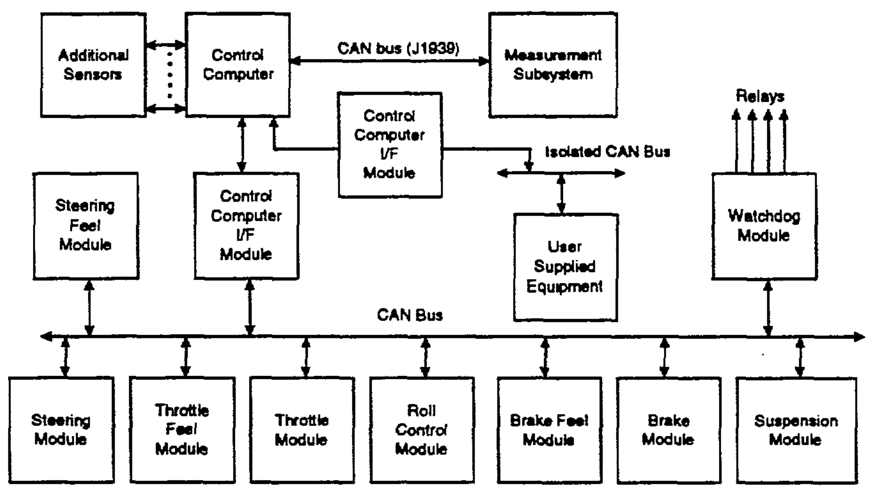


Figure 1. Overall Architecture

Electrical Interface

The only electronic communication between the master processing module (MPM) and the measurement subsystem (M S/S) is a digital data bus based on the CAN protocol. There will also be an electrical power interface per Exhibit I.

Details of the data interchange protocol will be finalized during Tasks 1 and 2. Tentatively, ERIM and JPL have agreed to base the CAN implementation on the 51939 version. Any deviations from 51939 will be determined during Tasks 1 and 2. Handshaking protocol based on J1939 will be used by the M S/S to inform the MPM that the M S/S is busy or ready to receive data.

The following is an initial estimate of data traffic over the interface.

Item	Data Rate	Bus Overhead	Total
	K samples/sec		K samples/sec
Sensor and Signal Data	10000	1 .5	25000

Tentatively, a second CAN bus is planned to handle special purpose data from the M S/S to the control computer for applications such as lane tracking, and so forth. The main CAN bus will handle the normal configuration data and sensor/signal data from the control computer.

Equipment Commonality

While ERIM and JPL could use the same physical platform to host the M S/S and the MPM, the advantages of separate chassis were considered to override the benefits of a single chassis. However, both platforms will be based on the Intel X86 processor residing on a PCI or ISA bus backplane. It is anticipated that the operator interface of the MPM will run under Windows95

Tentatively, the CAN interface will be handled at both ends (control computer and M S/S> with identical CAN interface cards. Cards from Softing and I+ME are being evaluate-d.

M S/S Emulator

ERIM will use a COTS CAN interface board to emulate the input/output (I/O) traffic between the MPM and the M S/S. This interface board will be used to test handshaking between the two subsystems. This emulator will be needed approximately 9 months after contract start.

Cabling

Some M S/S cabling will be installed within the VDTV structure. JPL will specify the cabling and connectors needed by a date to be determined but no later than March 1, 1997. JPL will buy the cabling and the connectors. ERIM will specify any particular physical requirements on the cabling and connectors. JPL will specify sensor locations, and ERIM/Roush will determine the cable paths and M S/S computer (and data storage) locations.

M S/S location

ERIM and JPL will negotiate any changes from the Exhibit I document with regard to computer and data storage locations and size changes.

Personnel Interface

The primary interface between JPL and ERIM on the M S/S will be Mike Koffman and Tom Blessing. Phone, e-mail, and fax are all acceptable forms of communication. Koffman and Blessing will he present at every other weekly phone conference to discuss status, technical issues, and so forth. Face-to-face meetings are to be scheduled as the program progresses and need dictates.

M S/S Specifications

Any Society of Automotive Engineers (SAE) specifications that the M S/S must comply with will be decided upon by JPL and ERIM ERIM will use the same specifications for its development.

M S/S Tests

ERIM expects JPL to have verified the internal operation of the M S/S and the interface to the CAN bus prior to delivery to ERIM. ERIM presence at these tests is to be determined as need dictates.

M S/S Integration

ERIM expects JPL to support on site the integration of the M S/S into the VDTV for a period of time as need dictates and for at least one week.

1.1.5 Recommendations and Requirements Review

The results of Task 1 will be assembled into a recommendation supported by rationale from the trade studies and backup safety systems and presented at the Requirements Review to be held at the completion of Task 2.

1.2 TASK 2 — VDTV Requirements Definition

1.2.1 Conduct Analyses to Evaluate Requirements

Subcontractor MDI will build a fully parameterized vehicle dynamics model of the VDTV using the multibody system simulation software ADAMS. This model will consist of the baseline Ford Taurus SHO (Generation II) plus the additional equipment required for the project: rear steer, front and rear steer-by-wire, front and rear dynamic anti-roll bars, and high-performance tires.

1.2.2 Define Interface Requirements for All Elements of the Delivered System

In this subtask, ERIM will establish requirements for the entire software suite, which will then be flowed down to the individual software modules. In the same way, the requirements will be flowed down to the electronics modules. This flow-down can occur once high-level requirements have been finalized.

Figure 2 shows the details of the interface for one example subsystem element, in this case the steering-by-wire element. Note that the steering electronic control unit (ECU) and the steering feel ECU do not interface directly to the CAN bus. A common bus interface module will be used to interface the ECUs of all the dynamic subsystem elements to the CAN bus. This approach is being used for all of the dynamic subsystems.

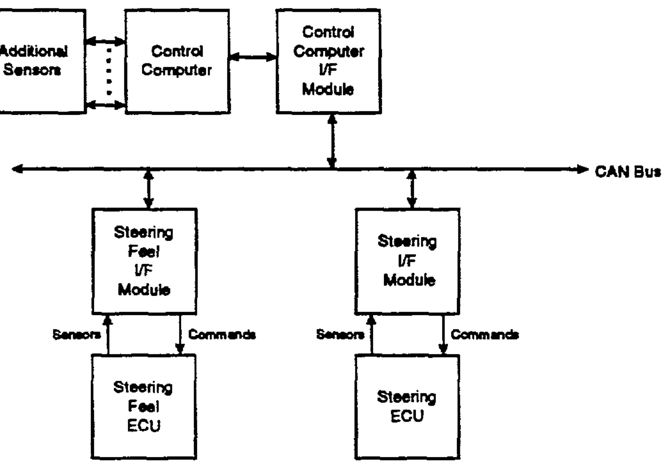


Figure 2. Steer-by-Wire Element

1.2.3 Define System Test Requirements

ERIM, with input from Roush, will define all system test requirements, including system-level testing and acceptance testing. This activity will commence after the design phase.

1.2.4 Requirements Definition Report and Requirements Review

ERIM will prepare a document for review and revision that will detail the requirements and their flow-down as performed on the subtask defining interface requirements. During this subtask, the software interface control documentation (ICD) will be initiated, including data format for the measurement subsystem interface. This material is to be completed by March 3, 1997. Draft forms of the ICD will be made available as they are developed, with an appropriate approval process to be determined.

At the completion of Task 2, results from Tasks 1 and 2 will be documented in a Requirements Definition Report, and we will conduct a Requirements Review on December 5 at our facility.

1.3 TASK 3– VDTV Design

1.3.1 Perform Design Analyses

The TRW, Delphi, Goodyear, and Bosch subsystems have already been selected and all meet the requirements of Exhibit I. Roush assumes responsibility for building the mockup of the vehicle with the subsystems and to work with the subsystem contractors to integrate their subsystems into the vehicle.

1.3.2 Select Hardware and Software Tools

The hardware and software for the VDTV electronics will be selected in this subtask. This includes the computing environment for the master processing module (MPM) and the individual electronic interface modules. The environment includes the processor, hardware configuration, operating system, and software development tools. Potential candidates for these item have already been identified. This subtask will coordinate the selection process with the measurement subsystem development activity.

Languages/Operating Systems/Environments

There are two primary environments that the software for the VDTV will be operating in (excluding the embedded software which resides in the vendor-supplied dynamic subsystem elements). First, the control computer will be an X86 (probably a P6) based personal computer operating under the Windows95 or NT 4.0 operating system. This PC will be responsible for the operator interface and for managing communications between the M S/S and the ERIM equipment. This computer will also communicate set-up, status, and algorithm updates to the microcontrollers resident on the CAN I/F modules. The user interface will be a GUI programmed in Microsoft Visual Basic or C++.

The second environment will be on the CAN I/F modules. This software will be programmed in C (C++ where appropriate). The hardware will be based on the Intel 80196CA microcontroller or the Siemens Cl67 microcontroller. CAN interface cards from Softing and I+ME are being evaluated.

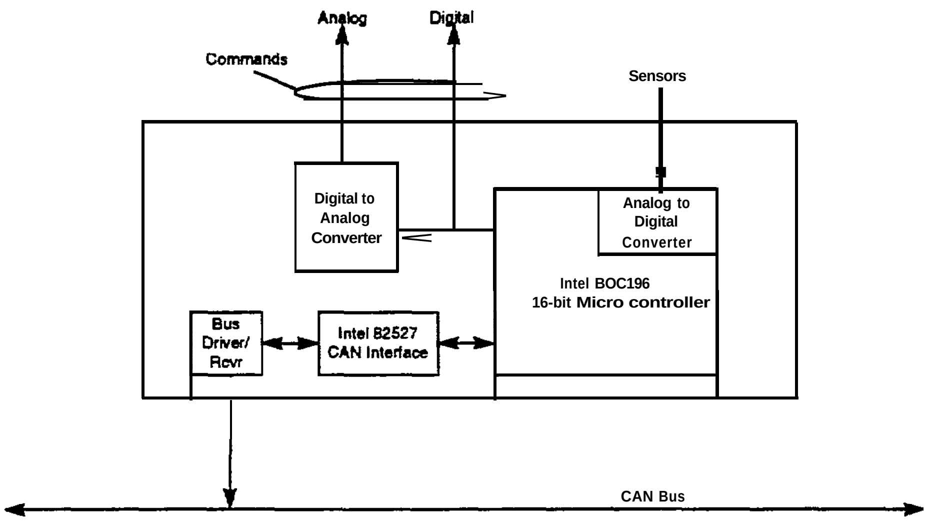


Figure 3. CAN Interface Module

1.3.3 Design Software

This subtask will cover the design of the software and accompanying electronics for the VDTV. The software ICD will be finalized during this subtask. The data dictionary document will be initiated, and it will be updated as needed during the coding phase. Software design will include specifying the individual software modules and their functions, and needed control algorithms will be identified.

Software Typing/Sizing

The following is a first estimate of the different software module types and sizes.

Software Module	**Lines of Code**
	(C)
I/F Modules	
Common I/F	750
Brake specific	500
Steering specific	500
Throttle specific	500
Suspension specific	250
Watchdog specific	500
User supplied equip. I/F	500
Control Computer I/F	500
Subtotal	4000
Control Algorithms	
Brake	500
Steering	750
Throttle	500
Suspension	500
Subtotal	2250
Control Computer	
GUI	8000
Measurement S/S I/F	500
Safety	2000
Independent Sensor I/F	1000
Subtotal (except GUI)	3500
Total	17750

1.3.4 Design Feel Subsystems

The feel electronics needed for the steering, brake, and throttle subsystems will be addressed during this task. TRW is responsible for the steering subsystem, which they will provide by recreating their original feel system. Delphi will be responsible for the brake feel, which will be provided as their standard system. The Bosch throttle only comes with a sensor, not an actuator. ERIM will build or procure an actuator, an activity that is currently underway.

1.3.5 Document Analyses and Design and Hold Design Review

At the completion of Task 3, the analyses and design will be documented, and this material will be presented at the Design Review to be held at our facility.

1.4 TASK 4 — Acquisition Fabrication, and Subsystem Test

1.4.1 Perform Make-or-Buy Tradeoffs

We will perform make-or-buy tradeoffs and decisions consistent with minimizing risk and cost wherever this is appropriate.

1.4.2 Code Software

The actual software coding will occur during this subtask The coding team will be small (1 to 2 people), so interaction will be maintained on an informal level, with the software ICD and data dictionary ensuring compatibility between the software modules. Informal version control will begin during this subtask.

1.4.3 Test Software in SIL

The software will be tested in the SIL during this subtask. The software modules will first be tested individually, and then tested in concert with each other. Interfacing to the measurement subsystem will begin during this subtask, as will software test plans for the system testing and the acceptance testing.

1.4.4 Front and Rear Steer-by-Wire and Front Feel

TRW is establishing the details of the front and rear steering rack and feel system that will be designed and integrated into the Taurus SHO. Software management will be developed and evaluated by ERIM in the SIL.

1.4.5 Brakes, Active Anti-roll Bar, and Shocks

Delphi has established the brake-by-wire package we will use and is designing the accompanying feel system. This will be integrated into the vehicle by Roush in the mockup and build process. The active anti-roll bar control hardware has been defined and will be provided by Delphi. The electronic interface will be defined by Delphi and the interface performed by ERIM, with the physical manufacture of the components and the installation to be provided by Roush.

1.4.6 Throttle-by-Wire

Bosch is providing the throttle-by-wire components and interface requirements. ERIM will provide software control, and Roush will integrate the subsystem into the VDTV.

1.4.7 Provide Photos, Video Tapes, and Drawing

At the end of Task 4, we will provide photographs of assemblies and subassemblies and vehicle video tapes documenting the fabrication, assembly, and test activities. In addition, we will provide an artist's rendering of the VDTV suitable for display and presentation.

1.5 TASK 5-Integration and Assembly

1.51 Transition to VDTV

The software and electronics will be completely hosted on the VDTV during this subtask. While some of the SIL testing will actually occur on a vehicle, the final installation wilI occur during this subtask Version control (without the requirement for formal reviews) will also be established at this time.

1.5.2 Vehicle Testing

The software will be tested for full functionality at the vehicle level during this subtask. Once the software has been verified at the vehicle level, the software effort is incorporated into the mainstream integration and acceptance tests. Once system testing is complete, formal version control will be instituted.

1.6 Sysfem Testing

1.6.1 System Test Plan and Test Readiness Review

ERIM, with support from Roush, will prepare a System Test Plan, which will be presented at the Test Readiness Review prior to the initiation of testing. The plan will include system testing that we have conducted and acceptance testing that we will conduct at the test site. The Test Readiness Review will be held at our facility.

1.6.2 Conduct System Tests and Acceptance Tests

Roush, with support from ERIM, will conduct the system tests and the acceptance tests in accordance with the approved System Test Plan.

1.7 Safety

1.7.1 Develop and Document a Safety Plan

ERIM will develop and document a Safety Plan for the VDTV. We will address failure modes and any required backups to the dynamic subsystems through MDI’s evaluation with the ADAMS model. The envelope of safe operation of the VDTV will be assessed using simulations such as braking-in-a-turn, a reverse J-turn maneuver, and a road-holding test involving the vehicle striking a bump while performing MDI's Maximum Lateral Acceleration test. Any simulations that would cause the VDTV to fail will be flagged and the combination of parameters used will be recorded. Failure criteria will include, but not be limited to, two-wheel liftoff. The Safety Plan will be presented at the Requirements Review on December 5.1996.

1.7.2 VDTV Development

ERIM will ensure development of the VDTV in accordance with the approved Safety Plan.

1.8 Maintenance

1.8.1 Develop and Document Maintenance Procedures

In conjunction with our subcontractors, we will develop and document maintenance procedures for the VDTV that are consistent with the requirements of Exhibit I.

1.8.2 Determine and Provide Spare Parts

Roush will determine and provide spare parts consistent with the maintenance and availability requirements of Exhibit I.

1.8.3 Provide As-Built Documentation

Roush will provide as-built documentation as described in Exhibit I.

1.9. Project Management and Reports

1.9.1 Designate Project Manager and Establish Project Management Function

ERIM has designated Mr. David R. McLellan as the Project Manager for the VDTV program. As further described in Section 3, Program Management, Mr. McLellan has full responsibility and authority to fulfill the program's objectives within the negotiated contract costs and schedule.

1.9.2 Technical Liaison

Mr. McLellan is maintaining continuous informal liaison with Mr. Al Marriott and Mr. Dan Griffin, as well as conducting weekly telephone conferences with them. Mr. McLellan will continue to respond to Mr. Marriott's and Mr. Griffin's requests for program data and notification of significant problems. In addition, ERIM will conduct one-day Quarterly Management and Technical Status meetings, as requested by JPL, at our facility and in our format.

1.9.3 Cost Management

ERIM will prepare and submit Financial Management Reports in accordance with Exhibit III, DRD PMS-003 and NASA Forms 533M and 5334. We will also prepare, submit, and update as required a Baseline Cost Estimate in accordance with Exhibit III, DRD MA-004 and JPL Form 0548- 1.

1.9.4 Management and Other Technical Reports

ERIM will prepare and submit Monthly Progress Reports, Subcontractor Reports for Individual Contracts and Summary Subcontractor Reports in accordance with Exhibit III prepare and submit a Project Implementation Plan describing the technical and management plan for accomplishing the project, and prepare and submit a Final Project Report summarizing the effort performed and including the as-built documentation.

2. SCHEDULE

This section contains the overall VDTV program schedule, the subsystem schedule, and a description of software-specific milestones.

2.1 Overall Schedule

The overall program schedule was prepared in Microsoft Project and includes the following components:

- Tasks and subtasks
- Dependencies
- Program deliverables (in italics)
- Key milestones requested by JPL after the statement of work.

The key milestone concept was introduced by JPL at the end of September. JPL requested establishing one milestone, delivery of the vehicle, that would be a NHTSA-driven and controlled milestone, meaning it cannot be changed without NHTSA approval. The second level of milestones would be JPL-driven and controlled, identified as JPL2 milestones, and the third level would be ERIM-driven and controlled, identified as ERIM3 milestones. The full list of these milestones follows.

NHTSA1	Deliver Vehicle	4/1/98
JPL2	Subcontracts in Place	12/5/96
JPL2	Requirements Review	12/5/96
JPL2	Software Design Completed	1/31/97
JPL2	Feel Subsystem Design Completed	1/31/97
JPL2	Design Review	3/3/97
JPL2	Software Completed in SIL	8/1/97
JPL2	Test Readiness Review	11/3/97
ERIM3	Software Requirements Definition	12/5/96
ERIM3	Electronic Interface Modules Ready for SIL	5/1/97
ERIM3	Software Committed to SIL	5/1/97
ERIM3	Software Completed in SIL	8/1/97
ERIM3	Partial Software Version Control	9/1/97
ERIM3	Full Software Version Control	4/1/98

See pages 18 to 20 for the overall schedule.

2.2 Subsystem Schedule

In addition to the overall schedule, we have developed an auxiliary schedule that covers the subsystem cadence. The primary intent of the subsystem cadence is to demonstrate that the completion and integration of the nine subsystems are independent of one another. This gives us scheduling flexibility in terms of being able to respond to subsystems as they are delivered from the subcontractors. See pages 21 to 24 for the subsystem schedule.

2.3 Software-Specific Milestones

The following sections describe the milestones that are software-specific.

2.3.1 Software Requirements Defined (ERIM3 Milestone) – December 5,1996

At this point, all requirements pertaining to software will be identified. These will be derived from the Exhibit I performance specifications as evaluated by MRA and confirmed by MDI.

2.3.2 Software Design Complete (JPL2 Milestone) – January 31,1997

On this date the software design will be completed and software coding can begin. Completion of software design includes the following:

- The architectural concepts from Task 2 will be incorporated.
- The list of sensors and signals for the control subsystem (Table 4- 1 from Exhibit I) will be fmalized.
- The requirements flow down from Task 1 to individual software modules will be complete.
- The hardware interfaces to the software will be defmed.
- The overall structure (framework) of the software will have been defined.
- The Data dictionary will be underway, with the format procedure for adding data items in place.
- The software module ICDs will be drafted.
- Preliminary CAN messages defined.

2.3.3 Individual Dynamic Subsystems Completed in SIL (ERlM3 Milestones) – Subsystem Schedule Dates of April 1,1997, to August 8,1997

These milestones will mark the completion of SIL testing for each of the dynamic subsystems. These milestones may be grouped into three higher level milestones. This includes initial software testing on the subsystem before and after installation onto the VDTV. The exact sequence of these milestones will be determined once subcontractor schedules are firmly in place. These milestones include the completion of the following:

- Interface hardware complete
- Subsystem control verified with bus loading 50 percent greater than normal

- Sensor data acquired and stored in desired format

Scheduling for this portion of the program is shown in the auxiliary subsystem schedule shown on pages 21 to 24.

2.3.4 Electronic Interface Modules Ready for SIL (ERIM3 Milestone) – May 1, 1997

The interface modules will be ready for software testing in the SIL at this point. Depending on the electronics needed, these modules will be either purchased (if possible) or adapted from another program underway at ERIM.

2.3.5 Software Committed to SIL (ERIM3 Milestone) – May 1,1997

At this point, the software will be ready for testing with the hardware in the SIL.

2.3.6 Software Completed in SIL (JPL2 Milestone) – August 1,1997

At this point, all of the subsystem software will have been tested in the SIL and will be ready for vehicle testing. This milestone includes:

- Verification of the operation of the GUI.
- Successful control of each of the dynamic subsystems.
- Successful sensor data acquisition and storage in desired format.
- Successful interfacing to the M S/S, including data transfer.

2.3.7 Partial Software Version Control (JPL3 Milestone) – September 1,1997

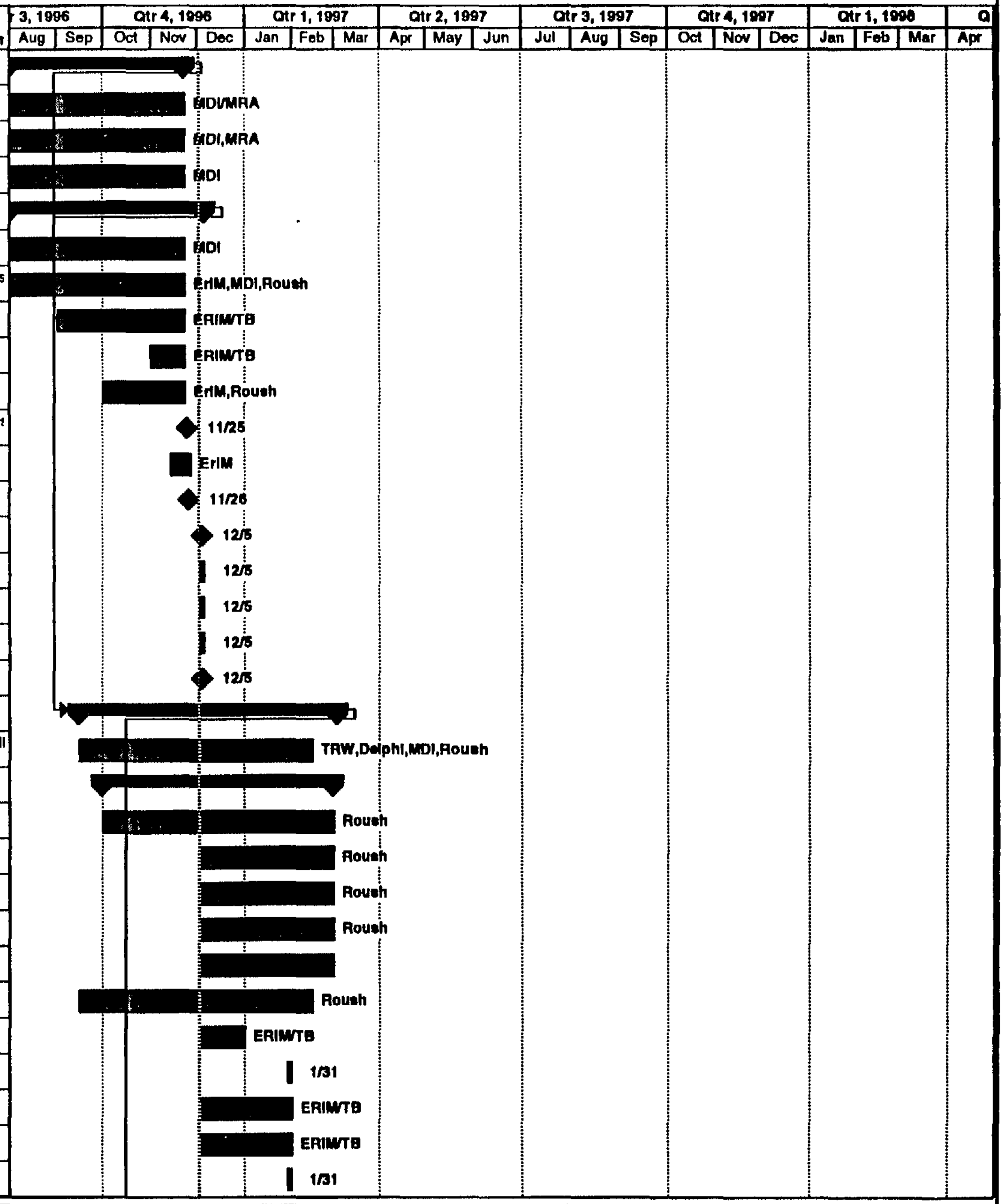
Once vehicle testing begins, version control will be tightened. Until the end of the acceptance tests, the lead software engineer must approve all code changes (with consultation by the safety engineer when appropriate).

2.3.8 Full Software Version Control (Level III Milestone) – April 1,1998

Once acceptance tests have been completed, full version control will be implemented. Under full version control, any modifications must be approved by the sponsor before installation on the VDTV.

VDTV

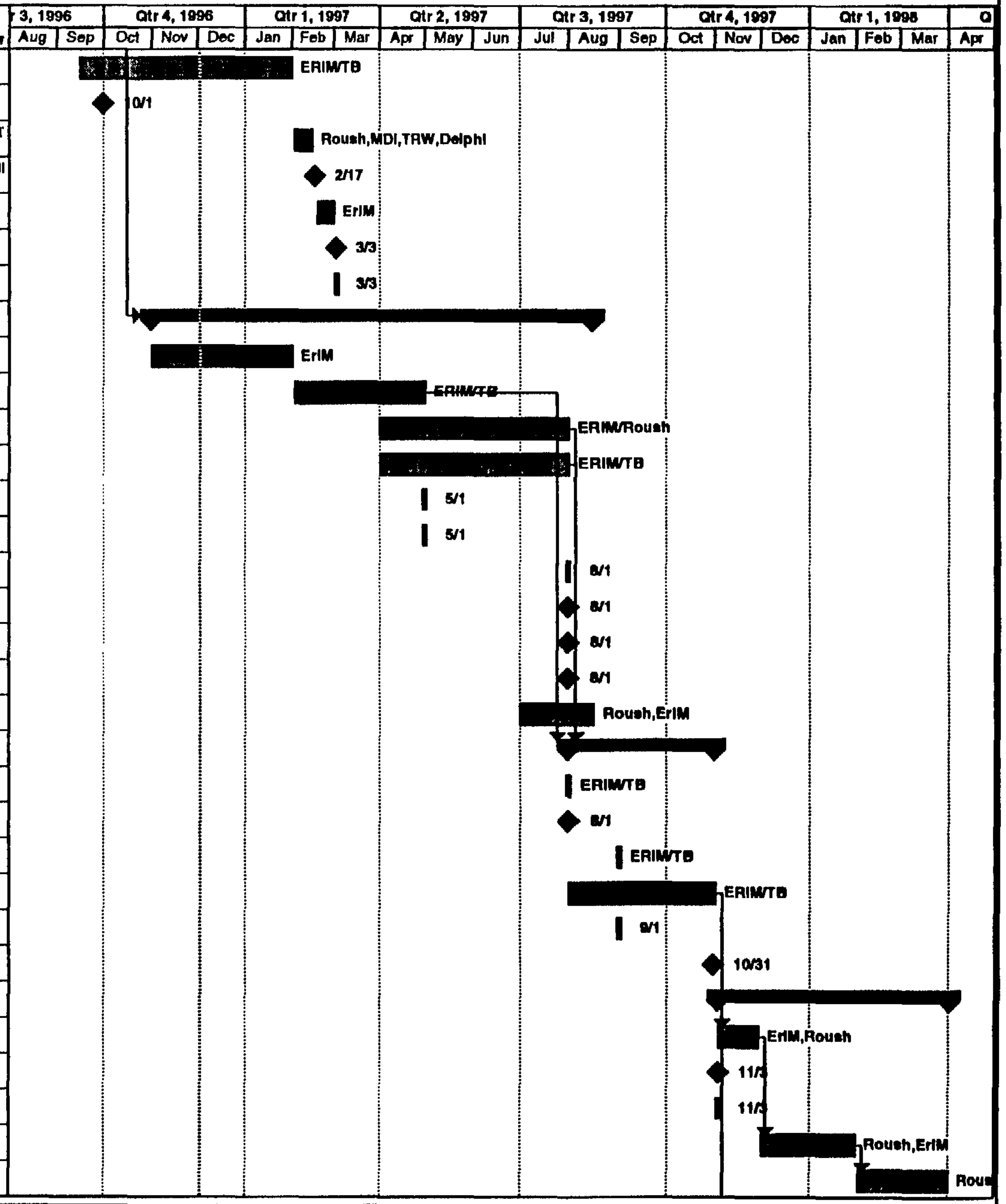
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Nan
1	**1. VDTV Design Concept Def**	**82d**	**Thu 8/1/96**	**Fri 11/22/96**		
2	Perform trade studies	82d	Thu 8/1/96	Fri 11/22/96		MDI/MRA
3	Conduct dynam analysis	82d	Thu 8/1/96	Fri 11/22/96		MDI,MRA
4	Address backup to dynar	82d	Thu 8/1/96	Fri 11/22/96		MDI
5	**2. VDTV Reqrmnts Definitior**	**91d**	**Thu 8/1/96**	**Thu 12/5/96**		
6	Conduct anal to eval reqr	82d	Thu 8/1/96	Fri 11/22/96		MDI
7	Define interface reqr	82d	Thu 8/1/96	Fri 11/22/96		ErIM,MDI,Rous
8	SW. Flow-down archit rec	60d	Mon 9/2/96	Fri 11/22/96		ERIM/TB
9	SW. Finalize reqmts	16d	Fri 11/1/96	Fri 11/22/96		ERIM/TB
10	Define system test reqr	39d	Tue 10/1/96	Fri 11/22/96		ErIM,Roush
11	Receive subc des/req rpt	1d	Mon 11/25/96	Mon 11/25/96		MDI,MRA,Rous
12	*Complete draft reqr def re*	9d	Thu 11/14/96	Tue 11/26/96		ErIM
13	*Submt drft reqr def to JPL*	1d	Tue 11/26/96	Tue 11/26/96		ErIM
14	*Reqr review*	1d	Thu 12/5/96	Thu 12/5/96		ErIM
15	***JPL2 SC contracts***	1d	Thu 12/5/96	Thu 12/5/96		
16	***JPL2 Reqr review***	1d	Thu 12/5/96	Thu 12/5/96		
17	***ERIM3 SW reqmts defi***	1d	Thu 12/5/96	Thu 12/5/96		
18	*Provide artist's rendering*	1d	Thu 12/5/96	Thu 12/5/96		ErIM
19	**3. VDTV Design**	**121d**	**Mon 9/16/96**	**Mon 3/3/97**	1FS-12w,5FS-12	
20	Perform design analyses	110d	Mon 9/16/96	Fri 2/14/97		TRW,Delphi,MI
21	**V1. Design integ ssys**	**109d**	**Tue 10/1/96**	**Fri 2/28/97**		Roush,ErIM
22	Overall design integ	109d	Tue 10/1/96	Fri 2/28/97		Roush
23	Power & electrical	65d	Mon 12/2/96	Fri 2/28/97		Roush
24	4 corner calipers	65d	Mon 12/2/96	Fri 2/28/97		Roush
25	Hydraulic pump	65d	Mon 12/2/96	Fri 2/28/97		Roush
26	Bondurant roll bar	65d	Mon 12/2/96	Fri 2/28/97		
27	V1. Mockup ssys	110d	Mon 9/16/96	Fri 2/14/97		Roush
28	SW. Select h/w & s/w too	22d	Mon 12/2/96	Tue 12/31/96		ERIM/TB
29	***JPL2 SW design comple***	1d	Fri 1/31/97	Fri 1/31/97		
30	SW. Design s/w	45d	Mon 12/2/96	Fri 1/31/97		ERIM/TB
31	SW. Design feel ssys	45d	Mon 12/2/96	Fri 1/31/97		ERIM/TB
32	***JPL2 Feel ssys design c***	1d	Fri 1/31/97	Fri 1/31/97		



Project: VDTV_dependencies.MPP
Date: Mon 12/2/96

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

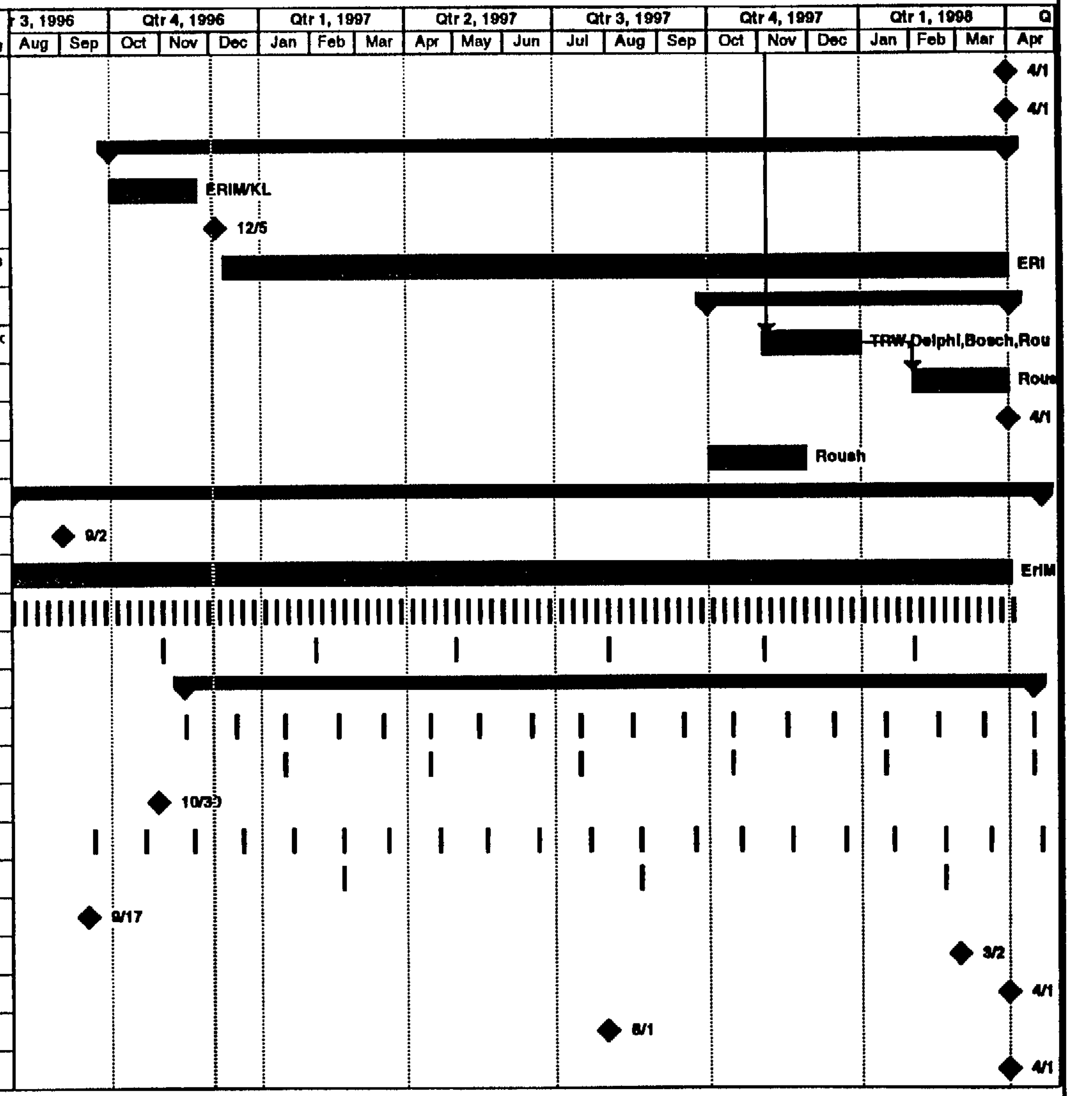
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Nan
33	Design for measure ssys	100d	Mon 9/16/96	Fri 1/31/97		ERIM/TB
34	Long-lead release	1d	Tue 10/1/96	Tue 10/1/96		
35	*Doc analyses & design*	10d	Mon 2/3/97	Fri 2/14/97		Roush,MDI,TR
36	Receive subc analy/des r	1d	Mon 2/17/97	Mon 2/17/97		TRW,Delphi,MI
37	Write design review rpt	9d	Tue 2/18/97	Fri 2/28/97		ErIM
38	*Hold design review*	1d	Mon 3/3/97	Mon 3/3/97		ErIM
39	***JPL2 Design review***	1d	Mon 3/3/97	Mon 3/3/97		
40	**4. Acquisition, Fabrication &**	**206d**	**Fri 11/1/96**	**Fri 8/15/97**	**19FS-20w**	
41	Perform make-or-buy trac	66d	Fri 11/1/96	Fri 1/31/97		ErIM
42	SW. Code s/w	63d	Mon 2/3/97	Wed 4/30/97		ERIM/TB
43	9 ssys proc SIL/Roush	88d	Tue 4/1/97	Thu 7/31/97		ERIM/Roush
44	SW. SIL	88d	Tue 4/1/97	Thu 7/31/97		ERIM/TB
45	***ERIM3 EIM ready for SIL***	1d	Thu 5/1/97	Thu 5/1/97		ERIM/TB
46	***ERIM3 SW commit to SI***	1d	Thu 5/1/97	Thu 5/1/97		ERIM/TB
47	***JPL2 SW completed SIL***	1d	Fri 8/1/97	Fri 8/1/97		
48	*Provide photos, video tap*	1d	Fri 8/1/97	Fri 8/1/97		ErIM
49	*Acquire/fab all*	1d	Fri 8/1/97	Fri 8/1/97		ErIM
50	*Demonstrate performanc*	1d	Fri 8/1/97	Fri 8/1/97		ErIM
51	AHS San Diego option	34d	Tue 7/1/97	Fri 8/15/97		Roush,ErIM
52	**5. Integration & Assembly**	**66d**	**Fri 8/1/97**	**Fri 10/31/97**	**42,43,44**	
53	***ERIM3 sw completed SI.***	1d	Fri 8/1/97	Fri 8/1/97		ERIM/TB
54	SW. Transition to VDTV	1d	Fri 8/1/97	Fri 8/1/97		ERIM/TB
55	***ERIM3 partial sw versio***	1d	Mon 9/1/97	Mon 9/1/97		ERIM/TB
56	SW. Vehicle testing	66d	Fri 8/1/97	Fri 10/31/97		ERIM/TB
57	***JPL2 Init VDTV maneuv***	1d	Mon 9/1/97	Mon 9/1/97		
58	*Integ/assemb w/meas su.*	1d	Fri 10/31/97	Fri 10/31/97		ErIM,JPL
59	**6. System Testing**	**108d**	**Mon 11/3/97**	**Wed 4/1/98**		
60	*Prepare sys test plan*	20d	Mon 11/3/97	Fri 11/28/97	56	ErIM,Roush
61	*Readiness rev sys test pl*	1d	Mon 11/3/97	Mon 11/3/97		ErIM,Roush
62	***JPL2 Test readiness rev***	1d	Mon 11/3/97	Mon 11/3/97		
63	Conduct system tests	45d	Mon 12/1/97	Fri 1/30/98	60	Roush,ErIM
64	Conduct accept tests	42d	Mon 2/2/98	Tue 3/31/98	63	Roush,ErIM



Project: VDTV_dependencies.MPP
Date: Mon 12/2/96

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Nan
65	*ERIM3 full sw version c*	1d	Wed 4/1/98	Wed 4/1/98		ERIM/TB
66	*NHTSA1 Deliver vehicle*	1d	Wed 4/1/98	Wed 4/1/98		ErIM
67	**7. Safety**	**391d**	**Tue 10/1/96**	**Tue 3/31/98**		
68	Develop/doc safety plan	39d	Tue 10/1/96	Fri 11/22/96		ERIM/KL
69	*Present plan reqr rev*	1d	Thu 12/5/96	Thu 12/5/96		ERIM/KL
70	Develop VDTV according	342d	Mon 12/9/96	Tue 3/31/98		ERIM/KL,Rous
71	**8. Maintenance**	**131d**	**Wed 10/1/97**	**Wed 4/1/98**		
72	*Develop & doc maint pro*	43d	Mon 11/3/97	Wed 12/31/97	56	TRW,Delphi,Bc
73	Determ & provide spare p	42d	Mon 2/2/98	Tue 3/31/98	72	Roush
74	Provide as-built documen	1d	Wed 4/1/98	Wed 4/1/98		Roush
75	Trailer option	43d	Wed 10/1/97	Fri 11/28/97		Roush
76	**9. Project Management & Re**	**448d**	**Thu 8/1/96**	**Mon 4/20/98**		
77	*Designate proj mgr & est*	1d	Mon 9/2/96	Mon 9/2/96		ErIM
78	Provide tech liaison	435d	Thu 8/1/96	Wed 4/1/98		ErIM
79	***Weekly phone conf***	**436d**	**Fri 8/2/96**	**Fri 4/3/98**		
168	***Conduct 1-day qtrly mg***	**327d**	**Fri 11/1/96**	**Mon 2/2/98**		ErIM
175	***Submit fin mgmt reports***	**369d**	**Fri 11/15/96**	**Wed 4/15/98**		ErIM
176	***Mo NASA 533M***	**369d**	**Fri 11/15/96**	**Wed 4/15/98**		
195	***Qtrly NASA 533Q***	**326d**	**Wed 1/15/97**	**Wed 4/15/98**		
202	*DRD MA-004,JPL0548-1*	1d	Wed 10/30/96	Wed 10/30/96		ErIM
203	***Submit monthly prog re***	**412d**	**Fri 9/20/96**	**Mon 4/20/98**		ErIM
224	***Submit subc SF294***	**262d**	**Thu 2/20/97**	**Fri 2/20/98**		ErIM
228	*Submit project implemen*	1d	Tue 9/17/96	Tue 9/17/96		ErIM
229	*Submit draft final report*	1d	Mon 3/2/98	Mon 3/2/98		ErIM
230	*Deliver VDTV*	1d	Wed 4/1/98	Wed 4/1/98		ErIM
231	*Subj invent rpt 1*	1d	Fri 8/1/97	Fri 8/1/97		ErIM
232	*Subj invent rpt 2*	1d	Wed 4/1/98	Wed 4/1/98		ErIM

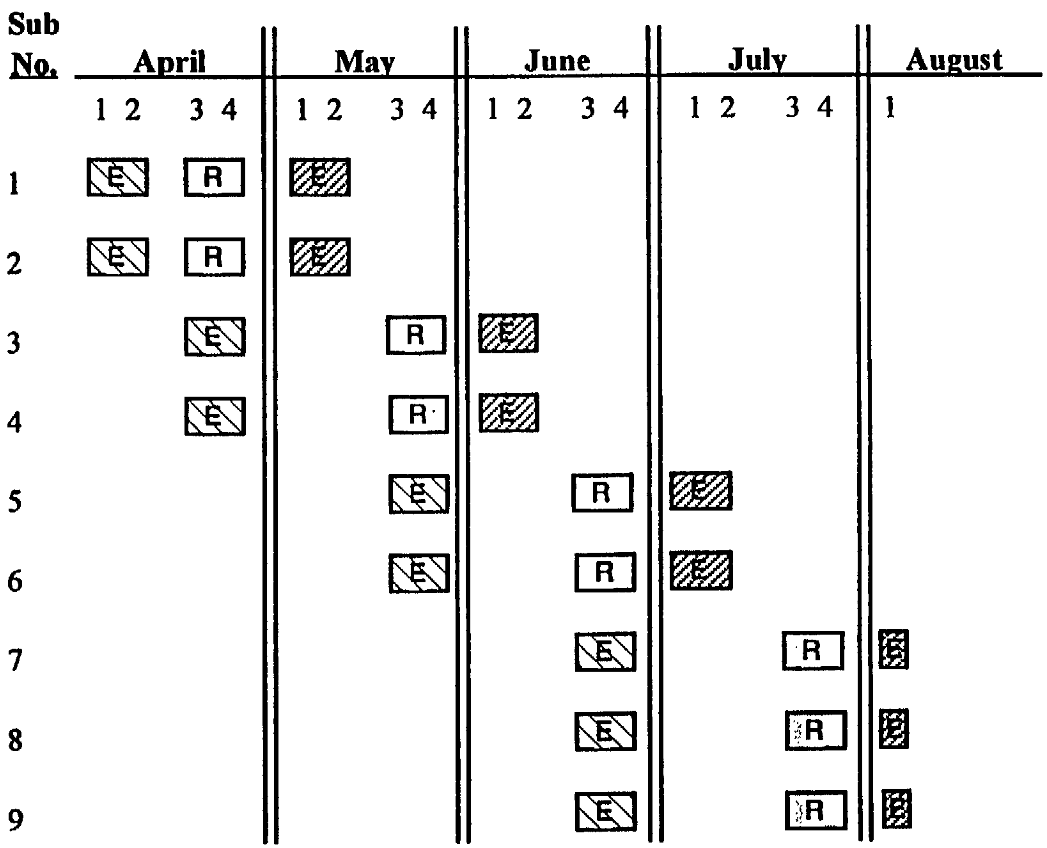


20

Project: VDTV_dependencies.MPP
Date: Mon 12/2/96

Task		Milestone	◆	Rolled Up Task		Rolled Up Progress	
Progress		Summary		Rolled Up Milestone	◇		

VDTV Subsystem Cadence



Subsystem List

Brake-by-Wire
Brake Feel
Front Steer-by-Wire
Rear Steer-by-Wire
Steer Feel
Roll Control
Suspension
Throttle-by-Wire
Throttle Feel

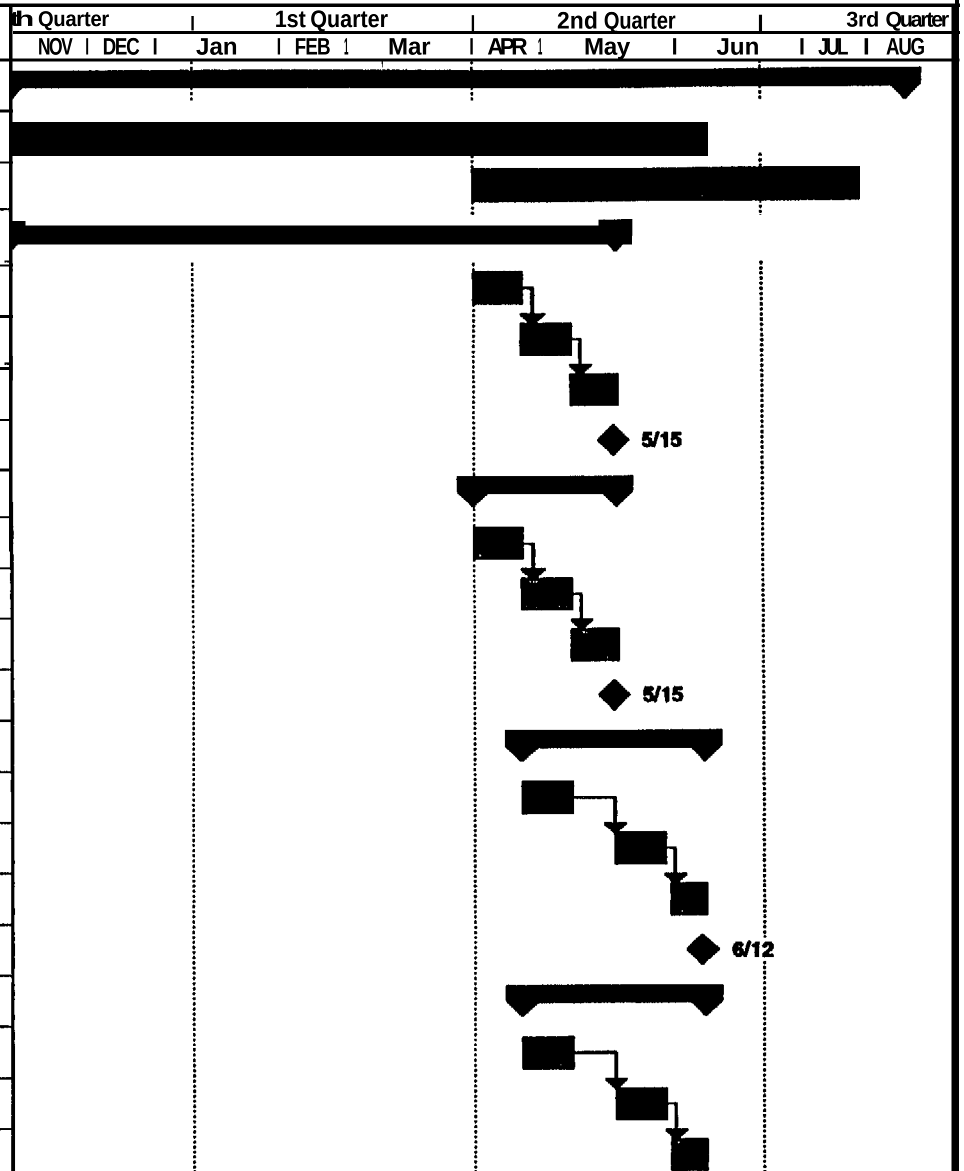
E = ERIM out of vehicle

R = Roush in vehicle

E = ERIM in vehicle

VDTV

ID	TaskName	Duration	Start	Finish	Predecessors
1	4. Acquisition Fabrication d	206d	Fri 11/1/96	Fri 8/15/97	
2	SSYS suppliers design, bi	161d	Fri 1 1/1/96	Fri 6/1 3197	
3	9 ssys proc SIL/Roush	88d	Tue 4/1/97	Thu 7/31/97	
4	#1 Subsystem	140d	Fri 1/1/96	Thu 5/15/97	
11	#1 to SIL	I I d	Tue 4/1/97	Tue 4/1 5/97	
12	#1 to Roursh	I I d	Wed 4/16/97	Wed 4/30/97 1	1
13	#1 back to SIL	I I d	Thu 5/1/97	Thu 5/15/97	12
14	#1 completed	1d	Thu 5/15/97	Thu 5/1 5/97	
15	#2 Subsystem	33d	Tus 4/1/97	Thu 5/15/97	
16	#2 to SIL	11d	Tue 4/1/97	Tue 4/15/97	
17	#2 to Roush	11d	Wed 4/16/97	Wed 4/30/97	16
18	#2 back to SIL	11d	Thu 5/1/97	Thu 5/15/97	17
19	#2 completed	1d	Thu 5/15/97	Thu 5/15/97	
20	**#3 Subsystem**	**42d**	**Wed 4/16/97**	**Thu 6/12/97**	
21	#3 to SIL	11d	Wed 4/16/97	Wed 4/30/97	
22	#3 to Roush	12d	Thu 5/15/97	Fri 5/30/97	21FS+2w
23	#3 back to SIL	9d	Mon 6/2/97	Thu 6/12/97	22
24	#3 completed	1d	Thu 6/12/97	Thu 6/12/97	
25	**#4 Subsystem**	**42d**	**Wed 4/16/97**	**Thu 6/12/97**	
26	#4 to SIL	11d	Wed 4/16/97	Wed 4/30/97	
27	#4 to Roush	12d	Thu 5/15/97	Fri 5/30/97	26FS+2w
28	#4 back to SIL	9d	Mon 6/2/97	Thu 6/12/97	27



22

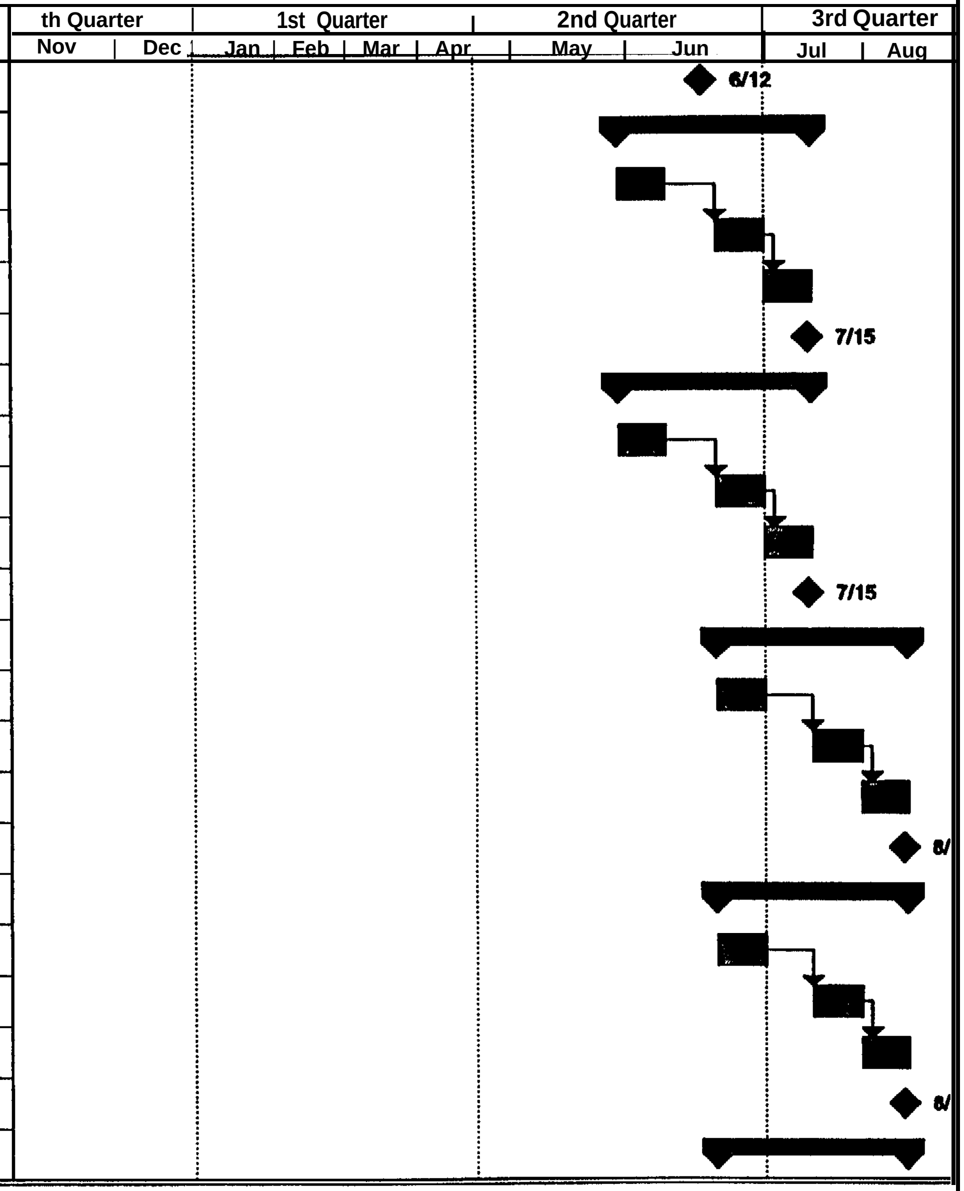
Project subsystem1.MPP
Date: Tue 10/15/96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

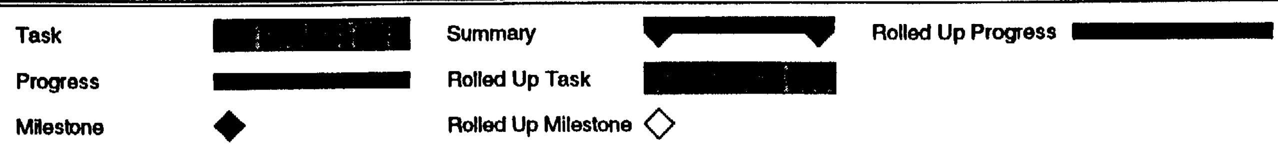
23

VDTV

ID	Task Name	Duration	Start	Finish	Predecessors
29	#4 completed	1d	Thu 6/12I97	Thu 6/I 2/97	
30	#5 Subsystem	43d	Fri 5/16/97	Tue 7/15/97	
31	#5 to SIL	I I d	Fri 5/1 6/97	Fri 5/30/97	
32	#5 to Roush	11d	Mon 6/16/97	Mon 6/30/97	31FS+2w
33	#5 back to SIL	11d	Tue 7/1/97	Tue 7/15/97	32
34	#5 completed	1d	Tue 7/15/97	Tue 7/15/97	
35	**#6 Subsystem**	**43d**	**Fri 5/16/97**	**Tue 7/15/97**	
36	#6 to SIL	11d	Fri 5/16/97	Fri 5/30/97	
37	#6 to Roush	11d	Mon 6/16/97	Mon 6/30/97	36FS+2w
38	#6 back to SIL	11d	Tue 7/1/97	Tue 7/15/97	37
39	#6 completed	1d	Tue 7/15/97	Tue 7/15/97	
40	**#7 Subsystem**	**45d**	**Mon 6/16/97**	**Fri 8/15/97**	
41	#7 to SIL	11d	Mon 6/16/97	Mon 6/30/97	
42	#7 to Roush	12d	Wed 7/16/97	Thu 7/31/97	41
43	#7 back to SIL	11d	Fri 8/1/97	Fri 8/15/97	42
44	#7 completed	1d	Fri 8/15/97	Fri 8/15/97	
45	**#8 Subsystem**	**45d**	**Mon 6/16/97**	**Fri 8/15/97**	
46	#8 to SIL	11d	Mon 6/16/97	Mon 6/30/97	
47	#8 to Roush	12d	Wed 7/16/97	Thu 7/31/97	46
48	#8 back to SIL	11d	Fri 8/1/97	Fri 8/15/97	47
49	#8 completed	1d	Fri 8/15/97	Fri 8/15/97	
50	**#9 Subsystem**	**45d**	**Mon 6/16/97**	**Fri 8/15/97**	

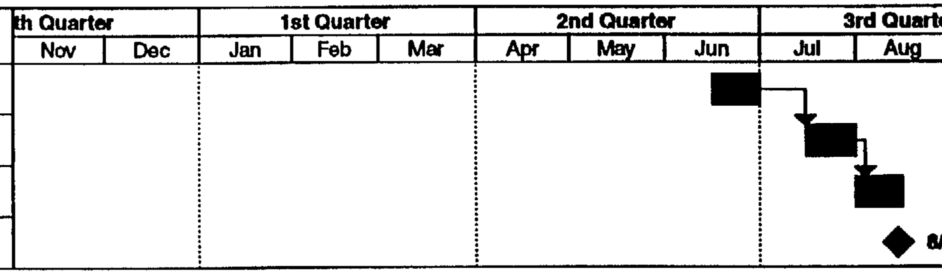


Project: subsystems1.MPP
Date: Tue 10/15/96



VDTV

ID	Task Name	Duration	Start	Finish	Predecessors
51	#9 to SIL	11d	Mon 6/16/97	Mon 6/30/97	
52	#9 to Roush	12d	Wed 7/16/97	Thu 7/31/97	51
53	#9 back to SIL	11d	Fri 8/1/97	Fri 8/15/97	52
54	#9 completed	1d	Fri 8/15/97	Fri 8/15/97	



Project: subsystems1.MPP
Date: Tue 10/15/96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

3. PROGRAM MANAGEMENT

3.1 Organizational Structure

The organizational structure of the VDTV program is shown in Figure 4. ERIM has assumed overall program management responsibility for the program with subcontracts to each member.

The organizational structure of this program allows the Program Manager to obtain all necessary resources to accomplish the program objectives. A group of key program staff personnel support the Program Manager. As the point of central control for the program, the Program Manager interfaces directly with each sub-component supplier and the vehicle integrator, who report directly to him. This reporting allows for direct communication of all technical and administrative issues and provides the Program Manager with positive control and oversight.

3.2 Program Reporting and Authority

The VDTV program resides in the Automotive & Transportation Programs Department of the Information and Materials Applications Laboratory of ERIM

The VDTV Program Manager has single-point control and full authority for all aspects of this program, including contract, cost control, and schedule. The Program Manager holds monthly program reviews with ERIM management to ensure program oversight. He also has full authority to obtain resources to support/perform the contract effort. These resources will be made available from ERIM, team members, or from contract consultants or suppliers. ERIM has all the necessary support staff to provide the Program Manager with all contract support, including accounting, purchasing, personnel, legal, and contract management support. In addition, the Program Manager has full access to the Senior Management of each team member to ensure the effective communication of issues.

3.3 Team Structure and Division of Responsibilities

Team structure is shown in Figure 4. The program is based on a team approach with subcontracts to specific members for hardware or engineering services. In addition, several members will provide hardware or service to the team without cost. This approach is common among the automotive community in that it provides members the ability to use proprietary and non-proprietary items with the protection of intellectual property. The VDTV division of responsibilities is provided in Table 1.

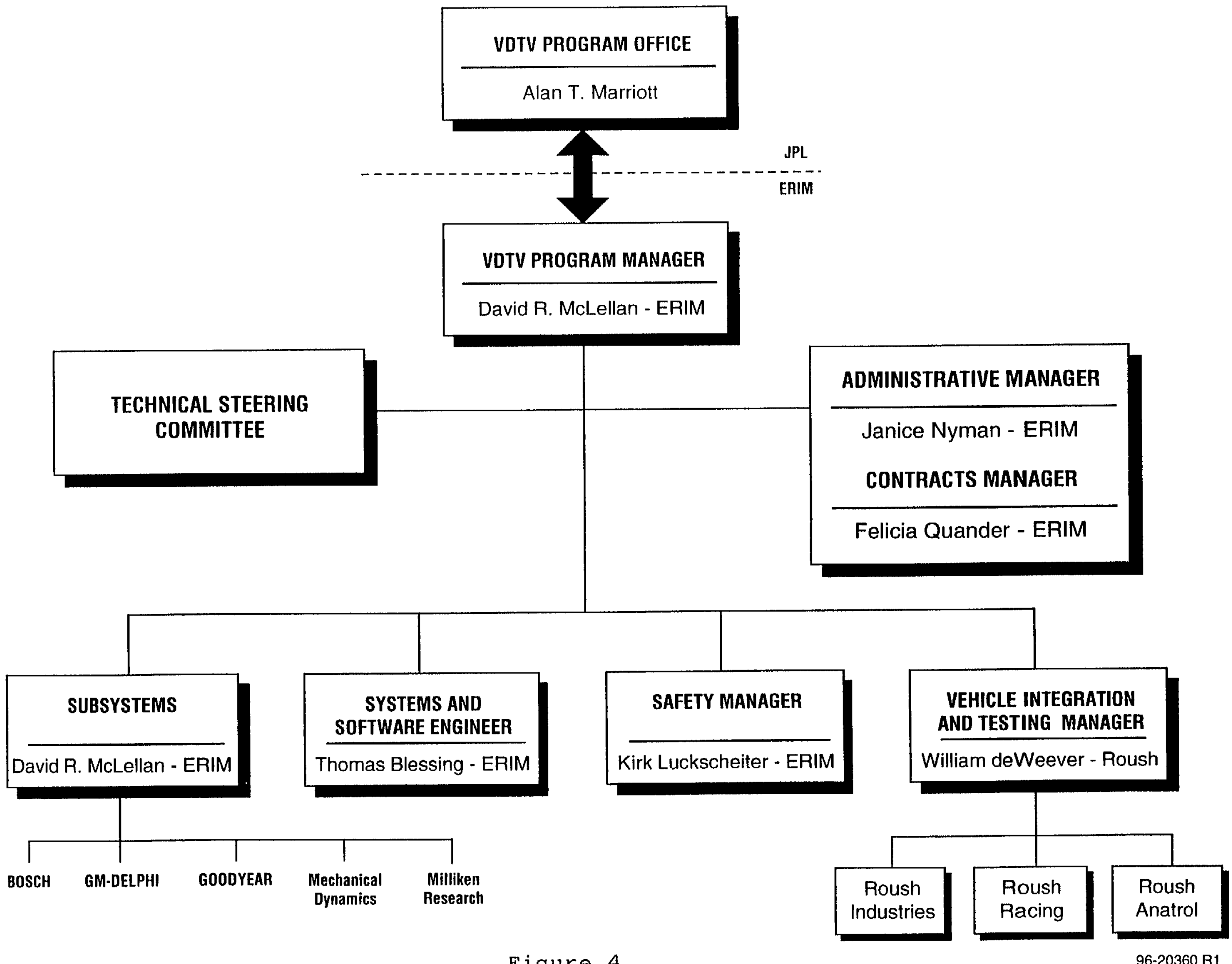


Figure 4
ERIM VDTV Program Organization

Table 1

ERIM VDTV Team Member Responsibilities

Team Member	Responsibilities			
ERIM	• Program Management • TSC Management • Industry Forum	• Systems Engineering & Design • Vehicle-level Software SIL • Testing	• Safety • Data Items • Algorithms	
ROUSH INDUSTRIES	• Prototype Vehicle Design • Fabrication • Hardware Integration	• Safety Hardware • Vehicle Testing	• Trailer • Lateral / Longitudinal Performance	• NVH • Maintenance • Appearance
TRW	• Electric Steer-by-Wire Subsystem (Front / Rear)	• Safety • Steering Feel Subsystem		
GOODYEAR	• All VDTV Tires (Production and Experimental)			
GM-DELPHI	• Human Factors • Electric Brake-by-Wire Subsystem • Brake Algorithm Data • Safety	• Front / Rear Active Roll Bar Hardware • Yaw Control • Traction Control	• Feel Feedback • NVH • Continuously Active Semiactive Suspension	
Mechanical Dynamics and Milliken Research	• Vehicle Dynamic Modeling • Vehicle Performance Data • Subsystem Modeling	• Feel Feedback • Performance Analysis • VDTV Characterization		
BOSCH	• Throttle-by-Wire Subsystem			

3.4 Project Planning

ERIM has in place a structured process for program management. Project planning, control, and execution for the VDTV program are conducted by an experienced team. ERIM has a well defined set of management tools, methodologies, and support staff to assist the Program Manager in the execution of the VDTV program. These processes provide ERIM management and the program Contracting Officer's Technical Representative (COTR) with timely and essential information about technical, financial, and schedule status for review. The program manager is fully supported by an Administrative Manager and a Contracts Manager.

3.5 Program Schedule and Milestones

The VDTV program Gantt chart schedule is shown in Section 2. Based upon our assessment of the technical risk and the maturity of the available subsystems, this program can be accomplished within 20 months. The team will ask for early release of long-lead items to comply with the delivery schedule. The program schedule will also dictate testing location due to climate conditions, since system testing may occur during the winter months of 1997.

3.6 Risk Management

Risk management is an on-going activity. Because the core team for this program is small and composed of members who are well known to one another and have a record of performing very responsibly, risk identification is expected to be a continuous and visible component of each member's contribution to the program. Through their historical performance, team members have demonstrated their abilities to accurately assess identified risks. Concerns to date for this program have focused on software and electronics development and subsystem delivery dates. In both cases, these items are discussed at a minimum on a bi-weekly basis and monitored for any divergence. Consequently, no first-order risks have so far been identified. Should a first-order risk be identified, the Program Manager will assume responsibility for immediately informing the sponsor and presenting a plan for its mitigation.

3.7 Performance Assessment

The Program Manager holds monthly meetings with his team to review the program against the work breakdown structure, schedule, and costs. A component of the program meetings is the regular feedback received from JPL through weekly teleconferences and other communications. The primary metrics for measuring performance are the (1) schedule milestones as recorded on the Microsoft Project schedules and (2) costs incurred as reported through our Resource Planning System (RPSIII), an automated computer system used for project cost planning (pricing), manpower loading, cost plan tracking, and time-phased expenditure tracking. Between milestones, the Program Manager and the small number of team members will rely on each task leader's demonstrated high level of responsibility and good judgment.

3.8 Configuration Management

Configuration management is not expected to be relevant until after the subsystems have been installed and the vehicle is generally assembled, which will occur in the July 1997 time frame.

3.9 Corporate Policy and Procedures

ERIM has 50 years of experience with federal government programs (including NASA, DoD and DOT) and operates in compliance with all FARs. ERIM has corporate processes and procedures in place that guide project management. These procedures define requirements applicable to accounting, purchasing, time reporting, and other administrative functions that are being performed on the VDTV program. The Program Manager is charged with execution of the program within FAR and other applicable regulations. In addition, the Program Manager employs project management tools including ERIM Policy, Procedure, and Guidance (PPG) requirements, the ERIM Program Manager's Guide, the ERIM Cost Estimating Guide, and other applicable documents to guide the project management process.

To ensure timely communication between all program team members, the program will use common software, including Microsoft Project, Microsoft Word, and e-mail.

3.10 Contract Administrafion, Project Review, and Reporting

This team is experienced with contract administration, project review, and reporting functions with regard to both FAR and JPL programs. ERIM currently has over 205 active contracts in place that have similar reporting and contract administration requirements. The Contracts Manager is a key member of the program team and will be responsible for ensuring that all contract items are identified and satisfied. The Administrative Manager will be directly responsible for coordinating all project review and reporting inputs into a delivery schedule.