Illinois Institute of Technology

Interprofessional Project Opportunity

497-342: Real World Data Usage – Sponsored by Navistar Inc.

Final Project Report

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IPRO 497 – 342, sponsored by Navistar has a focus of assisting in the data analysis process for the large amounts of data that is collected from Navistar equipment operating in the real world environment. Collecting data in a real world environment is a unique and very powerful ability that both Navistar and IIT realize has massive potential and automating the workflow and data question is key to optimizing the data collected. IPRO 342 has divided into three teams to undertake three specific tasks in the data analysis and automation process. Due to the high level of coordination required for this IPRO, IPRO 497 – 342 kept a very open dialogue with Navistar personnel. Listed below is an outline of what each group did over the course of the semester.

Chthonian Lucidity Project Report

Performance against Goals

I. Original goals of project:
    1. The original goal of Chthonian Lucidity can be broken down into two main areas since it was originally two groups. Chthonian Lucidity started as Chthonian Data Mining and Nintex Lucidity each with different but related goals. The primary goal of the Chthonian Data Mining group was to develop a more robust yet still dynamic tool for the analysis of CAN Data that had been collected by Navistar over time. Nintex Lucidity was focused on the data flow and user interface of this tool through the Navistar SharePoint.

II. Determination of relevant performance metrics to Chthonian Lucidity project
    1. For the Analysis Tool some of the most relevant performance metrics were the ability for the tool to analyze the CAN Data files even when there were inconsistencies in the CAN Data.
        i. These inconsistencies can range from a variation in the sampling rate, or single time stamp that does align with the others.
    2. A large excel sheet that contained all of the tasks that were required for both the analysis tool and the SharePoint integration was created.
        i. With a project of this magnitude, containing so many different tasks, it was necessary to have this document with the requirements easily displayed for all to see.
    3. For the SharePoint and data flow the limiting factors and constraints will need to be identified and then evaluated to determine the best path forward

III. Key metrics
    1. Understand how the CAN Data flows from the truck to Navistar servers
        i. Understand all of the components that are in line with this data flow
    2. Understand where the software needs to be more robust
        i. Examples of items that will crash other programs
            1. Null CAN entries
            2. Future time stamps
            3. Sampling rates that are inconsistent with the desired 1hz
    3. Ensure that the tool is dynamic enough to be expandable and incorporate other analysis needs as they arrive
        i. The tool will be based on a modular system to incorporate this need

1. Visual Basic was chosen so that it could easily be maintained and added to by Navistar staff

Performance against Schedule

I. Key milestones
    a. Analysis tool
        i. Gain an understanding of the tasks at hand
        ii. Develop an outline for the analysis tool
        iii. Begin the development of the framework for the analysis tool
        iv. Begin the writing of modules for the analysis tool
        v. Test the analysis tool with modules
        vi. Further develop and write modules
        vii. Generate user interface
    b. SharePoint
        i. Gain an understanding of the SharePoint and data flow
        ii. Create a form for users to input vehicle information into a SharePoint List
        iii. Create a schedule so that the SharePoint List is automatically updated with metadata from an external site pertaining to the input vehicles.
        iv. The projected goal is to have SharePoint function as the interface for logging and retrieving data for vehicles and their applications

Performance against Quality

The performance of both the analysis tool and SharePoint integration against quality was favorable. The analysis tool that was created by IIT has significant advantages to those that are currently deployed by Navistar in that it is able to work through many of the inconsistencies in the data that they have. The SharePoint integration did not get as far due to hurdles but discovering these hurdles was valuable for future development and a proposal was put together on a possible way to accomplish the original goals of the SharePoint team.

Performance against Budget

The performance of both the analysis tool and SharePoint integration against budget was favorable. The costs were minimal for the amount of programming and research that was done. Further more the proposal for high-level SharePoint integration (Exhibit 1) would save Navistar money since they could forgo several expensive software license.

Key Lessons

Establishing a sure understanding of the project and goals prior to starting any work was one of the main lessons learned. The next biggest lesson was that it is imperative to have the right people for the job, the description of the IPRO may have mislead some people and therefore people may not have had the correct set of skills for this type of project

What Went Right

I. Conference calls with Bethany worked well
    a. They worked even better after we started establishing an agenda

II. Class time was productive
III. Status reports we provided a lot of information to Navistar

What Went Wrong

I. Misunderstanding between Navistar and IIT team on the initial tasks and information
II. Access to Navistar's SharePoint took a significant amount of time and resources on both IIT and Navistar's end
III. Having people who did not have the skills to be coding and working on software working on the project made it less efficient since they were not able to contribute as much to the deliverable
    a. This was primarily due to a misunderstanding of the IRPO description

IIT students were able to work around the majority of these problems through open minded solutions and learning new areas of technology. There was also a lot of help from Navistar personal on filing in some of the gaps.

Recommendations

We would recommend that the group have a better understanding of the current state of the project and restrictions prior to starting and ensuring that the right people are in the right places. Specifically for this project more computer science majors since it was a very program heavy project.

Questions & Comments

None at this time.

Project Planning

How was the Project Planned?

The project was primarily laid out by Bethany Glish of Navistar in a very clean and legible excel document that outlined a timeframe with assignments and goals

Was the Plan the Right One?

The plan was a good plan but it was too ambitions for a single semester, 3 credit IPRO, especially when it took so long for the non disclosures to get worked out and for everyone to get up to speed

Research and Development

How was R&D Managed?

R&D was managed by researching the metrics required for the module and then developing the code to implement it in the tool. This was assisted by equations and specifications from Navistar. There was a lot of research done on SharePoint and SharePoint integration for the analysis tool and CAN data flow from the trucks to the server at Melrose Park

How Effective & Efficient was R&D?

R&D was made more efficient once Navistar was able to start giving us equations for modules and we had access to their SharePoint for testing and research

Project Management

How was the Project Managed?

The project was primarily managed though heavy email contact with Navistar and a weekly conference call that involved all group members and Navistar contacts. The project was also tracked and guided by weekly reports that reflected the original project plan and Gantt Chart.

Exhibit 1

Chthonian Lucidity

October 25, 2013

High Level Recommendations for Analysis Tool Access Through SharePoint

Due to the complications of actually running the CAN Data Analysis tool in SharePoint, Chthonian Lucidity has put together a concept that would allow for access of the tool through the SharePoint. It should be noted that this recommendation is based on what the group has been able to see and without full access to all of the servers and applications, exact sets for implementation can not be given. Again, Chthonian Lucidity wants to make it clear that this is the path that we feel would be most viable from what we have seen up to this point but we can not implement this or investigate it further without full access to all servers and equipment involved.

Overview

Chthonian Lucidity would establish a power shell script that retrieves the data over FTP on whatever schedule was desired; the data would then be organized into the desired file structure via a power shell script (this would eliminate Nintex). This organization would very closely resemble that of the VIN decoder excel sheet. The SharePoint could access the files based on what the user is looking to analyze. The user would select engine or transmission type (or whatever other information can be gained from the VIN) and then the appropriate files would be located, then run through the analysis tool that is on the server. This would require the analysis tool to be written in a way that would allow it run on server. The main changes would be to the input and output functionality since more than one user could be accessing the tool at a given time. This would eliminate the need to download the executable file of the analysis tool. This is still not running the analysis application in SharePoint it is using SharePoint to call the tool on the server which then runs the analysis.

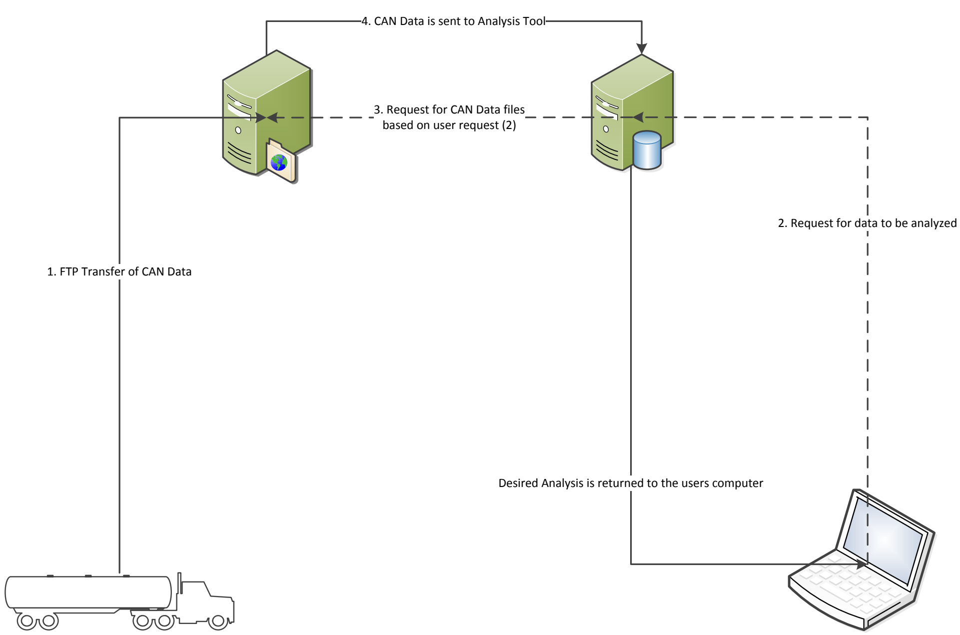

Exhibit 2 (Erebus User Guide)

Automation Acumen Project Report

PERFORMANCE AGAINST GOALS

IV. The original goals of the project are as follows:
   1. Automate the electrical test Navistar does on their vehicles at the testing facility through LabVIEW.
   2. Use LabVIEW to create a software interface to communicate with the vehicle and perform desired electrical tests automatically.
   3. Read and write signal to the vehicle and signal from the vehicle using the interface we create.

V. Determination of relevant performance metrics to Automation Acumen project
   1. In order to determine what metrics would be appropriate to use in order to measure the success of the project, we first needed to break down the steps required to accomplish the goals of the project. The preliminary steps to accomplish these goals were identified as follows:
      i. Understand the message structure of the code handled through LabVIEW
         1. This step includes understanding the message structure of CAN data as per J1939 protocols
      ii. Initializing the Nexiq USB Link through LabVIEW
      iii. Write pseudo code in LabVIEW for reading and writing CAN data to and from the vehicle
         1. Be able to identify the input and output message structure and verify correct format
         2. In order to complete the above step, needed to fully accomplish step (1) in part (i)
   2. In order to link performance metrics to the project, team utilized visuals such as flowcharts, block diagrams, and other images. This helped us understand the overall process as well as correctly link specific details with their respective parent task. These visuals are listed provided below:
      i. Constructed preliminary software flowchart showing initialization of Nexiq cable through LabVIEW (flowchart shown on next page)

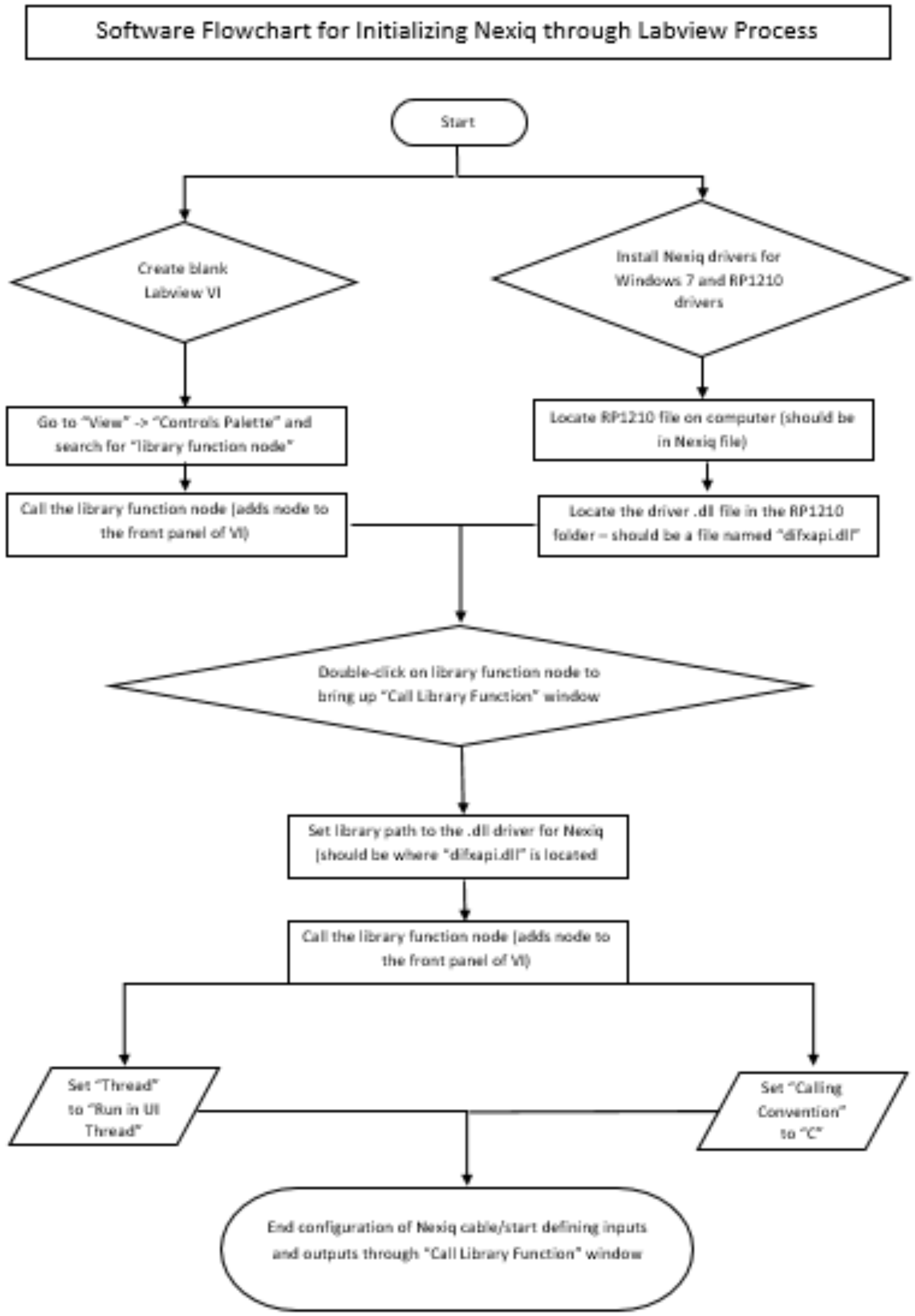
Software Flowchart for Initializing Nexiq through Labview Process
Start
Create blank Labview VI
Install Nexiq drivers for Windows 7 and RP1210 drivers
Go to "View" -> "Controls Palette" and search for "library function node"
Locate RP1210 file on computer (should be in Nexiq file)
Call the library function node (adds node to the front panel of VI)
Locate the driver .dll file in the RP1210 folder – should be a file named "difxapi.dll"
Double-click on library function node to bring up "Call Library Function" window
Set library path to the .dll driver for Nexiq (should be where "difxapi.dll" is located
Call the library function node (adds node to the front panel of VI)
Set "Thread" to "Run in UI Thread"
Set "Calling Convention" to "C"
End configuration of Nexiq cable/start defining inputs and outputs through "Call Library Function" window

Figure 1: Software flowchart displaying Automation Acumen's plan to initialize the Nexiq connector cable through the software LabVIEW.

ii. Along the course of the team's work with creating CAN channels through LabVIEW in order to be able to read and write signals from the vehicle and to the vehicle, we used several toolkits provided by National Instruments. We primarily used the toolkits NI-CAN and NI-XNET. The images provided below display what we worked with in terms of a software interface using NI-CAN as well as channel creation in NI-CAN, respectively.

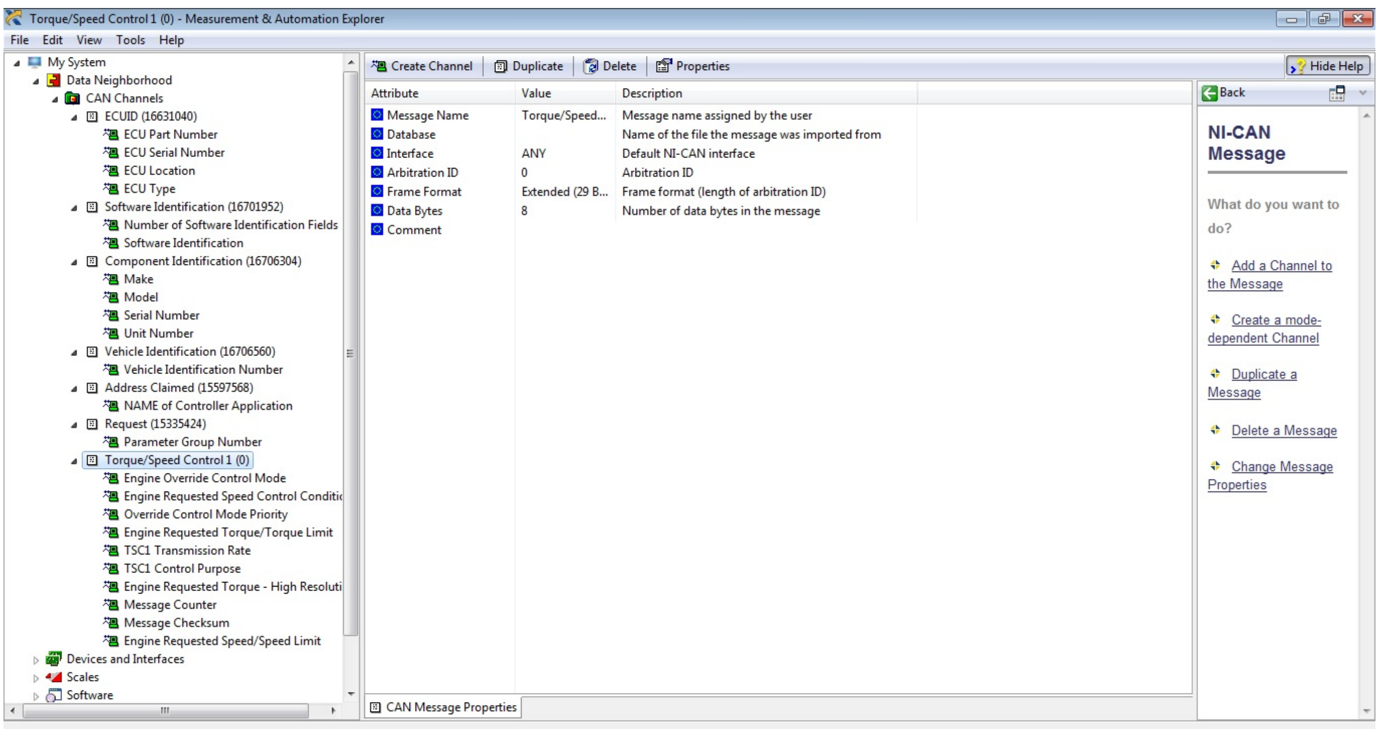

Figure 2: the Automation Acumen team used National Instrument's toolkit NI-CAN to create CAN channels based on parameters provided by Navistar Engineer Leads.

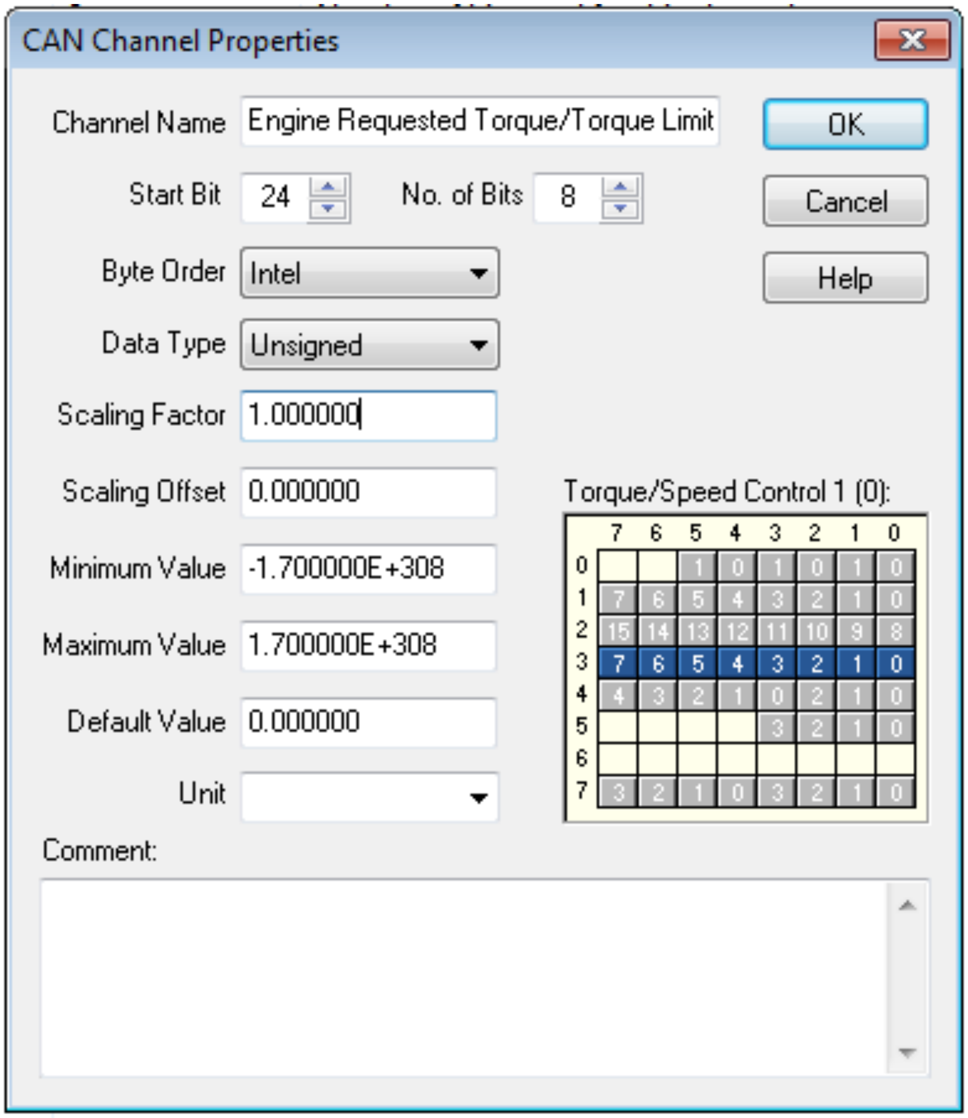

Figure 3: the Automation Acumen team used National Instrument's toolkit NI-CAN to create CAN channels based on parameters provided by Navistar Lead Engineers. The image above displays information specified by NI-CAN.

3. Use of NI-CAN to read and write signals to and from the vehicle provided to be a cumulative process based upon the creation of a series of NI-CAN Channel API's. CAN channel API's are predefined channels created to facilitate programming within CAN. The steps to creating an interface using NI-CAN are as follows:
   i. Define or import CAN channels.

        1. To import a CAN database (.dbc) file must be used. NI-MAX is used to create CAN channels in the event that there are no .dbc files available.
        2. Because of the resources available to us, we created CAN channels using NI-MAX.
    ii. Define Channel API functions used to initialize, read or write, and clear functions within NI-CAN.
        1. During the last few weeks of the semester, this step was our goal and would have been the final step in creating a workable software interface.
    iii. Become familiar with functions provided through NI toolkits for use with LabVIEW.

VI. Key metrics – organized according to respective focus throughout duration of project

1. CAN J1939
    i. In order to work with CAN data, we needed to learn the message structure as per J1939 protocol
    ii. Also needed to understand CAN data
        1. CAN = Controller Area Network
        2. CAN buses have a message-based protocol and are designed for automobiles
        3. Multi-master broadcast serial bus used to connect electronic control units (ECUs)
        4. Nodes are able to send and receive messages but cannot do so simultaneously
2. Required to obtain several SAE documents to become versed in J1939 message structure and further learn about CAN data
    i. J1939: Serial Control and Communications Heavy Duty Vehicle Network – Top Level Document
    ii. J1939-21: Data Link Layer
    iii. J1939-71: Vehicle Application Layer
    iv. J1939-73: Application Layer – Diagnostics
    v. J1939-75: Application Layer – Generator Sets and Industrial
    vi. J1939-81: Network Management
    vii. SAE CS1939: Companion Spreadsheet to J1939
    viii. Documents pertain to SAE recommended practice for the requirements, design, and use of devices that transmit electronic signals and control information among vehicle components
3. Vehicle Testing
    i. Understand electrical tests done on medium and heavy duty trucks and the corresponding recommended practice for dealing with test data
    ii. Learn what signals are analyzed during electrical tests
    iii. Understand the testing procedure done at Navistar with respect to electrical validation tests on trucks at the facility
    iv. Learn how to translate results from these tests to steps that can be automated

v. Become proficient with means of collecting data off of trucks that are undergoing electrical tests

4. SAE Protocol
    i. Become proficient with input and output message structure as defined by SAE recommended practice documents
5. Nexiq Tool
    i. Establish initialization and communication with Nexiq cable through LabVIEW
    ii. Please note that upon further review this metric was deemed out of scope given the timeline of the project (further details regarding this decision can be read below). It is simply included here because it was part of the original scope of the project and was a goal for the IIT Automation Acumen team.
6. Software
    i. Display proficiency in LabVIEW
    ii. Know how to troubleshoot problems in LabVIEW
    iii. Utilize toolkits provided by National Instruments to manipulate CAN data

PERFORMANCE AGAINST SCHEDULE

I. Brief schedule of project:

Project Timeline for Fall 2013		
Goal	***Due Date***	***Results***
IIT team to determine access to SAE documents	9/6/2013	Team achieved goal by due date
Team to learn SAE J1939 protocol and messages needed to execute test - need to have identified the J1939 messages required for the test	9/13/2013	Team achieved goal by due date
Team to outline flow chart for designing software Interface between LabVIEW and Nexiq USB link	9/18/2013	Unable to complete task by due date - completed on 10/3/2013
Team requests Nexiq cable to test communication between cable and LabVIEW as well as better understand the hardware	Requested on 9/24/2013	Received Nexiq cable on 10/9/2013
Team to send update on completion of communication between Nexiq and LabVIEW link	10/9/2013	Team expressed inability to complete goal - re-organized project scope with Nina at Midterm Presentation at Navistar on 10/17/2013
Read test procedure for J1939 Network/Messaging - Test requirements document and respond with questions	10/23/2013	Team received answers to clarifying question about test documents.

Create CAN channels as per test documents through NI-CAN	11/12/2013	Team was able to create CAN channels as per test documents.
Create software interface in LabVIEW to read and write CAN data	11/19/2013	Team was able to create skeleton of a software interface to work with CAN channels

II. Key milestones

a. The IIT Automation Acumen team underwent a re-scoping process of the project's goals at the Midterm Presentation with engineering lead Nina Hickland. This provided a new direction for the team to focus on; working with reading and writing CAN data through LabVIEW. This was key to initializing our progress with creation of an outline of a software interface in LabVIEW.

b. Upon researching methods for manipulating CAN data through LabVIEW, the IIT Automation Acumen team learned about NI's toolkits NI-CAN and NI-XNET. These toolkits were crucial to our ability to start working with defining CAN channels and creating a skeleton for a software interface.

c. The difference between NI-CAN and NI-XNET is that NI-CAN involves the creation of CAN channels while NI-CAN allows you to upload channels if you have the CAN database file (.dbc file). After defining the CAN channels through NI-CAN, we found that NI-XNET has a transport frame that allows one to upload predefined channels in NI-XNET. We also found that there is a way to automate the transmitting process to improve efficiency.

Performance against Quality

The original goal for quality was to incorporate hardware tests of software interface with Nexiq cable. This test would be done early on to troubleshoot any problems and test the robustness of the code for the software interface. The key metrics relevant to quality assurance included a successful test run of the code for the software interface as well as a level of accuracy obtained regarding correlation between the outputs and the J1939 message structure.

Performance against Budget

The original quality goal for the budget of the project was to minimize expenditure costs. This was balanced against the goal of giving precedence to expenses necessary to allow for future progress of the project. Necessity of purchases made by the IIT team was determined by the restrictions the item imposed on the project schedule. The expenditure limits were set by our professor as well as IIT's IPRO office. Thus far into the project, the Automation Acumen has only purchased one thing; the J1939 Companion Guide document. We were unable to obtain the document through the same portal with which we acquired all the other necessary SAE documents because of the nature of the information contained within the document. Since it was required to learn the J1939 message structure that we would be working with, precedence was given to purchasing the document and this was done by the IPRO office in order to keep the project schedule on track. At the conclusion of our project, we had only purchased on thing; the J1939 Companion Guide document.

Key Lessons

What Went Right

IV. Conference calls with Nina, our Engineering Team lead, worked well
    a. Efficient means of updating and communicating problems
V. Early morning meetings with the IIT team were productive
    a. Additionally, utilizing time after class for meeting was extremely productive because it eliminated a loss of work with the conclusion of class
VI. Status reports (both from IIT and Navistar) provided accurate performance metrics as well as contributed to progress according to project timeline

What Went Wrong

IV. Misunderstanding between Navistar contact and IIT team on what construction of a software interface entailed
V. Found that there is no driver for Nexiq cable in LabVIEW further research and process of writing pseudo code for initializing Nexiq cable
    a. Found that solution was to write a driver and began researching requirements for doing so
    b. Embarking upon this task would extend the project schedule past original completion goal for software flowchart showing initialization of Nexiq cable in LabVIEW
    c. Upon further research, IIT team determined that to establish communication between Nexiq cable and LabVIEW a set of Instrument VI's making up a Nexiq driver for LabVIEW would have to be created; would need to extend project timeline past current project schedule to complete driver
VI. Time was lost through process of figuring out how to interface Nexiq cable and LabVIEW
VII. IIT team invested in figuring out a "work-around" solution for communication between Nexiq cable and LabVIEW to work around missing driver problem
    a. Tried to utilize "Call Function Library" node within LabVIEW to call Nexiq cable .dll drive
VIII. This issue was resolved upon meeting with Nina after the Midterm Presentation and re-scoping the project. The results from this meeting included both a new focus for the IIT Automation Acumen team as well as brought a conclusion to our previous attempts since the team was no longer required to initialize the Nexiq cable through LabVIEW

Response to problems

The IIT team's response to problems was dynamic and open-minded given the nature of the problems. When a problem arose, the IIT team took a systematic approach to diagnosing the full extent of the problem, researching potential solutions, and executing a solution that was unanimously agreed upon. After identifying a problem, each team member would research the problem and potential solution outside of class time and communicate via email or text messaging their findings. We would then meet as a group and discuss each potential solution before deciding to execute the best possible plan to solve the problem. This approach is best described by our approach to the task of figuring out how to initialize the Nexiq connector through LabVIEW. None of the IIT team members had any experience with the Nexiq connector but we did have experience with other data acquisition tools within LabVIEW. After systematically trying these previous solutions, we turned to researching other methods of communicating with the device in LabVIEW as well as other hardware that was available and compatible with LabVIEW. After researching, we would then meet and discuss our findings and determine a solution that we all agreed upon. Upon our decision we would try to implement our solution and get as far as we could while simultaneously asking for guidance or asking clarifying questions along the way. We would submit our best solutions to the problem as well as ask questions to Nina, our engineering team leader. Unfortunately, this process was lengthy and we were unable to have much success with a workable solution with the Nexiq cable. It did help us greatly, however, in working with CAN data in LabVIEW because it lead us to find the National Instruments toolkit's NI-CAN and NI-XNET, which allowed for us to do some CAN programming.

Additionally, open communication between all team members as well as positive thinking was crucial to progress throughout the duration of this project. Each team member had all of the contact information for each member in the group and updates were sent out frequently during the week. Communication with Navistar engineers was also crucial to the success of the project since they provided guidance to any issues we ran into as well as answered questions about topics we were not as familiar with at the time being. A positive attitude also helped push past discouraging problems and brought excitement back to the IIT Automation Acumen team after encountering difficult crossroads in the project. Our professor was also very helpful in providing a positive outlook throughout the duration of the project.

Recommendations

For future projects similar to Automation Acumen's goals, one recommendation we would like to stress is dealing with specifics when outlining the overall goals of the project. For example, in addition with marketing the project as creating a software interface within LabVIEW, we would recommend stating any problems or other goals that this would entail. During this project, creating a software interface also included creating a driver that would be used to interface with the Nexiq cable in LabVIEW. This step may not be an apparent goal to people involved that are not as familiar with PC to vehicle communication. We recommend this to help team members fully understand the requirements as well as the deliverables of the project. We also recommend this to reduce time lost to misunderstandings and efforts expended in pursuing an incorrect direction while trying to accomplish the goals of the project.

Questions & Comments

None at this time.

Project Planning

How was the Project Planned?

The Automation Acumen team planned all aspects of the project together. Due dates as well as the overall project schedule was determined as a group in coordination with engineering team lead's guidelines. Project status updates were helpful in determining plans of action as well as checking in with the original project schedule

Planning the project in this way worked well; IIT's team consists of students who are eager to solve problems and continue to strive for success regardless of obstacles that come up during progression of the project.

Was the Plan the Right One?

The plan to set a project schedule as well as set due dates for deliverables was a good one in terms of the size and skills of the IIT team. Since the team is so small, coordinating one solution between three people was not too difficult.

Unfortunately, the original goal of initializing the Nexiq cable through LabVIEW were unrealistic given the time constraints of the project and the specific skill set of the IIT team. Nevertheless, IIT's team worked towards completing each goal on time to the best of our abilities.

Over time, the plan to construct a software interface between the Nexiq cable and LabVIEW evolved to focus more on reading and writing CAN data to and from the vehicle through LabVIEW. This evolution was done after the Midterm Presentation with Nina to move past the problems encountered with initializing a Nexiq cable in LabVIEW. In terms of good and bad; while it was disappointing to have to bypass the first part of constructing a software interface (i.e. initializing the cable through LabVIEW), it was good to move onto a more realistic aspect of the project and attempt to have progress with reading and writing CAN data to and from the vehicle.

The changes made after the Midterm Presentation caused the IIT team to be able to progress with writing pseudo code in LabVIEW to read and write CAN data to and from the vehicle. The team then re-focused its attention to the J1939 message structure and determining a plan to building an interface to automate the reading and writing of messages in this format. We also researched into ways for working with CAN data within LabVIEW and became familiar with NI-CAN and NI-XNET. Upon utilization of these toolkits, we were able to create CAN channel's and outline a skeleton of a software interface for manipulation of these CAN channels.

Research and Development

How was R&D Managed?

The Automation Acumen team consisted of three IIT students. The team reported to Nina Hickland, project manager at Navistar. Email communication as well as conference calls worked well to have questions answered in a timely matter.

The IIT team communicated through emails, text messages, phone calls, and separate meetings outside of class. The lines of communication were open and this ensured progress because each team member was involved with the project.

How Effective & Efficient was R&D?

With regards to identifying and solving technical problems, there were some time delays on IIT's end because of a learning curve that each team member underwent while researching and planning how to communicate with the Nexiq cable in LabVIEW. Consequently, issues were not identified early enough; time would have been saved in knowing that a software interface to automate electrical testing would require a software driver to be written for initializing the Nexiq cable through LabVIEW.

Despite this time lapse, problems were solved well. Each problem was clearly identified and questions were asked to the correct people if anything was unclear. Upon receiving answers, each member would research problems and potential solutions and meet to discuss the best option. Following discussion, a solution would be agreed upon and executed to the best of the team's ability.

Improved communication regarding specific objectives pertaining to the goals of the project would have greatly influenced the progress of the project and we stress the important of identifying these objectives very early in the project because of this reason.

Project Management

How was the Project Managed?

The IIT team for Automation Acumen scheduled additional meeting times outside of class on a weekly basis; when required, the team would meet early before class times on Tuesdays and Thursdays as well as stay later after class to continue work. Additionally, early morning meetings were utilized in order to meet and discuss solutions for problems encountered throughout the progression of the project. All team members were present at these meetings. Conference calls with Nina were also held during specially scheduled meeting times; at least two of the three members were in attendance during these calls and if a member was unable to attend they were promptly provided with the minutes from the meeting.

Communication between team members was constant throughout the duration of this project. Each team member communicated at least five to six times within the week and updates were included on the status of tasks distributed after meeting. This plan worked well for communication throughout the duration of the project.

The IIT team communicated with the Navistar engineering team leaders normally once or twice a week. Improved communication between the Navistar engineering team leaders with the IIT students would have ensure that the team is keeping to the project schedule as per Navistar's timeline as well as putting forth efforts towards a solution that is relevant to the objectives of the project.

Changes in project scope as well as strategy were tracked with project status updates and email updates to both the IIT team members, Professor Lewis, and the engineering team leaders at Navistar. This method worked very well in terms of informing people relevant to the project about major changes to the project timeline and/or strategy.

A strong communication tool that the IIT Automation Acumen team has utilized throughout this project is Google Drive; a folder was created and shared with each team member to easily share documents and make edits to project status updates, questions, and other project management documentation.

Quality Assurance

Product quality was measured with periodic check-ins with the IIT Automation Acumen's engineering team lead contact at Navistar (Nina Hickland). This method was efficient for re-directing or re-focusing the team when looking to execute a possible solution to a problem.

Currently no products can be compared against quality goals; however, in terms of issues with products and quality, we had ran into fairly insurmountable problems regarding National Instruments and LabVIEW. In additional to the difficulties that attempting to initialize a Nexiq cable in LabVIEW incurred, we have also run into problems with locating resources and documentation on the problems that we have been tasked with solving. While the IIT IPRO office provided support for software and hardware related problems to the best of their abilities, no official support teams were prepared for helping with LabVIEW. Therefore, each time an issue arose with the software it was difficult to obtain answers in a timely manner from either National Instruments of the Technical Support provided by the IPRO office because of the time it required for us to relay problems and describe the problem that allowed support to have enough information to solve the problem. Navistar, however, provided a very helpful resource for LabVIEW to us. An engineer fluent in LabVIEW, Tony Rogness, attended one of IIT's IPRO class periods and was able to answer all of our questions regarding LabVIEW as well as provide us with more information on what the differences between NI-CAN and NI-XNET were. This was extremely helpful during the end of the project when we were working exclusively with LabVIEW and creating CAN channels.

Real World Vehicle Response Project Report

Performance against Goals

VII. Original goals of project:

1. Develop an analysis method, through DIAdem, for full vehicle, system and component characterization of data acquired from instrumentation including GPS, CAN, thermocouples, steering sensors, strain gauged U-bolts, cross members and drive axles.
2. Increase robustness, effectiveness and efficiency of the LabVIEW data acquisition software, originally built by Ed DeWitt, and provided by Navistar.
3. Modify the DIAdem analysis tool for increased effectiveness and robustness through the use of LabVIEW data acquisition software.

VIII. Determination of relevant performance benchmarks by which to judge success of the RWVR sub-group project.

1. In order to determine what benchmarks would be appropriate for measuring success of the project, we first needed to break down the steps required to accomplish the goals of the project. The preliminary steps to accomplish these goals were identified as follows:
   i. Investigate raw data supplied by Navistar and familiarize ourselves with the provided data channels.
   ii. Study the DIAdem data analysis program and determine the necessary functionality requirements demanded by the project guidelines.
   iii. Familiarize ourselves with the LabVIEW data acquisition software and functionality necessary for achieving the outlined goals as specified by the project.
2. Utilize gathered information and apply it to the project goals.
   i. Apply acquired knowledge of DIAdem input file limitations, based on individual file types.
   ii. Apply acquired knowledge of LabVIEW data acquisition software to be used in conjunction with DIAdem analysis tool.
3. Ideal benchmarks for the project:

IX. Ideal benchmarks going into the project:

1. Thorough understanding of raw data in general, and provided data channels specifically.
2. Reformatting of raw data files, such that files can be loaded into DIAdem for analysis.
3. Able to load individual files into DIAdem data analysis tool, and manually use analysis and report "drag and drop" features in DIAdem for raw data analysis and reports.
4. Write script within DIAdem such that this manual style of data analysis is automated.
5. Write script within DIAdem such that multiple files can be loaded and analyzed successively or simultaneously.
6. Successfully read and understand existing LabVIEW data acquisition tool and preferred formatting of data files.
7. Understand the calibration file creation process and methodology used in applying it to the LabVIEW data acquisition process.
8. Design new logical process for LabVIEW data acquisition and calibration programs in order to enhance efficiency and ease of use.
9. Create new LabVIEW interface that will combine both the calibration process and the data acquisition process.

X. Key Accomplishments:

1. Define proper data format to input into DIAdem.
    i. It was discovered that rows of "event data", existent in all .CRE and .txt files, were not allowing all raw data channels to be properly loaded into DIAdem for analysis.
    ii. After trial and error, it was found that manual file conversion to excel format and removal of the first four lines of data allowed all channels to be properly loaded into DIAdem for analysis.
    iii. Due to the length of time taken to load a single excel file however, this method proved to be extremely inefficient. As such, it was determined that the .CRE file format must be maintained.
2. A LabVIEW VI, built and supplied by those at Navistar, was able to reformat the .CRE files such that they were able to be consistently and efficiently called into DIAdem for analysis and report generation.
3. Once proper file formatting was achieved, DIAdem script was built to replace manual loading of individual files into DIAdem for analysis and report generation.
    i. The script was written such that any reformatted file was able to be loaded into DIAdem by simply copying and pasting the file name into said DIAdem code.
    ii. Automated DIAdem analysis code was created for analysis of:
        1. Steering system temperature.
        2. Steering system temperature compared to ambient temperature.
        3. "Adjusted" steering system temperature compared to ambient temperature.
        4. Pressure, flow, and turn angle histograms.
        5. Lateral acceleration histograms.
4. After in depth analysis of the existing LabVIEW VI, it was discovered there were many tiers to the process for which it acquires data.

i. The way in which the tiers needed to be assembled, and the complexity of separate VI's calling upon each other to complete the task of acquiring data from the different instrumentation used at Navistar was more than the IIT group could comprehend in the allowed timeframe.

Performance against Quality

As previously stated, the quality of deliverables for this project was to be measured in two ways. The first goal was to create new or alter existing LabVIEW VI programs such that raw data channels could be fed directly through these inter-connected programs for analysis in DIAdem. Quality for this portion was to be measured by the robustness of said programs, and their ability to read and convert multiple file types into usable data for DIAdem analysis. The second goal of this project involved creating an automated Diadem analysis tool that Navistar technicians and engineers around the globe would be able to use with little to no advanced training. Quality for this portion was to be defined by the DIAdem script's ability to fully automate analysis for several different file types, different channel layouts, as well as its ability to do so with multiple files at the same time.

Performance against Budget

Ideally, expenditures for this project were to be kept to a minimum without negatively impacting progress and completion of said project. As LabVIEW and DIAdem software were necessary for any advancement of the previously stated goals and benchmarks, licenses for both were acquired by the Inter-Professional Project department at the Illinois Institute of Technology, and installed on laptops provided by the university. It was deemed that no further expenditures were required for the completion of this project, beyond minimal personal expenses for travel to and from Navistar offices located in Melrose Park and Lisle, Illinois.

Key Lessons

What Went Right

I. Communication between Navistar contacts and the IPRO sub-group proved, for the most part, to be useful.
II. While initially difficult, out-of-class meetings between group members proved helpful in advancing the goals of the project.
III. Weekly status reports between the group and our Navistar Liaison, Daniel Gapinski, proved helpful in righting the ship, so to speak, when the group began to drift off course from the overarching goals of the project.

What Went Wrong

I. The description of this project, provided before the beginning of the semester, and available online at my.iit.edu, varied sharply from the actual goals and scope of the project provided by Navistar at the beginning of the semester. Due to this, the learning curve for this project was significantly steep, considering student backgrounds and respective majors.
II. Misunderstandings of the goals and scope of the project delayed work on the analysis of the supplied raw data.

III. Disagreements between the Illinois Institute of Technology and Navistar legal departments left the entire project team in the dark for a number of weeks. During this time, we were unable to get information, suggestions, or feedback on project progress from our respective Navistar liaisons.

IV. A working plug-in for .CRE files was not included with documentation and files supplied to the group by Navistar. National Instruments, the license-holder for DIAdem, offered to build a custom data plug-in for this project at no charge. It was, however, decided by Navistar that this was unnecessary, costing the group several weeks while trying to find an alternative solution.

V. Existing LabVIEW VI programs, built by Ed DeWitt prior to beginning this project, were not made available to the group until ten weeks into the semester, making previously stated LabVIEW goals nearly impossible to complete in a timely manner.

These issues, by and large, took precious time needed for completing previously stated goals from the group. The team ended up spending a large part of the project simply trying to find a workable solution to file formatting, such that all raw data channels could be analyzed in DIAdem. Our Navistar Liaison, Daniel Gapinski, while quite helpful in keeping the scope of the project in sight, had little to no experience with either LabVIEW or DIAdem, and thus learning both programs on the fly was left to the group for most of the semester. Another Navistar employee, Tony Rogness, a near expert in both LabVIEW and DIAdem, was made available twelve weeks into the project, and was able to help us solve our formatting issues in a matter of days. Had this resource been available earlier in the project, it is the belief of the group that much more progress could have been made.

Recommendations

When working with two types of specialized software as a group, it would have been extremely helpful to have had both DIAdem and LabVIEW installed on multiple computers. Due to logistical issues related to living in different areas or cities, it was often difficult to get together as a group on weekends. This meant that only one person was able to work on either software package at any time, slowing the progress of the project. Furthermore, in the future, we believe that a clearer definition of the original goals and scope of the project would have saved the group valuable time and resources. Additionally, more direct contact with Navistar liaisons, rather than inefficient communications, such as email or last minute conference calls, and sooner availability to the resources in Navistar's possession, could have prevented delays based on misunderstandings at the beginning of the project. This would ensure that time and effort is not wasted on parts of the project that are either not part of the benchmarks and deliverables for the project, or are ancillary, such as file conversion, to the main scope of the goals of the project.

Questions & Comments

No questions at this time; see recommendations for comments.

Project Planning

How was the Project Planned?

It was suggested by Navistar that the team split into two groups, one focusing on DIAdem, the other on LabVIEW. However, it was decided by the IPRO team that the entire group should work first on DIAdem before moving on to LabVIEW, as LabVIEW information supplied to the team at the beginning of the project was rather limited. This was decided due to the entire group's lack of familiarity with both DIAdem and LabVIEW software. Research was done individually outside of class, and findings were shared at either out-of-class meetings or during class time. Outside resources, such as National Instruments, were consulted both individually and by the group as a whole.

Eventually, as previously written LabVIEW VI programs and other information began to be provided to the group by Navistar, the IPRO team split into two sections, with one working on DIAdem analysis, while the other began to work on the LabVIEW data acquisition VI programs.

Was the Plan the Right One?

Looking back on it now, it might be easy to say that this plan was the wrong one, as very little was able to be accomplished in the LabVIEW section of the project. However, with limited knowledge of both DIAdem and LabVIEW, and limited LabVIEW resources available at the beginning of the project, it cannot be assumed that a two-pronged approach to the project from the beginning would have yielded a more favorable result. It was decided midway through the semester that a solid deliverable in one of the two areas was better than two partially completed projects.

Research and Development

How was R&D Managed?

The Real World Vehicle Response team consisted of five Illinois Institute of Technology students. The team reported directly to Daniel Gapinski, senior project development manager at Navistar. Despite his lack of experience with DIAdem and LabVIEW, questions on the overall scope and ambition of the project were answered by him in a timely manner via email or phone.

The IPRO team communicated with each other regarding findings, questions, and suggestions regarding the project via email and text messaging. Additionally, the technology experts in the IPRO office were consulted when the team ran into any technical issues that seemed beyond the scope of our knowledge.

How Effective & Efficient was R&D?

While issues or problems were identified early, often, and efficiently, solutions were often slow to come, either due to a lack of understanding of the goals of the project, or due to lack of technical savvy. Technical experts consulted in the IPRO office were often unable to find solutions, despite their high level of technical expertise.

Communication concerning deliverables between IIT's team and Navistar contacts could have been better with respect to identifying more specific objectives early on in the project. A great deal of time was wasted at the beginning of the semester simply trying to understand the goals and final deliverables needed from the Real World Vehicle Response team.

Quality Analysis and Conclusions

Progress on the project was gauged by either weekly or bi-weekly check-ins with our Navistar contact, Daniel Gapinski. This helped the group not only further understand necessary goals and deliverables of the project, but to allow the group to stay on task, lest we veer in a direction not needed for the completion of said project.

Limited previous exposure to the DIAdem analysis tool, as well as LabVIEW data acquisition software, makes gauging the quality of progress and deliverables difficult to evaluate. A working DIAdem script, capable of fully automated analysis for a single properly formatted .CRE file has been achieved. The analyzed file can be chosen by simply copying and pasting the file name from the modified raw data files into the existing DIAdem script. However, progress toward a fully automated program, capable of analyzing multiple files, was unable to be completed, due to the time taken to modify .CRE files into usable formats, as well as other time constraints.

Very little was accomplished on the LabVIEW portion of the project. The complexity of the LabVIEW VI's needed for completion of the second portion of this project made writing new programs from scratch impossible, given previous and acquired knowledge of the software. Partially built LabVIEW VI's were supplied to the group just four weeks before deliverables were due; as such, little to no progress was made on this aspect of the project.

Upon resolving issues with file types and formatting to be used in conjunction with DIAdem, a great deal of progress was made on this part of the project over the last third of the semester. A script was written to automate the analysis of a single file of raw data supplied by Navistar. Unfortunately, little to no progress was made on the LabVIEW end, either writing new VI programs or understanding and modifying existing VI's for data acquisition and translation into DIAdem. Ultimately, the deliverable for this project is a working DIAdem script, capable of performing the necessary analysis on steering and chassis systems, as requested by Navistar. However, this script works only for a single file, and is currently unable to analyze multiple data files simultaneously. This script is a good start, and, given more time, could be modified for use with multiple file analysis in the future.