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16. Abstract
This report describes the procedures to use hardware-in-the-loop (HITL) simulation as an evaluation tool. These procedures were developed at TTI and have been extensively used in numerous research projects. The report describes the requirements for setting the HITL. The report then documents the procedures to set up HITL simulation to evaluate signal controllers features and signal control strategies.

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USER'S GUIDE FOR INSTALLING AND OPERATING TTI'S HARDWARE-IN-THE-LOOP SIMULATION SYSTEM

Hassan A. Charara
Research Scientist

Roelof J. Engelbrecht, P.E.
Associate Research Engineer

Srinivasa R. Sunkari, P.E.
Associate Research Engineer

and

Kevin N. Balke, PhD., P.E.
Center Director
TransLink® Research Center

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TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

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Henry Wickes, TxDOT-TRF

David Mitchell, TxDOT-TRF

David Danze, TxDOT-TRF

Kirk Barnes, TxDOT- Bryan District

Wade Odell, TxDOT - RTI

The research team would also like to acknowledge a special member of the research team – Roelof Engelbrecht, P.E. – who tragically passed away after a long illness during the course of this project. Roelof was the principal developer behind TTI's hardware-in-the-loop capabilities and was a leader in the industry in this arena. Most importantly, Roelof was a friend and an inspiration. We miss him greatly.

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OVERVIEW OF THE TTI HARDWARE-in-the-LOOP SYSTEM

Hardware-in-the-loop simulation is a new technique in traffic engineering, although it has been used extensively in the past in the aerospace and defense industries. Typically, a system consisting of a number of components is simulated. Usually, most of the system components are emulated in software, but one or more components are the real components that will be used in the actual system—the "hardware in the loop."

Hardware-in-the-loop traffic simulation uses real traffic signal controller hardware to control simulated traffic. This simulation is done by interfacing a traffic simulation model with one or more traffic signal controllers. The traffic simulation model is a computer model of the interaction of vehicles with each other, vehicles with the roadway, and vehicles with the traffic control system. In most traffic simulation models the traffic control system is emulated in software, but with hardware-in-the-loop simulation the emulated traffic control system is replaced with real traffic control hardware.

While the simulation runs, simulated vehicles drive over simulated detectors, generating simulated detector calls. These simulated detector calls are sent to the real controller hardware, resulting in phase changes in the controller. These phase changes in the real hardware are sent back to the simulation, specifically to the simulated traffic signals. The simulated vehicles then react to the simulated signals, for example by stopping when the signal turns red. Figure 1 illustrates the data flow in the hardware-in the-loop setup.

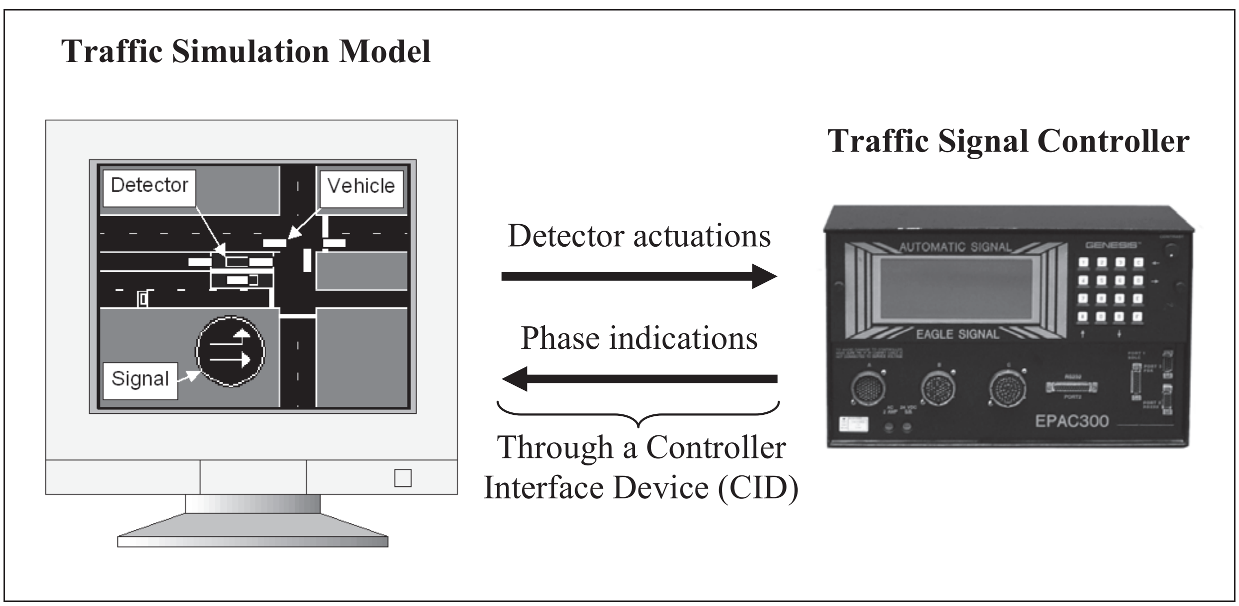


Figure 1. Flow of Data during a Hardware-in-the-Loop Simulation.

Using traffic simulation has many advantages:

- It is less costly than field studies and results are obtained quicker.
- It yields extensive measures of effectiveness, allowing for more comprehensive comparisons of alternative operating strategies.
- Traffic operations are not disrupted.
- Physical changes to the road network may be made.
- It is the only way to analyze future demand.
- The user has complete control over all variables, for example traffic demand.

Combining traffic simulation with hardware-in-the-loop simulation yields additional advantages:

- It adds realism to the simulation, since real traffic signal controllers are used.
- Some controller functions cannot be emulated in software, especially advanced features such as preempts and some coordination modes.
- The user can set up and test a controller in the lab with hardware-in-the-loop simulation and then deploy it directly in the field.

The TransLink® Laboratory is a leader in the field of hardware-in-the-loop traffic simulation. A Distributed Architecture for the Simulation, Control, and Optimization of Surface Transportation has been developed at the lab to facilitate hardware-in-the-loop traffic simulation of large, multi-modal transportation networks. The architecture allows the use of different simulation models and any type of traffic signal controller, including ramp meter controllers. Transferring these capabilities to TxDOT will allow the engineers and technicians to test hardware and their capabilities as well as evaluate and fine-tune strategies developed to improve traffic operations without deploying them in the field, saving a lot of resources as well as improving safety. This document describes the installation and use of the TTI Hardware-in-the-Loop (HITL) Simulation System with Traffic Software Integrated System (TSIS) version 5.0 and later. An appropriate version of TSIS should be installed on the computer before continuing with these instructions.

What's in This Document

This document provides:

- Software and hardware requirements to run the TTI HITL simulation software,
- Installation of the software needed to run the TTI HITL simulation software,
- Connecting and testing the HITL hardware components,
- Testing the TTI HITL software with TSIS software, and
- Using the TTI HITL software with TSIS software.

SOFTWARE AND HARDWARE REQUIREMENTS

To use the TTI HITL simulation software, you need:

- The software application Traffic Software Integrated System (TSIS) version 5.0 or 5.1. The TSIS software is provided by the Federal Highway Administration and is available from the Center for Microcomputers in Transportation (McTRANS) at the following address:

  McTRANS Center
  PO Box 116585
  Gainesville, FL 32611-6585
  Phone: (325) 392-0378
  Toll Free: 1-800-226-1013
  http://mctrans.ce.ufl.edu/

- The TTI HITL Simulation Software Installation CD.

- A TS1 or TS2 traffic controller and a TS1 or TS2 controller interface device (CID). If you are using an Eagle or Naztec TS2 controller, you need to use a TS2 CID (Naztec or Eagle) with it. On the other hand, if you are using a TS1 traffic controller (Eagle or Naztec), you need to use a McCain TS1 CID with it.

- A TS2 cable and an RS-232 cable that usually come with the TS2 CID order.

- A personal computer (PC) with a minimum of 1 Giga Hz central processing unit (CPU), 512 mega bytes (MB) of random access memory (RAM), and running one of Microsoft's operating systems: Windows NT, Windows 2000, or Windows XP.

INSTALLING THE SOFTWARE

The TSIS version 5.0 or 5.1 software and the TTI HITL simulation software need to be installed on a machine before the user can run the TTI HITL system. You must configure the TSIS software properly to run with the TTI HITL software. Follow these steps in the order they are listed to install the needed software.

Installing TSIS Version 5.0 or 5.1

To install the TSIS version 5.0 or 5.1 software, insert the TSIS software CD into your CD-ROM drive and follow the installation directions provided with the TSIS software CD. The TSIS software installation requires a user with administrative privileges on the machine where the software is being installed.

If you are installing TSIS version 5.1 software, you must start it once and close it for the TTI HITL software installation to work properly in the next step. If TSIS version 5.1 was not started once and closed before starting the TTI HITL installation program, the following message (Figure 2) will be displayed by the TTI HITL installation program to remind the installer to do that.

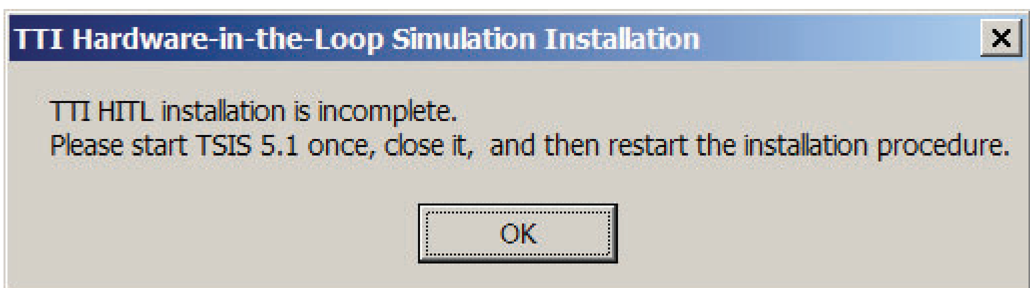


Figure 2. HITL Installation.

Installing TTI HITL Simulation Software and Configuring TSIS

Once the TSIS software installation is complete, the TTI HITL simulation software installation can be started. The TTI HITL software installation includes two steps: 1) TTI HITL software installation, and 2) TSIS software configuration to work with the TTI HITL software. To proceed with the TTI HITL software installation, insert the TTI HITL simulation software installation CD into your CD-ROM drive.

Step 1. TTI HITL Software Installation

This step includes the installation of the TTI HITL software in the default subdirectory "C:\Program Files\Hardware-in-the-Loop" on your machine. The TTI HITL installation program checks first if the TTI HITL software is already installed on the machine.

If the HITL software is not already installed on the machine, follow the directions in the following screens to install the TTI HITL software.

Click "Next" button (Figure 3) to proceed with the TTI HITL simulation software installation.

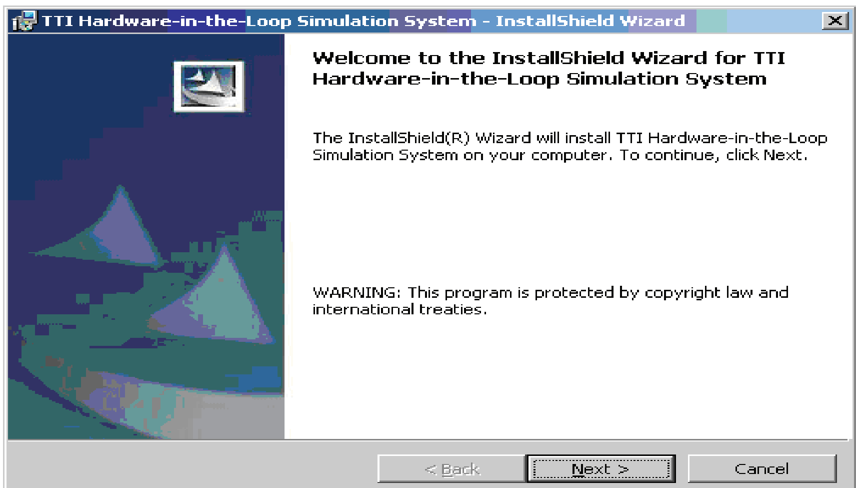


Figure 3. Install Shield Wizard Welcome Screen.

Click "Cancel" if you want to stop the TTI HITL simulation software installation.

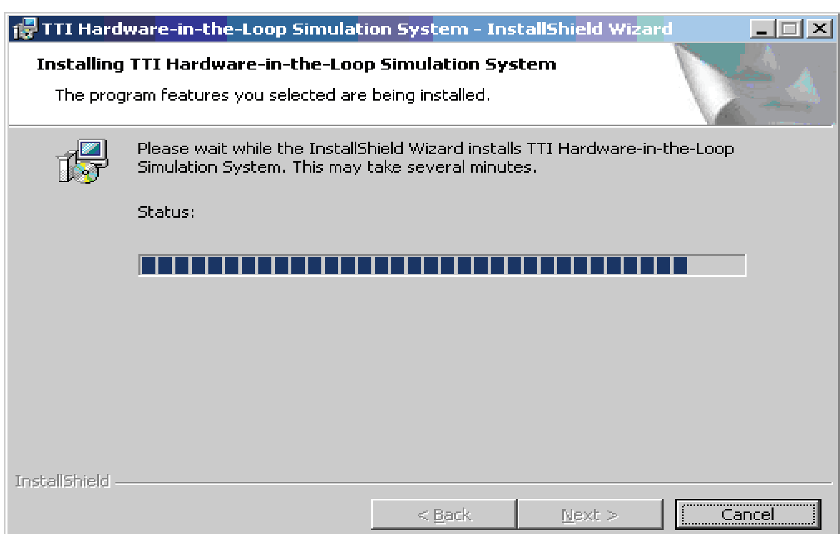


Figure 4. Install Shield Wizard Status Screen.

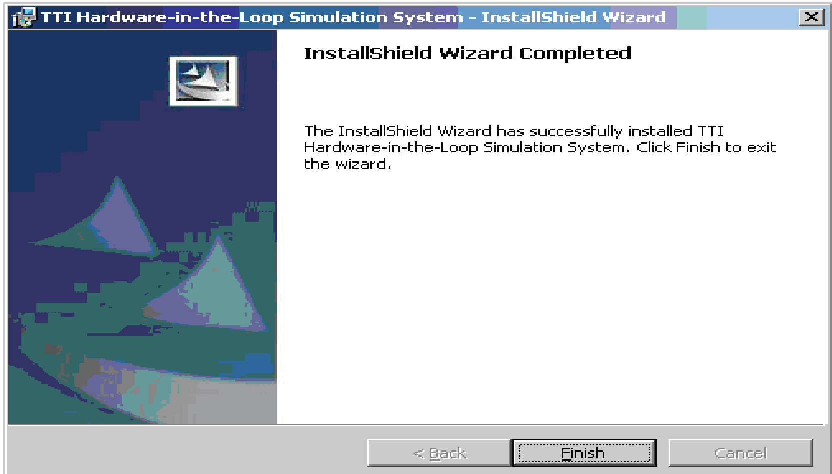


Figure 5. InstallShield Wizard Completed Screen.

Click "Finish" to complete the TTI HITL simulation software installation and proceed to step 2.

Step 2. TSIS Configuration

This step includes the configuration of the TSIS software by adding the "TTI Hardware-in-the-Loop Simulation" and the "Concurrent TRAFVU" tools to the TSIS "Tools" menu. The TTI HITL installation program checks first if the TSIS software is installed on the machine or not.

If TSIS is not already installed on the machine, the installation cannot proceed and the following message (Figure 6) is displayed to alert you that the installation is incomplete and you need to install the TSIS software and then retry to reinstall the TTI HITL software.

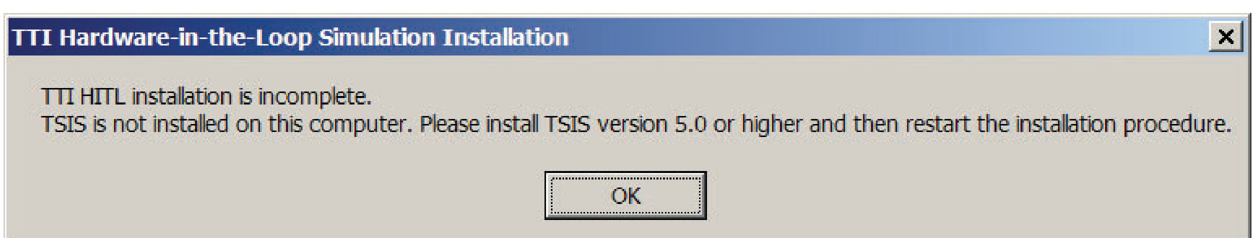


Figure 6. Incomplete Installation Message.

If the TSIS software is already installed on the local machine, the TTI HITL installation checks if the TSIS software is already configured to run with the TTI HITL software or not.

If the TSIS software is already configured, the following message (Figure 7) is displayed to inform you that the TTI HITL installation is complete.

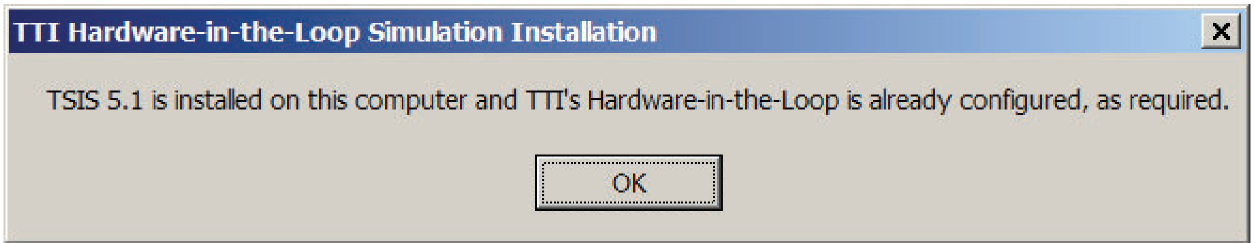


Figure 7. Installation Complete Message.

If the TSIS software is not configured to run with the TTI HITL software, the following message (Figure 8) is displayed. Click “Yes” to proceed.

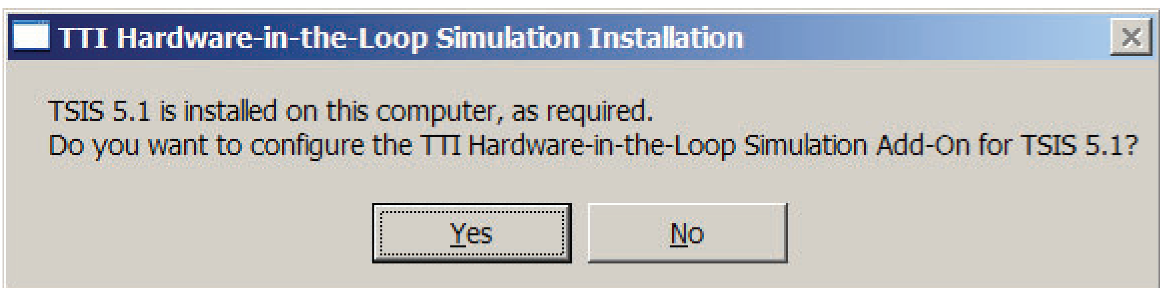


Figure 8. Configuration Message.

Click the “OK” button (Figure 9) to complete the TTI HITL installation and TSIS software configuration.

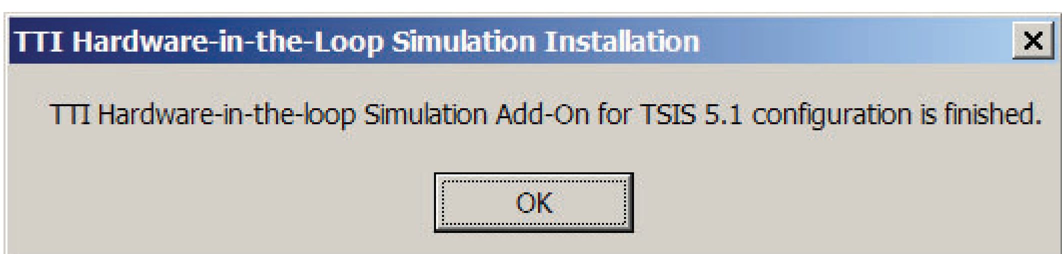


Figure 9. Configuration Complete Message.

CONNECTING AND TESTING HARDWARE COMPONENTS

The essential hardware components needed to run the TTI HITL simulation software include a personal computer, a TS1 or TS2 traffic signal controller, a TS1 or TS2 controller interface device (CID), a TS2 cable, and an RS-232 cable. The TS2 cable and the RS-232 cable are usually provided with the TS2 CID. A TS2 traffic controller is used with a TS2 CID and a TS1 traffic controller is used with a TS1 CID. Figure 10 illustrates a typical HITL setup.

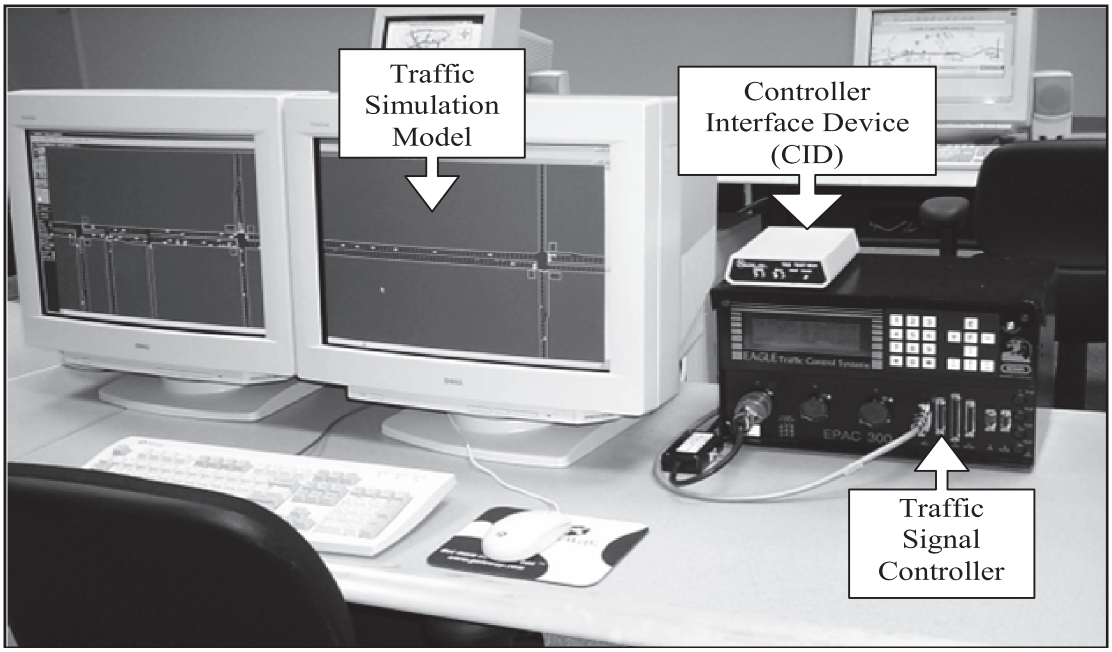


Figure 10. Typical Hardware-in-the-Loop Simulation Setup.

Connecting and testing the TTI HITL system hardware components consists of three steps:

Step 1. Connecting the Hardware Components

A. Connect the TS2 traffic signal controller to the TS2 CID via a TS2 cable.
   - Plug one end of the TS2 cable into the SDLC port on the controller as illustrated in Figure 11.

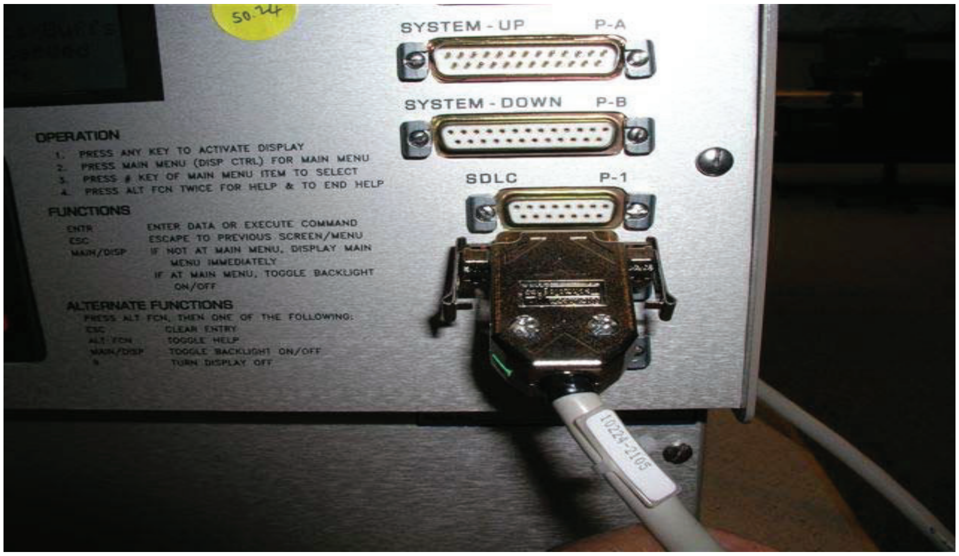


Figure 11. TS2 Connection to the Signal Controller.

- Plug the other end of the TS2 cable into the TS2 port at the back of the TS2 CID as illustrated in Figure 12.

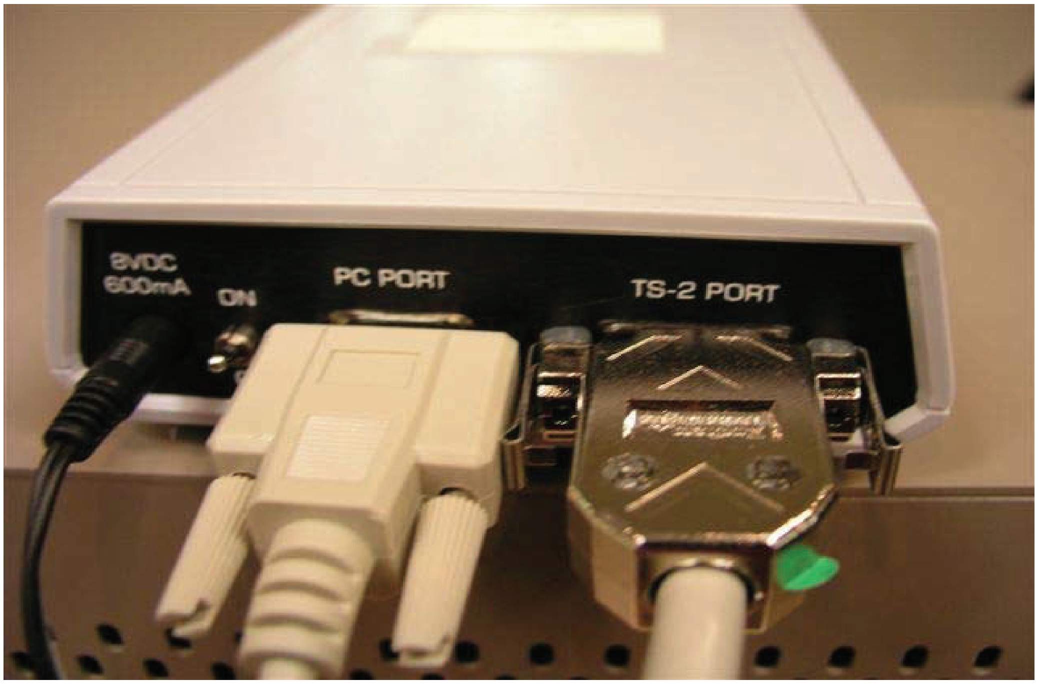


Figure 12. Connection of TS2 Cable and RS-232 Cable to the CID.

B. Connect the TS2 CID with the personal computer using an RS-232 cable.
   - Plug one end of the RS-232 cable into the PC port behind the TS2 CID as illustrated in Figure 12.

- Plug the other end of the RS-232 cable to the computer's RS-232 socket as illustrated in Figure 13.

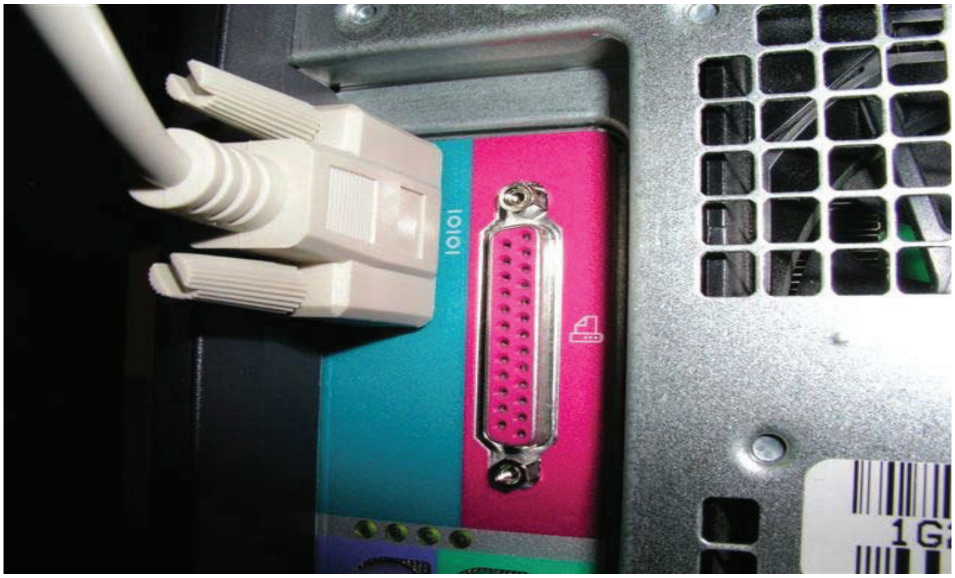


Figure 13. Connection of the RS-232 Cable to the Computer.

Step 2. Configuring the TS2 Traffic Controller

A. If you are using a TS2 Naztec traffic controller, power on the controller and select the following options from the controller's main menu (MM): "MM → 1. Controller → 3. Chan SDLC → 7. SDLC Devcs" to go to the SDLC devices screen as seen in Figure 14.

```
SDLC Device: Term/Fac Detector MMU Diag
      BIU #: 12345678 12345678
Dev. Present XX...... XX......  .   .
Peer-to-Peer ........ ........  .   .
  Msg 0 Enbl OFF
```

Figure 14. SDLC Devices Screen.

Verify that there is an "X" in the Bus Interface Unit (BIUs) columns 1 and 2 under the "Term/Fac" heading on the screen (Figure 14). Also, verify that there is an "X" in the BIUs 1 and 2 columns under the "Detector" heading on the screen. In order to place an "X" in one of the columns, move the cursor using the arrow keys on the front keypad to the desired location and then select any number key from the controller's front keypad. To remove an "X" in one of the columns, move the cursor to the desired location and press any number key on the keypad. Once "Xs" are placed in all the desired columns, press the "Esc" key to go back to the MM, and the Naztec controller configuration is done.

B. If you are using an Eagle TS2 traffic controller, power on the controller and select the following options from the controller's main menu (MM): MM → 4. Unit Data → 7. Port 1 Data.

In the "Port 1 Data" screen place a 1 under the "Pres" column in the following BIU rows:

T&F BIU # 1 TS2
T&F BIU # 2 TS2
DET BIU # 1 TS2
DET BIU # 2 TS2
MalFunction UNIT

Step 3. Perform Basic Connectivity Test

Once you have connected the TTI HITL system hardware components and configured the controller properly, power on the TS2 CID and the PC where the TTI HITL simulation software is installed and run the following tests:

A. If you are using a TS2 traffic controller with an Eagle TS2 CID, select the following options from the START menu on the PC:

START / All Programs / Hardware-in-the-Loop / EagleTS2Interface

Make sure the following screen (Figure 15) is displayed and go to step C.

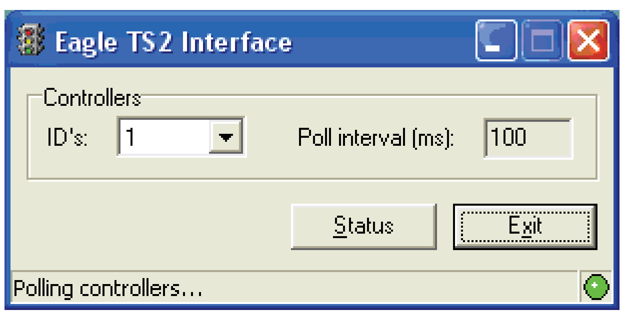


Figure 15. HITL Eagle TS2 Interface.

B. If you are using a TS2 traffic controller with a Naztec TS2 CID, select the following options from the START menu on the PC:

START / All Programs / Hardware-in-the-Loop / NaztecTS2Interface

Make sure the following screen (Figure 16) is displayed and go to step C.

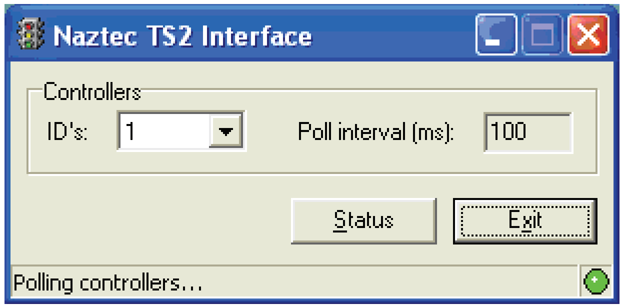


Figure 16. HITL Naztec TS2 Interface.

C. Click on the "Status" button on the Eagle or Naztec TS2 interface screen and the following screen (Figure 17) will be displayed.

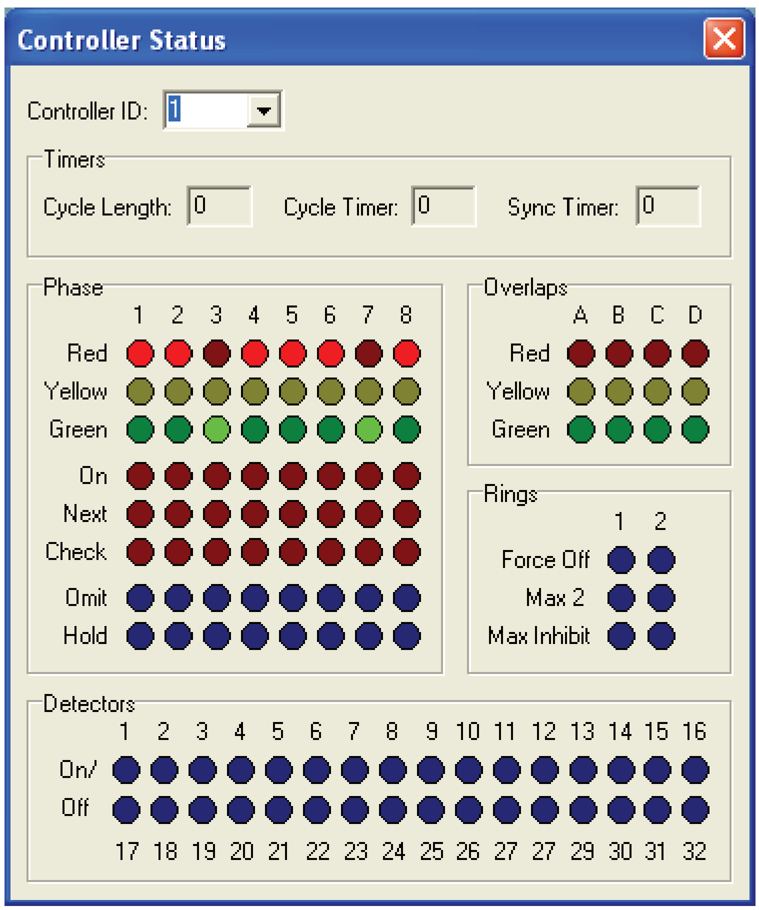


Figure 17. HITL Controller Status.

If the phase status indications green, yellow and red changes in the Controller Status window display match the phase status changes in the controller, then the TTI HITL software and hardware components are working properly. Otherwise, verify that the previous steps were done properly and try again. If the system does not work properly as described, please contact TTI at the phone numbers provided at the end of the manual.

TESTING TTI HITL SOFTWARE WITH TSIS SOFTWARE

The following steps describe the process of testing the hardware and software components of the TTI HITL system with the TSIS software by running an example provided on the TTI HITL installation CD.

A. Copy the directory “CORSIM-HITL” found on the TTI HITL software installation CD to your PC’s hard disk. It is recommended to copy the “CORSIM-HITL” directory into the “TSIS Projects” directory on your local hard drive.

B. Start the TTI HITL software as described in “Step 3. Perform Basic Connectivity Test” of the previous section.

C. Start the TSIS software.

D. Select “File / Open Project” from the TSIS main menu. The “Open Project File” (Figure 18) window appears on the desktop.

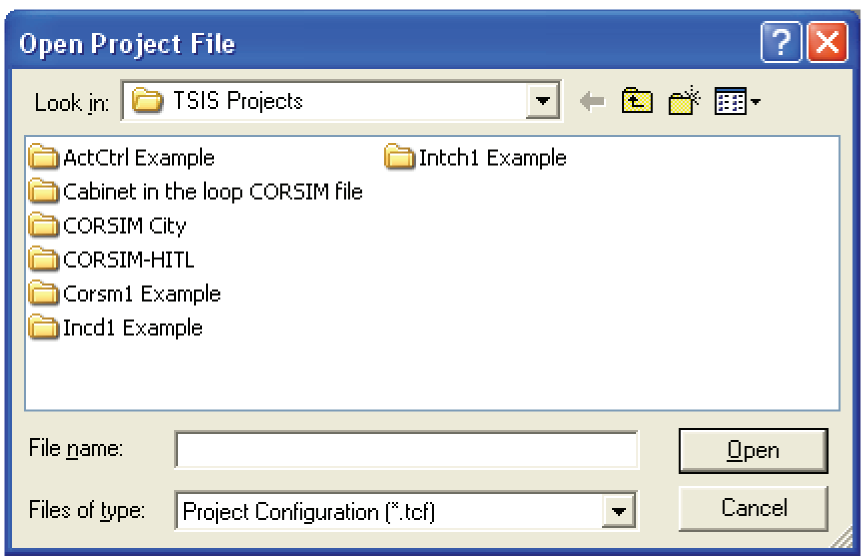


Figure 18. TSIS Open Project File Window.

E. Browse to the “CORSIM-HITL” directory on the hard disk, open the directory, select the “Example.tcf” project file, and click the “Open” button in the “Open Project File” window (Figure 18). The “Example.tcf” TSIS project will be opened in the TSIS projects window (Figure 19). Click on the “+” sign next to the “Example” project name to expand the project contents, then Click on the + sign next to the “Example” case to expand the case contents.

F. Double click on the “Simulation (*.trf)” entry under the “Example” project to select it and then click on the  icon in the TSIS toolbar to start the TTI Hardware-in-the-Loop simulation as shown in Figure 19. The simulation window will be opened in TSIS (Figure 20).

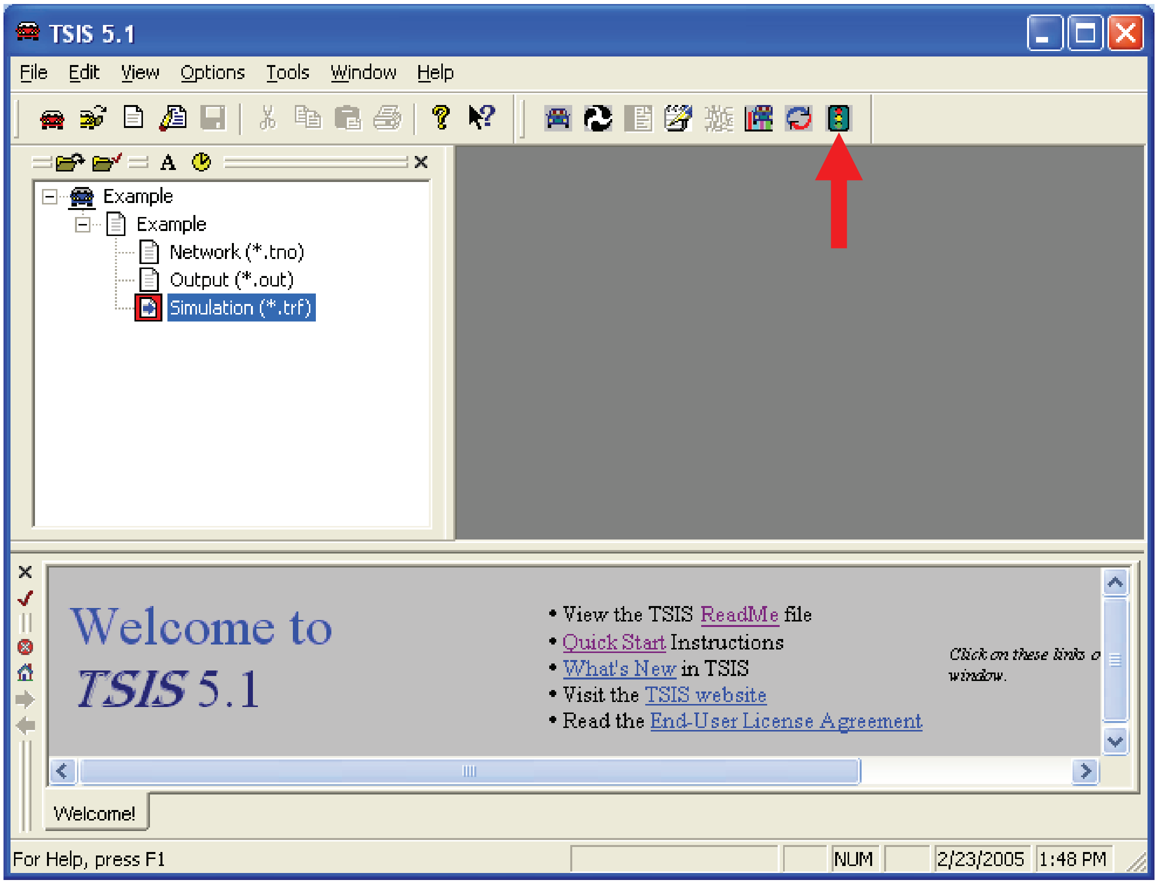


Figure 19. TSIS Project Files Screen.

G. Click on the "Start" button pointed to by the red arrow in Figure 20 to start the simulation. The simulation will be started as in Figure 21.

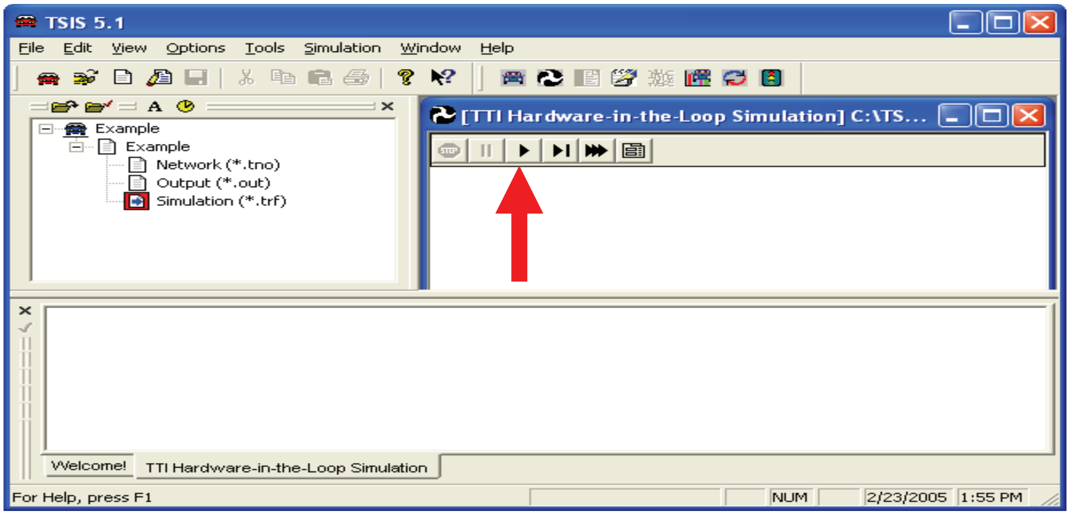


Figure 20. Starting TSIS Simulation Display.

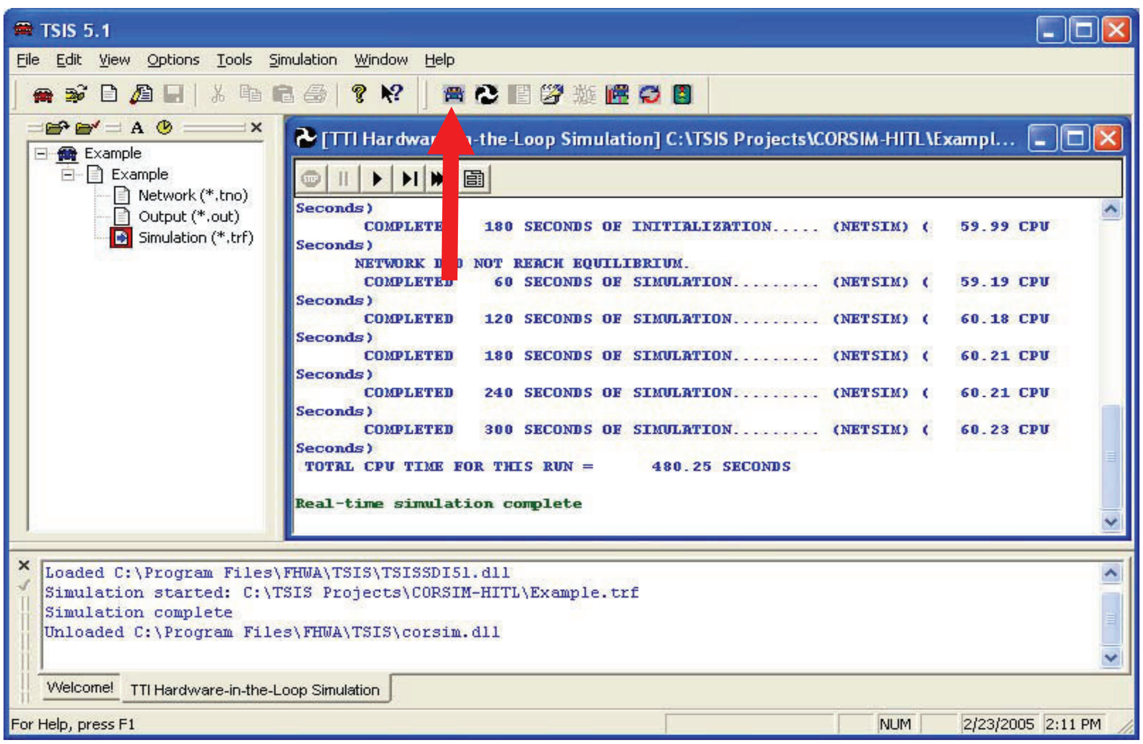


Figure 21. TSIS Simulation Run Display.

H. Wait until the "Initialization" message appears in the simulation window and then click on the "Concurrent TRAFVU" icon on the TSIS toolbar pointed to by the red arrow as shown in Figure 21. The TRAFVU application will be started (Figure 22).

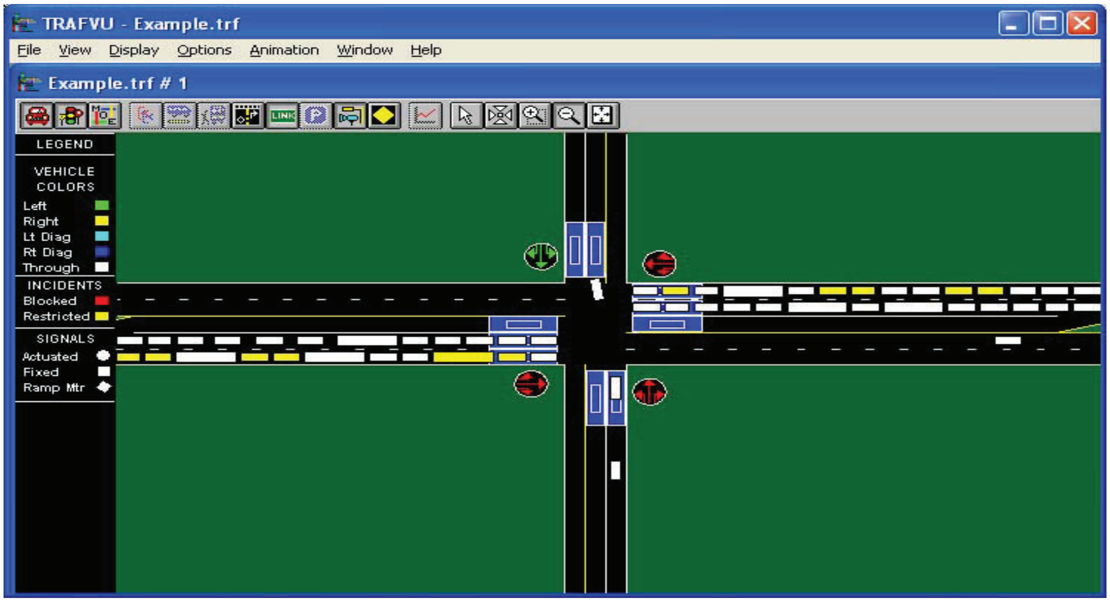


Figure 22. TRAFVU Simulation Display.

I. Select "Animation / Play" from the TRAFVU main menu to play the simulation file. This commences the animation, which is a very valuable tool to evaluate various control strategies visually.

USING THE TTI HITL SOFTWARE WITH TSIS SOFTWARE

To be able to use the TSIS software in conjunction with the TTI HITL software, a few changes must be made to the CORSIM network file (TRF), and you must create a simulation data interface (SDI) file that has the same name as the simulation input (TRF) file. The following sections provide more information about how to create the SDI file and the changes to be made to the TRF file.

CORSIM TRF File Setup

Code the CORSIM network as usual. It does not matter whether you code the signals as fixed time (card type 35 and 36) or actuated (card type 43), since the external real-time control will take over the signal operation. However, you must add a 2 or 3 in column 77 of card type 36 and 43 to indicate that you want to have external (i.e. real-time) control at the approach. A 2 in column 77 indicates that the node will not be modeled as a micronode, while a 3 indicates that the node will be modeled as a micronode.

The hardware-in-the-loop simulation system uses surveillance detectors (card type 42) to get detector actuations from CORSIM. Using card type 42, add surveillance detectors in all the detector positions, even if you used card type 46 to code other detectors for actuated control.
Give each surveillance detector a unique station number in columns 23 - 26. (Remember that surveillance detectors can extend over multiple lanes.) The detector station number is used by the send hardware-in-the-simulation system to identify individual detectors.

SDI File Creation

Since CORSIM knows nothing about controller phases, you have to tell it which turning movement is controlled by which controller phase. This is done with a simulation data interface (SDI) file. The SDI file has the same name as your simulation input (TRF) file, but uses a SDI extension. Both the TRF and SDI files must reside in the same directory (folder). For example, if your simulation input file is c:\tsisproj\proj1\test.trf, the SDI file must be c:\tsisproj\proj1\test.sdi. You can create the SDI file with any text editor, for example Windows Notepad. The format of the SDI file is shown below (Figure 23).

```
* from   to    turn  type contlr phases
   3      1      T   Prot    1   P2
   3      1      R   Prot    1   P2
   4      1      L   Prot    1   P4
   4      1      T   Prot    1   P4
   4      1      R   Prot    1   P4
   2      1      L   P+P     1   P1   O1
   2      1      T   Prot    1   O1
   5      2      T   Prot    1   P6
   5      2      R   Prot    1   P6
   6      2      L   Prot    1   P8
   6      2      T   Prot    1   P8
   6      2      R   Prot    1   P8
   1      2      L   Prot    1   P5
   1      2      T   Prot    1   O2
   9      3      T   Prot    2   P2
   1      3      T   Prot    2   P6
   1      3      L   Prot    2   P1
   10     3      L   Prot    2   P8
   10     3      R   Prot    2   P8
```

Figure 23. SDI File Format.

The first line is a comment, indicated by the * in the first column. Subsequent lines all have the same format and refer to the turning movements controlled by the external controller. The position of the items on the line is not important, but items should be in order and separated by one or more spaces or tabs.

The first item on the line is the upstream node number of the link from which the turn is made. The second item is the downstream node number of the link, i.e., the node number at which the turn is made. The third item is the type of turn, indicated by an L for left turns, R for right turns, T for throughs, and D for diagonal turns. The fourth item is the movement type, which can be "Prot" for protected turns, "Perm" for permitted turns, and "P+P" for protected and permitted (or permitted and protected) turns. The fifth item is the ID number of the controller used to control the turn. Each controller in the network must have its own unique ID number, starting from 1 and numbered sequentially. The last two entries on the line are the phase and/or overlap numbers that are used to control the turn. Phase numbers are preceded with a "P" and overlap numbers are preceded by an "O". For protected and permitted (P+P) phasing, you must enter two phases and/or overlaps. For P+P phasing the first phase/overlap should be the protected phase, and the second should be the permitted phase. The controller and phase/overlap numbers are used to get the phases status from the real controller(s) in the hardware-in-the-simulation system.

TTI HITL CID Interface

Configuration

There are three controller interfaces provided with the TTI HITL simulation system: `EagleTS2Interface.exe` for the Eagle TS2-CID, `NaztecTS2Interface.exe` for the Naztec TS2-CID, and NiattInterface.exe for the McCain TS1 CID.

The interfaces can be configured through a configuration file. The Eagle TS2-CID interface is configured through the `EagleTS2Interface.ini` file, the Naztec TS2-CID interface is configured through the `NaztecTS2Interface.ini` file, and McCain TS1 interface is configured through the NiattInterface.ini file. These `.ini` files have the following format (Figure 24):

```
[Client-Server]
CIDIniFile = .\EagleCID.ini
CIDPollingInterval = 100
CIDLatency = 10

NumberOfControllers = 1

[Controller 1]
ControllerID = 1
NumberOfPhases = 8
NumberOfRings = 2
NumberOfOverlaps = 4
NumberOfPreempts = 6
NumberOfDetectors = 64
NumberOfMappedDetectors = 0
MappedDetector[1] = SimulationDetector[1]->RealDetector[5]
MappedDetector[2] = SimulationDetector[2]->RealDetector[2]
MappedDetector[3] = SimulationDetector[3]->RealDetector[2]
MappedDetector[4] = SimulationDetector[4]->RealDetector[4]
MappedDetector[5] = SimulationDetector[5]->RealDetector[4]
MappedDetector[6] = SimulationDetector[6]->RealDetector[4]
MappedDetector[7] = SimulationDetector[7]->RealDetector[1]
MappedDetector[8] = SimulationDetector[8]->RealDetector[6]
MappedDetector[9] = SimulationDetector[9]->RealDetector[6]
MappedDetector[10] = SimulationDetector[10]->RealDetector[3]
MappedDetector[11] = SimulationDetector[11]->RealDetector[3]
MappedDetector[12] = SimulationDetector[12]->RealDetector[3]

NumberOfPreemptDetectors = 1
PreemptDetector[1] = SimulationDetector[20]->RealDetector[1]
PreemptDetector[2] = SimulationDetector[21]->RealDetector[2]

NumberOfPedestrianDetectors = 8
PedestrianDetector[1] = SimulationDetector[12]->RealDetector[2]
PedestrianDetector[2] = SimulationDetector[13]->RealDetector[2]
PedestrianDetector[3] = SimulationDetector[14]->RealDetector[4]
PedestrianDetector[4] = SimulationDetector[15]->RealDetector[4]
PedestrianDetector[5] = SimulationDetector[16]->RealDetector[6]
PedestrianDetector[6] = SimulationDetector[17]->RealDetector[6]
PedestrianDetector[7] = SimulationDetector[18]->RealDetector[8]
PedestrianDetector[8] = SimulationDetector[19]->RealDetector[8]
```

Figure 24. INI File Format.

`CIDIniFile` is the name of the file describing the CID interface configuration. `CIDPollingInterval` is the time (in milliseconds) between successive polls of the controller by the interface. A value of 100 milliseconds is usually sufficient. `CIDLatency` is the time (in milliseconds) that the interface waits for the controller to react after sending data to it. A default value of 10 is recommended.

The value of `NumberOfControllers` is the number of controllers in the CORSIM network that is controlled by the hardware-in-the-loop simulation system. For each of these controllers there

should be a heading in the `server.ini` with the format `[Controller X]`, where `X` ranges from 1 to the value of `NumberOfControllers`. Under each of the headings, a controller will be described as follows:
The value of `ControllerID` specifies the ID number of the controller, and should correspond to the controller ID number in the SDI file. The `ControllerID` should be unique.

The `interface.ini` file provides the opportunity to renumber and "wire together" detectors, similar to what can be done on the controller cabinet back panel. This is done by mapping detectors from the detector station number specified on card type 42 in the simulation input (TRF) file to the real controller detector numbers. If a detector is not mapped, the detector number is assumed to be the same in the simulation file and the real controller. The value of `NumberOfMappedDetectors` specifies the number of detectors that are mapped. If `NumberOfMappedDetectors` is not specified, the value is assumed to be zero and no detectors are mapped.

Each mapped detector is specified on one line with the format:

```
MappedDetector[X] = SimulationDetector[Y]->RealDetector[Z]
```

Where `X` is an index that ranges from 1 to the value of `NumberOfMappedDetectors`. `Y` is the detector station number specified on card type 42 in the simulation input (TRF) file. `Z` is the real controller detector number, i.e., that number of the controller detector input. By specifying the same real controller detector number for multiple simulation detectors (e.g., simulation detectors 2 and 3 of controller 1 in the example `.ini` file), the simulation detectors are "wired together" and an actuation on any one of these simulation detectors will actuate the real detector.

The `interface.ini` file also provides the opportunity to specify certain simulation detectors as preempt detectors. The value of `NumberOfPreemptDetectors` specifies the number of preempt detectors. If `NumberOfPreemptDetectors` is not specified, the value is assumed to be zero. Each preempt detector is specified on one line with the format:

```
PreemptDetector[P] = SimulationDetector[Q]->RealDetector[R]
```

Where `P` is an index that ranges from 1 to the value of `NumberOfPreemptDetectors`. `Q` is the detector station number as specified on card type 42 in the simulation input (TRF) file. `R` is the real controller preempt detector number. Preempt detectors can be "wired together" in the same way as other detectors by specifying the same real controller preempt detector number for multiple simulation detectors.

The values of `NumberOfPhases`, `NumberOfOverlaps`, `NumberOfDetectors`, `NumberOfRings`, and `NumberOfPreempts` gives the number of phases, overlaps, vehicle detectors, rings, and preempts that should be exchanged between the controller and the client.

Running the Interface

The simulation interface can be started by executing `EagleTS2Interface.exe`, `NaztecTS2Interface.exe`, or `NiattInterface.exe` after editing the configuration files. This will display the following window (Figure 25):

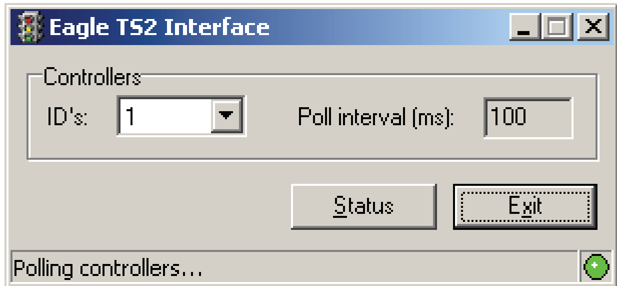


Figure 25. Eagle TS2 Interface.

The interface displays a combination subset of the client and server windows, as described in the preceding two sections.

Running the Snooper

The Snooper utility (`snooper.exe`) allows you to view and change data in the simulation data interface (Figure 26).

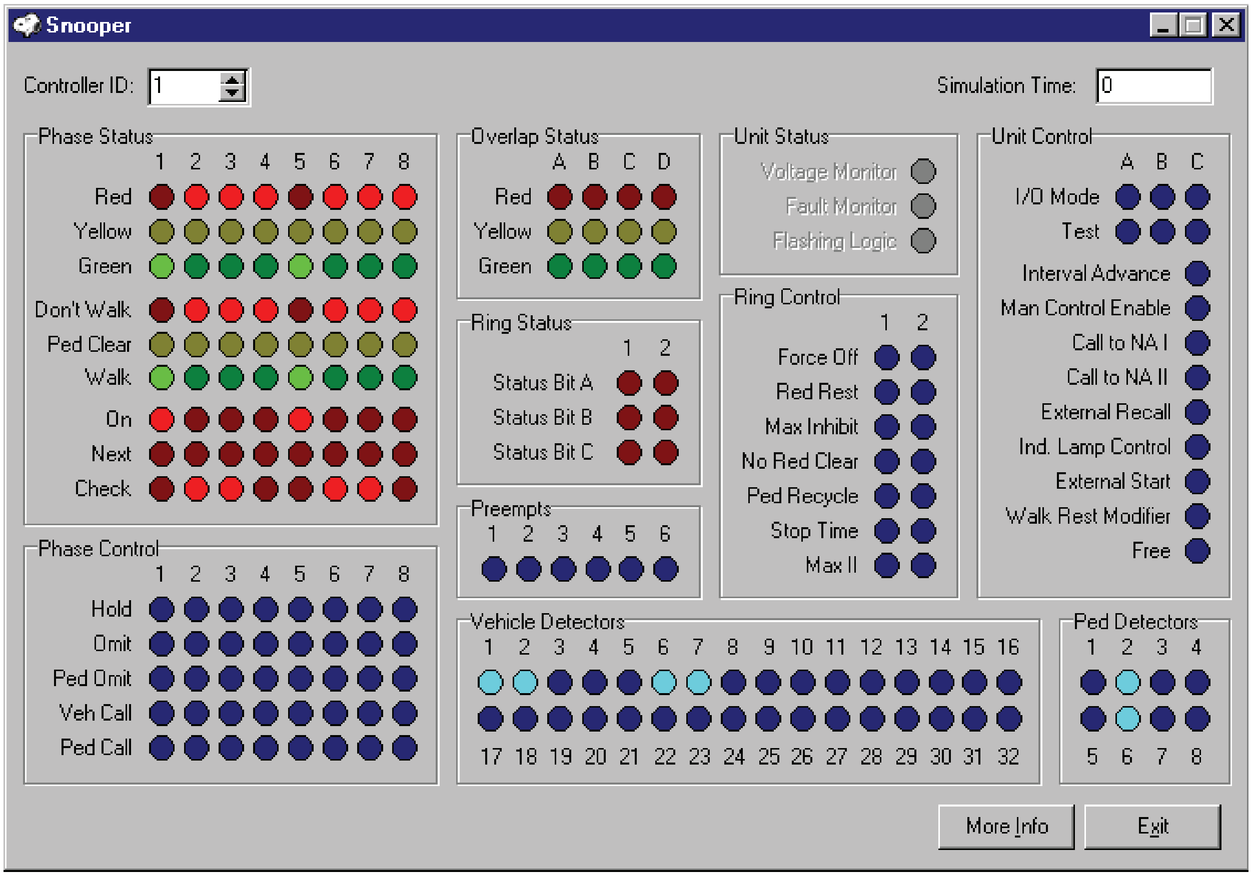


Figure 26. Snooper Utility Screen**.**

The `Simulation Time` field shows the current simulation time if a simulation is running. Clicking on any simulated light changes the status of the corresponding controller data. The [More Info] button brings up the following window (Figure 27):

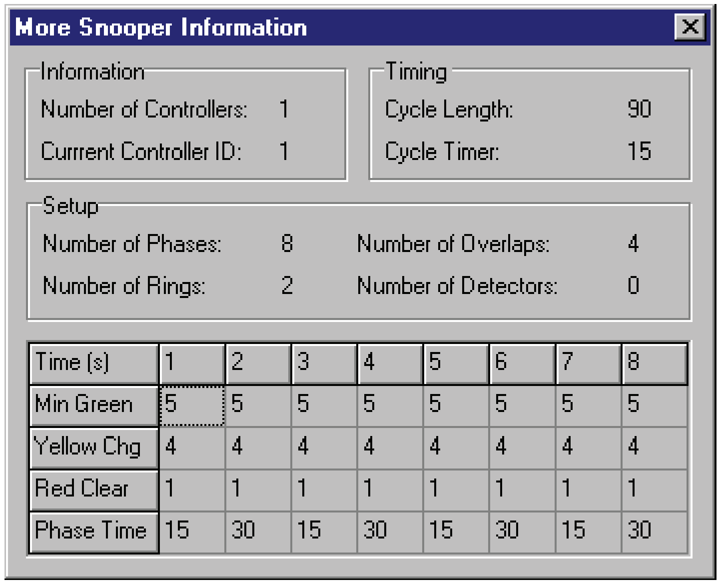


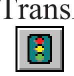
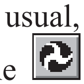
Figure 27. More Snooper Information Screen**.**

This window displays additional information such as the number of controllers and the current controller ID; cycle length and cycle timer (if available); number of phases, overlaps, rings, and detectors; and phase timing information (if available).

Running the Event Logger

The Event Logger utility (`EventLog.exe`) allows you to log into a text file the events that happen in the controller and are detected by the TTI HITL software such as detector actuations, phase status changes, and other events. The name of the log file is `eventlog.txt` and is stored in the same directory as the `eventlog.exe` utility.

Running TSIS

To use the TransLink® hardware-in-the-loop simulation system with TSIS, run TSIS as usual, but use the  "TTI Hardware-in-the-Loop Simulation" toolbar button instead of the  "CORSIM" button to start the simulation. You should get the following messages in the TSIS output window (Figure 28):

```
*** RT-TRACS IS ACTIVE ***
THE FOLLOWING NODES ARE FLAGGED FOR EXTERNAL CONTROL:
       X
       Y
       :
       Z
Calling real-time simulation initialization.
Reading TRF File DONE
Reading SDI File DONE
```

Figure 28. TSIS Output Messages**.**

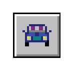
`X` to `Z` should be a listing of all the nodes flagged for external control by coding a 2 or 3 in column 77 of TSIS card type 36 and 43. If the "`Reading SDI File DONE`" message is not displayed, make sure that an SDI file with the same name as the TRF file exists in the same directory as the TRF.

Remember that since the simulation is running in real time, the initialization and run time will be much longer than usual. Consequently, you will not see any messages in the TSIS output window for a while. To verify that the simulation is running, you can use the Snooper and watch the Simulation Time—it should tick over once a second. The Snooper should also show some detector activity and phase changes.

Once the simulation initialization is complete you will get the following message in the TSIS output window (Figure 29):

```
Calling real-time simulation update.
```

Figure 29. Simulation Update Message

After this message is displayed, you can view the simulation in progress by clicking the  "Concurrent TRAFVU" toolbar button. To make sure that TRAFVU starts the simulation animation at the current time, select Animation / Set Time menu option from the TRAFVU menu and drag the `Current Time` slider to set the animation start time as close as possible to the current simulation time.

It is important to ensure that the simulation runs in real time, since the controller hardware expects real-time inputs and provides real-time outputs. The TSIS output window can be used to verify that the simulation is running in real time. During the simulation, the following messages will be written to the output window (Figure 30):

```
Calling real-time simulation update.
       COMPLETED    60 SECONDS OF SIMULATION......... (NETSIM) ( 58.66 CPU Seconds)
       COMPLETED   120 SECONDS OF SIMULATION......... (NETSIM) ( 60.03 CPU Seconds)
       COMPLETED   180 SECONDS OF SIMULATION......... (NETSIM) ( 60.27 CPU Seconds)
       COMPLETED   240 SECONDS OF SIMULATION......... (NETSIM) ( 60.97 CPU Seconds)
       COMPLETED   300 SECONDS OF SIMULATION......... (NETSIM) ( 60.99 CPU Seconds)
```

Figure 30. Simulation Messages.

The simulation is running in real time when the CPU seconds for each step are equal to the difference in the simulation seconds between the current and previous step. If the CPU seconds are more than about 102% of the simulation time, the simulation is running too slow, and the simulation results may not be valid. If the simulation is running too slow, close all applications except TSIS and the server. If the simulation is still running too slow, a faster computer should be used, or the network size and/or traffic volume should be reduced.

TECHNICAL SUPPORT

If you have problems with the TTI HITL simulation software setup or running it with the TSIS software, please contact the Texas Transportation Institute HITL technical support team at one of the following numbers:

Hassan Charara	Tel: (979) 845-1908	e-mail: h-charara@tamu.edu
Srinivasa Sunkari	Tel: (979) 845-7472	e-mail: s-sunkari@tamu.edu
Kevin Balke	Tel: (979) 845-9899	e-mail: k-balke@tamu.edu

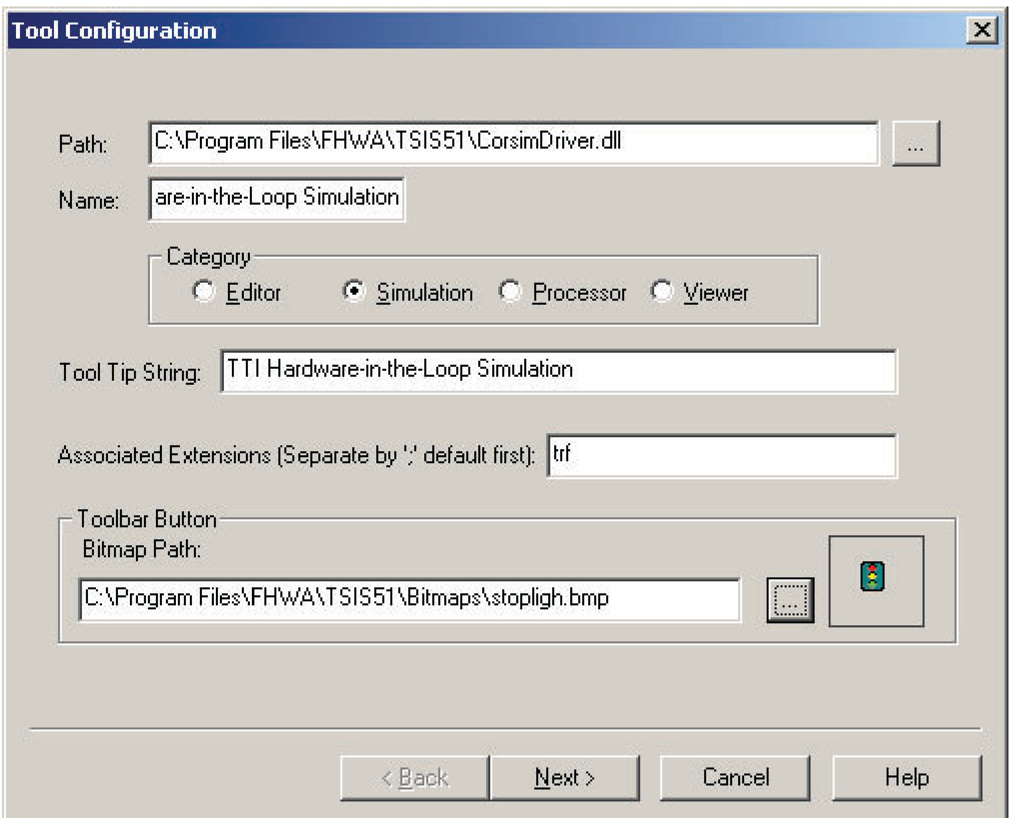
APPENDIX A

TSIS 5.1 Configuration

Use the following procedure to configure TSIS 5.1 to use the TTI HITL simulation system. First, create a new traffic tool by selecting Tools / Tool Configuration from the TSIS menu. Add a new traffic tool by clicking the “Add” button on the Tool Configuration dialog box. Enter the following information in the subsequent dialog boxes:

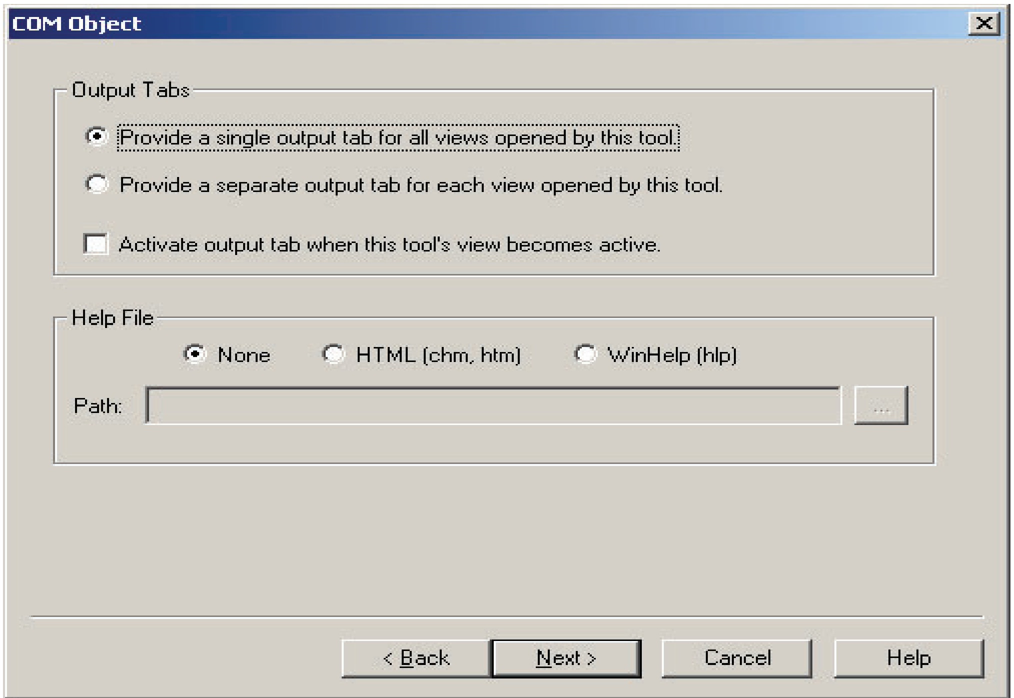
Tool Configuration Screen

Click on the “Browse” button on the right hand side of the Path and the Bitmap Path fields in the figure and browse to find the files in the directories shown in the figure. Enter “TTI Hardware-in-the-Loop Simulation” in the Name field. Click the “Next” button when finished.



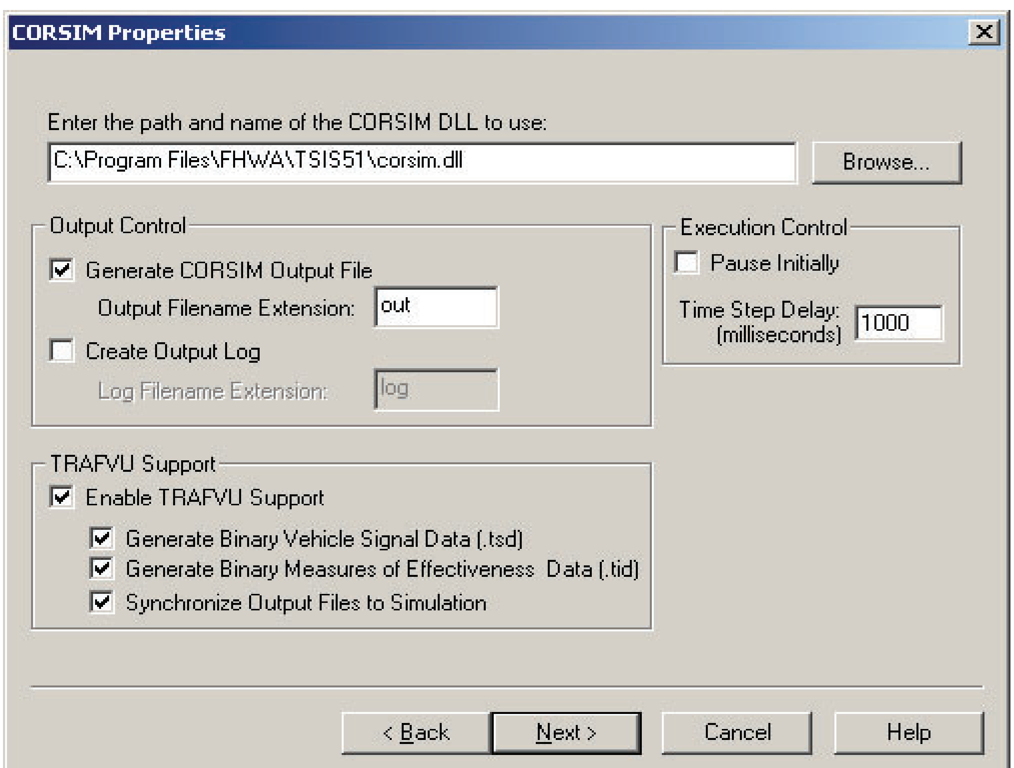
COM Object Screen

Click the “Next” button in the “COM Object” screen.



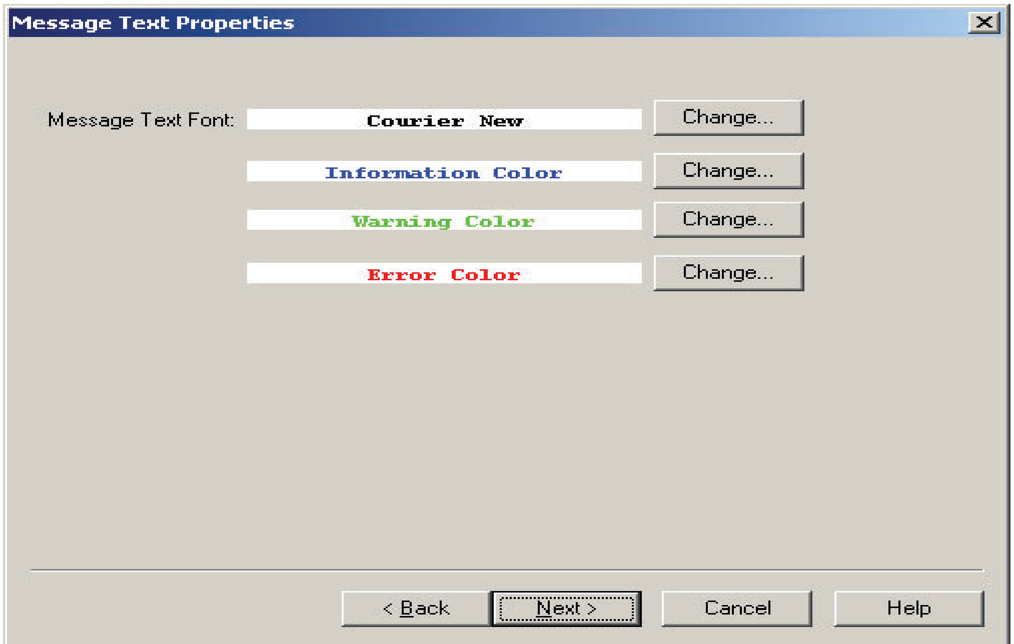
CORSIM Properties Screen

Make sure the proper boxes are checked and the Time Step Delay is changed to 1000. Then click the "Next" button.



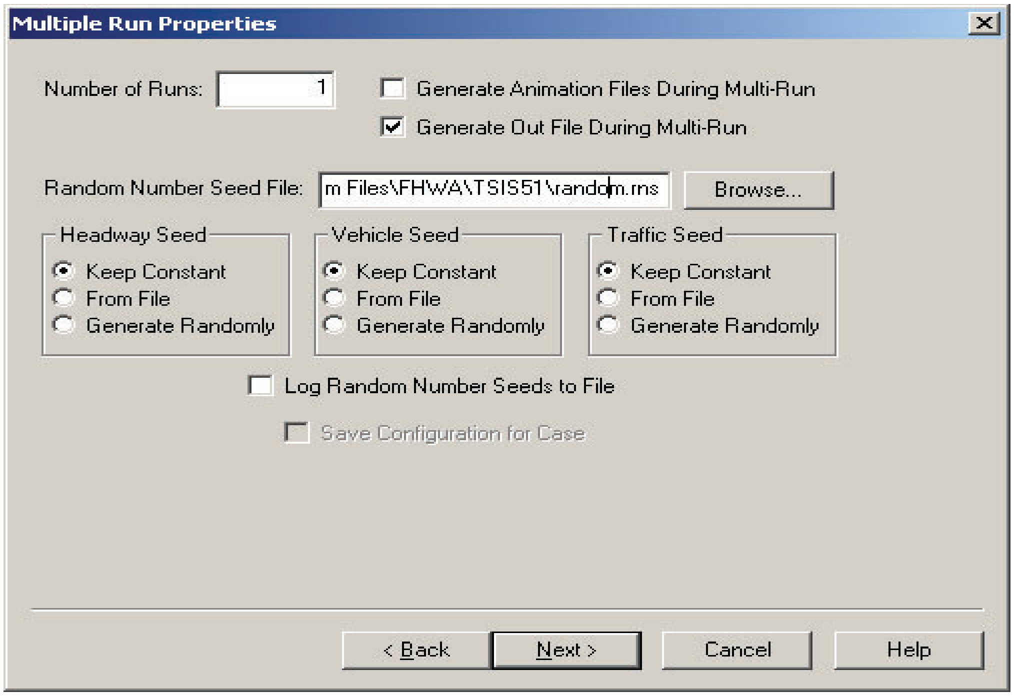
Message Text Properties Screen

Click the “Next” button.



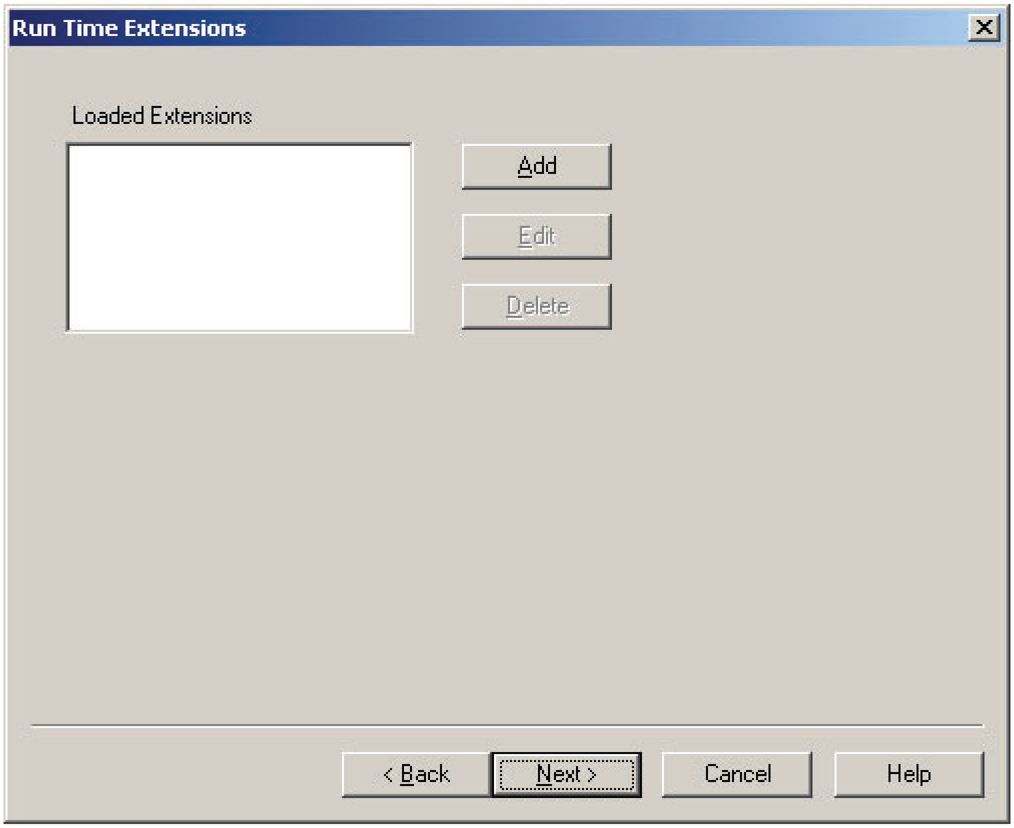
Multiple Run Properties Screen

Change the Number of Runs field to 1 and Headway Speed, Vehicle Speed, and Traffic Speed into Keep Constant. Then click the “Next” button.



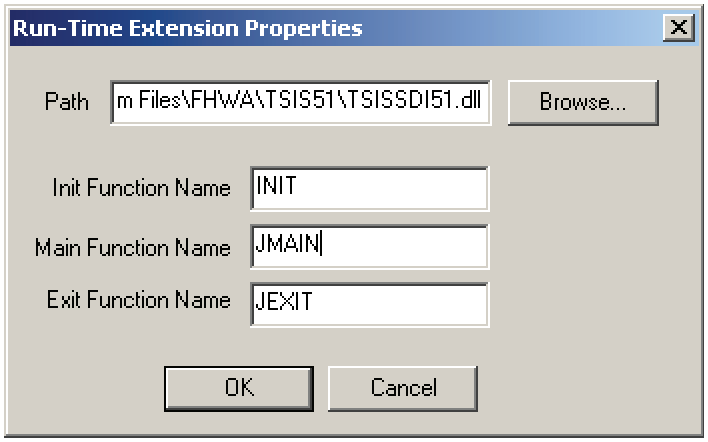
Run Time Extensions Screen

Click the "Add" button.



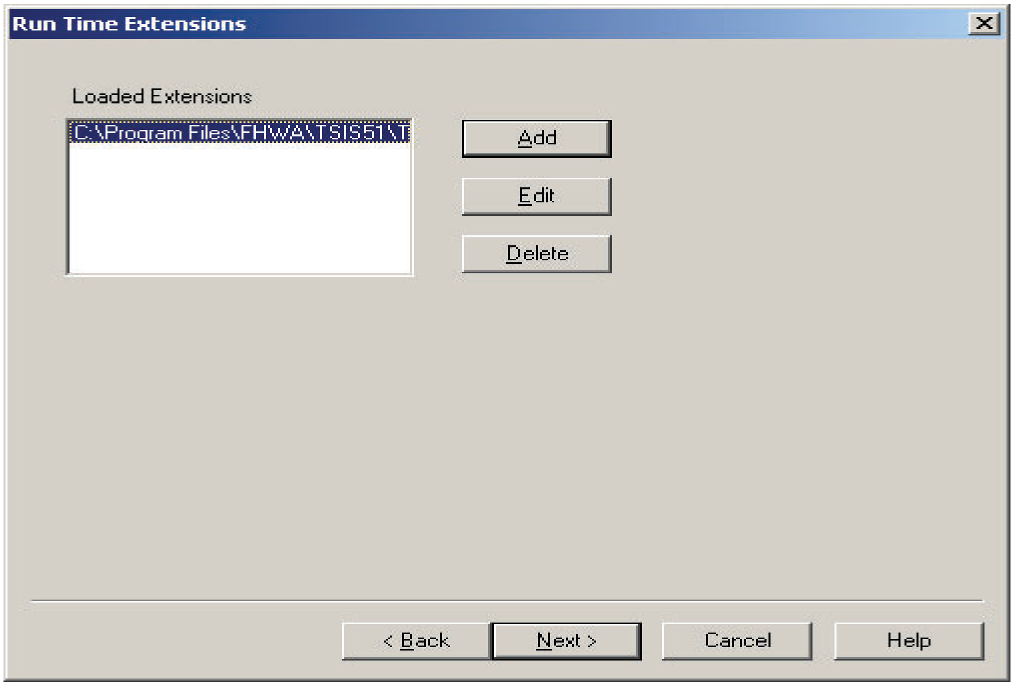
Run-Time Extension Properties Screen

Click on the "Browse" button next to the Path field and browse to the "C:\ Program Files\FHWA\TSIS\TSISSDI51.dll" file and open it. Enter the information as shown on the screen for the rest of the fields and click the "OK" button.



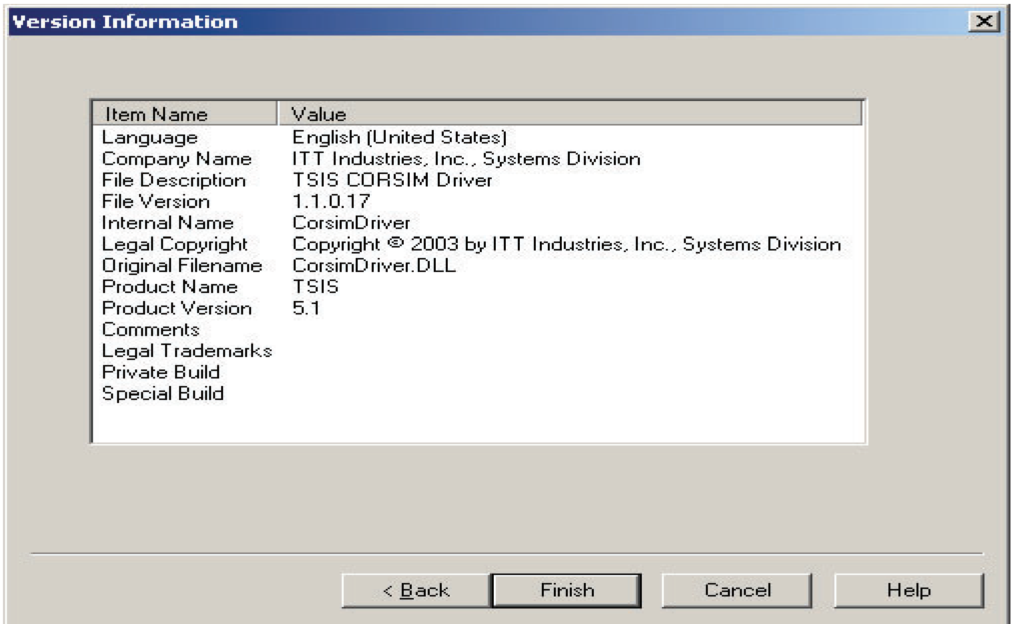
Run Time Extensions Screen

The new entry will show up in the Loaded Extensions window in the Run Time Extensions screen. Click the "Next" button.



Version Information Screen

The Version Information screen summarizes the information entered for the new tool. Click the "Next" button.



Tool Configuration Screen

The newly added tool shows up in the Configured Tools window in the Tool Configuration screen. Click the "OK" button and TTI Hardware-in-the-Loop Simulation configuration is done.