BDrive®
Power for Intelligent
Collaborative Infrastructures™

Putting Data to Work:
A Test Data Management System

1 Abstract

BDrive has developed several Test Data Management Systems (TDMS) for leading Automotive OEMs that links together related product test data and makes it accessible to the global community from a central access point. These new systems replicate the current manual process that is time consuming and error prone, with one that is centralized allowing engineers to quickly locate and validate existing test information. Through the use of a proprietary search methodology, and data transfer techniques, the new application greatly reduces the time required for data uploading and ensures that engineers find the right data on the first search attempt. BDrive has developed and deployed Test Management Systems for a number of engineering attributes: Aerodynamics, Cooling and Heat Management, Durability and High Mileage Testing, Noise and Vibration, Safety (Crash data), Power-train Benchmarking and Tear-Down studies. Consequent to building a test database, we have created intelligent structures that enable requirement analysis (post-benchmarking), target setting, data mining, the building of predictive utilities to conduct "what-if" studies, process management via Engineering Portals and the dissemination of training and best practices via Web-enabled education (e-Learning).

The development of the TDMS system provides a robust data foundation on which to build next generation product development tools quickly and efficiently. Several of these tools are discussed herein. The deployed system and subsequent development tools can and are having a profound effect on the product development process, by reducing time to market, controlling costs, and improving design quality.

Built using our Collaborative Development Platform, MANTRA these systems are web-enabled, data-driven and security-governed thus providing the community with infrastructures that are *agile, productive, and connected.*

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2 Introduction

Why do we test? Fundamentally, it is to validate that the products we develop perform as expected and if not, to improve the design so that they will perform to the required specifications. But before engineers can improve a design they need to make decisions on what works, what breaks and what needs improvement. In order to make these decisions, they require understanding. Understanding of why products perform they way they do - what leads to success or failure? To gain understanding they need information. Data they can analyze to reveal the elusive facts regarding a product's performance in the real-world. And for this they need to test.

Thus the primary purpose of testing is to capture information. Testing groups today are very good at capturing information. They have honed their techniques; they use state-of-the-art test equipment, and have the ability to capture very accurate information, and lots of it. One of the primary struggles of engineering departments in their quest for understanding of this information is dealing with the vast amounts of data that is captured. Traditionally, this data has been stored by testing groups in disparate databases with limited accessibility. Furthermore, IT infrastructures have not been robust enough to handle transferring large data sets across a company's intranet thus the data has been cut up into smaller sizes for easier handling and processing.

For all of these reasons and more, data processing has typically been handled as a manual process. If an engineer is interested in understanding a given data set then it is up to them to do the work. To search the various locations to find its location, transfer the data to their local machine and then to process the data as they see fit to better understand the test results, and finally to present the data as they understand it so that decisions can be made to move forward.

This process is tedious, error prone, and biased. It puts the confidence of the resulting decisions on the shoulders of the engineer who conducted the analysis. Now, we would all like to think that we have good engineers working for us. They are all quite capable, with degrees from reputable universities, but they are all human. They are all individuals with our own way of looking at problems and their own way of doing things, and like all humans they all make mistakes. So now were does your confidence lie with regards to the decisions you just made for that new product? Makes you a bit nervous doesn't it?

In order to alleviate many of these issues and improve the speed and accuracy of the work engineers are conducting on test data, BDrive has developed several test data management systems that provide a unique environment that promotes data accessibility, automates the test analysis processes, standardizes output, and greatly enhances the confidence of the decisions being made based on this information. Furthermore, these systems provide an excellent foundation for further enhancing the product development capabilities of any engineering department. By capturing test data in a central depository, accessible by the entire organization, this information becomes a gold mine of corporate intellectual property for historical referencing, development of Expert Systems for new concept designs, and for correlating between the physical and virtual environments. The benefits of these systems are numerous and significant to any product development group interested in reducing product development time, reducing development costs, and improving design quality.

3 Background

The Thermal Test Data Management System (T-TDMS) is an excellent example of putting data to better use. T-TDMS was developed for a leading automotive OEM. Their existing methods were distributed and manual resulting in a very time consuming and error prone process. Furthermore, the data that was processed became lost or hidden on individual computers through the company, forcing subsequent users to start the process from scratch, re-analyzing the same information or in worst cases conduct a re-test for the same information. Data was processed in a different manner based on who conducted the analysis and results were presented based on their individual bias and objectives. The resulting decisions that were made were often faulty and thus required significant amounts of re-engineering, and re-testing.

T-TDMS was established to eliminate many of these issues by providing global access to all thermal test data collected at various locations throughout the US and their facilities in Europe and Asia. The delivered system provides global access to a proprietary search methodology that enables engineers to find the right data quickly and efficiently. Easy upload capabilities are provided to ensure the database is populated with new data, processed analyses, and final reports. This upload feature takes advantage of grid computing technologies to accelerate the uploading process for large test datasets. Information can then be sorted and presented based on particular attributes or by vehicle model and year further facilitating filtering and searching. Introspection of the data is provided via a bolt on plotting service. The plotting service allows engineers to quickly present the data in a standardized format, or to visualize the data to assess its relevance and accuracy. Further analysis can be conducted on the data once downloaded to the individual engineers desktop.

The T-TDMS system has dramatically increased the speed and accuracy for finding and assessing thermal test data. It has removed the normal hurdles that engineers had to experience just to locate data and ensure data validity. Additionally, it has reduced overall testing demands. With the central access point, engineers can now quickly find relevant data without having to request duplicate or redundant tests.

With this foundation in place, next generation system will focus on putting this data to further use. The construction of automated analytics, expert systems and correlation with CAE results are planned next steps. These added elements will dramatically increase the re-use of test data thus decreasing the cost of collection. But more importantly, these features will accelerate the product development process by meeting performance targets earlier, and establishing more confidence in CAE results, resulting in reduced product development costs, development time, and testing requirements.

4 Architecture Methodology

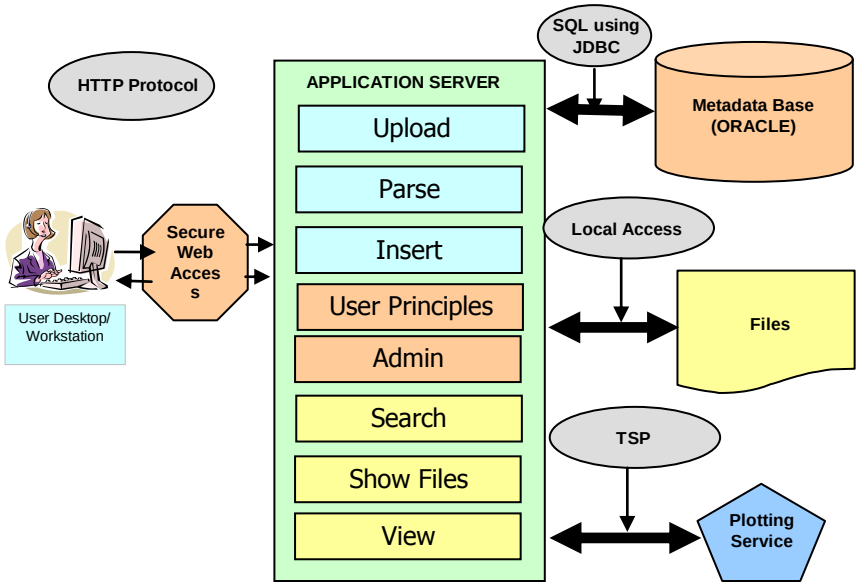
BDrive provides the next generation of applications to reduce inefficiencies during the Product Design and Development phase of Product Life-Cycle Management (PLM). These applications enable product development infrastructures to exploit information super-efficiently by embedding within them the intelligence and capability to "pull" and/or "push" the right information from the right source at the right time. Consequently, enterprises are able to save significant cost by shortening product development life cycle. These applications will also impact the revenue side positively through quicker time to market.

Architecture, Data Model & Framework

The high level architecture for the T-TDMS system is shown in the figure below. Some highlights include: secure log on from remote desktop, administration capabilities to manage metadata entities, upload and download features, bolt on plotting services for introspection of data sets prior to download, and metadata database for entity management.

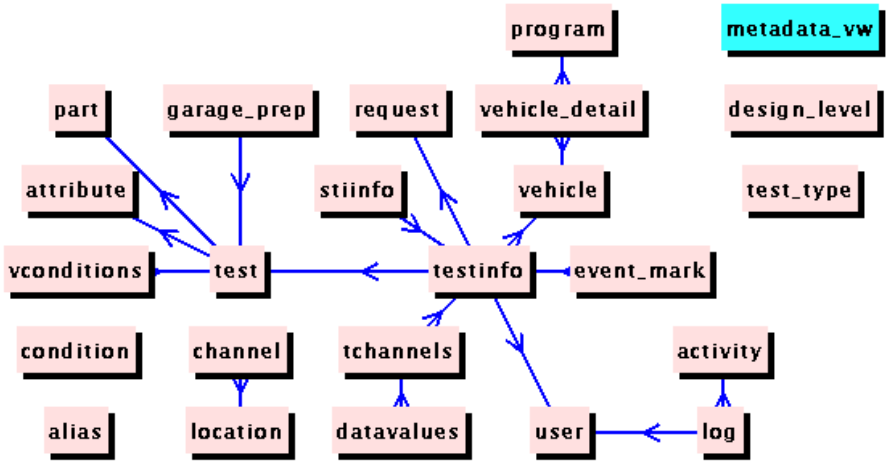
Architecture

Users access the system via a secure web based login following standard corporate security procedures. Once in the application, users have access to upload data from their local system to the database or search and retrieve data from the existing database. Once searching has been completed, but before users spend time downloading the wrong files, users can first visualize the data either in its raw data format or visually via the plotting service to ensure they are retrieving the correct data. Once downloaded the data can then be processes by the user based on their own procedures at their local desktop. After analysis and processing have been completed, users can upload processed data or engineering reports back to the database for storage, communication and use by others in the company.



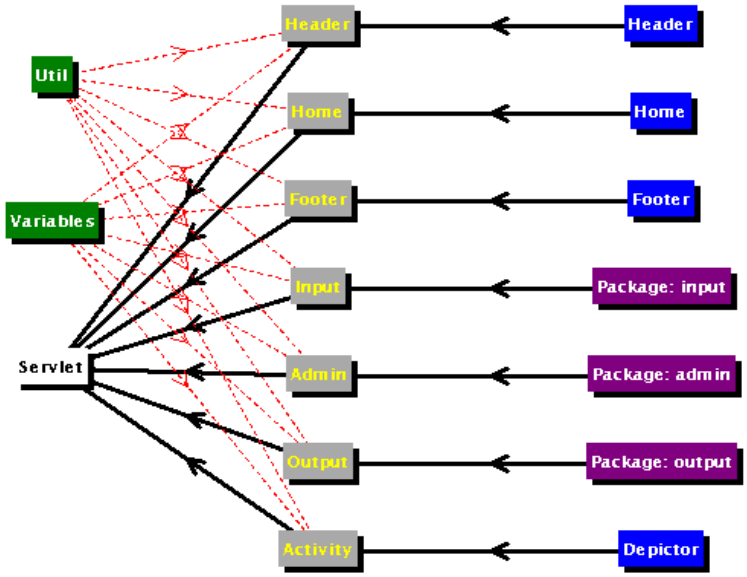
Data Model

The adjacent diagram graphically represents the data relationships that exist within the application. Arrows point toward the relationship parent or from where the data block receives its information.



Application Framework

The application framework graphically depicts how the application is built. Each of the block represents a stand alone JAVA application that when combined, unite to form the application.



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5 Features & Functionality

The primary functional elements of the T-TDMS application include:

- Data Input (accessible only by select users)
  - Manages uploading of data from disparate locations and systems.
  - Automatically parses files to extract metadata entities for robust searching.
  - Provides storage mechanism for post-processed data, engineering reports, etc.
- Administration (accessible only by select users)
  - Manages metadata entities.
  - Provides ability to add, delete, and rename entities.
  - Manages redundant names or aliases for metadata entities.
  - Application metrics showing performance of system and usability statistics.
- Data Output & Visualization
  - Provides progressive search capabilities – ensuring the right data is located quickly and efficiently.
  - Presents data by vehicle attribute or by vehicle model and year.
  - Ability to browse data before download.
  - Ability to plot data –
  - 1 axis, single & multi-sensor information.
  - 2 axes, single & multi-sensor information.
  - Download data via csv file format for further analysis.

Attribute Management

The T-TDMS system uploads and manages three types of vehicle thermal test data, which are:

- Thermal Test Data
- HVAC Test Data
- Powertrain Cooling Test Data

Each attribute can be searched independently or via modifications under the Administration Module, combinations of two or more attributes can be selected to narrow the search parameters. This capability facilitates faster results retrieval and is ideal if users are searching across several disparate systems or global intranets where connections speeds are not consistent or slow.

Data Formats

All BDrive applications are data format independent. The T-TDMS application has been developed to accept the following file formats based on client requests, but these the file types are not a constraint.

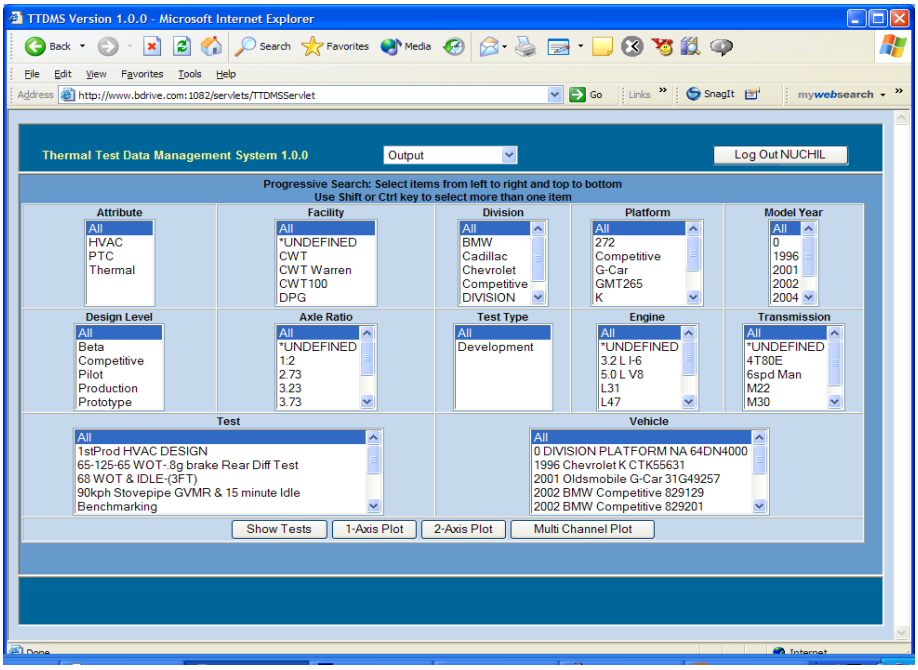
- MS Excel (Microsoft)
- CSV (comma separated)
- STI (raw data)
- ZIP (containing any valid file format type)

Other test data management formats have adhered to the specific hierarchy of data specified by the OEM or enabled the direct port of raw data from test silos to relational databases via XML based translator templates. In subsequent releases of our applications, we intend to support ASAM/ODS and the STEP object definition formats for engineering data management.

Unique Features

T-TDMS possess several unique features that are proprietary and only available to BDrive's clients. They include:

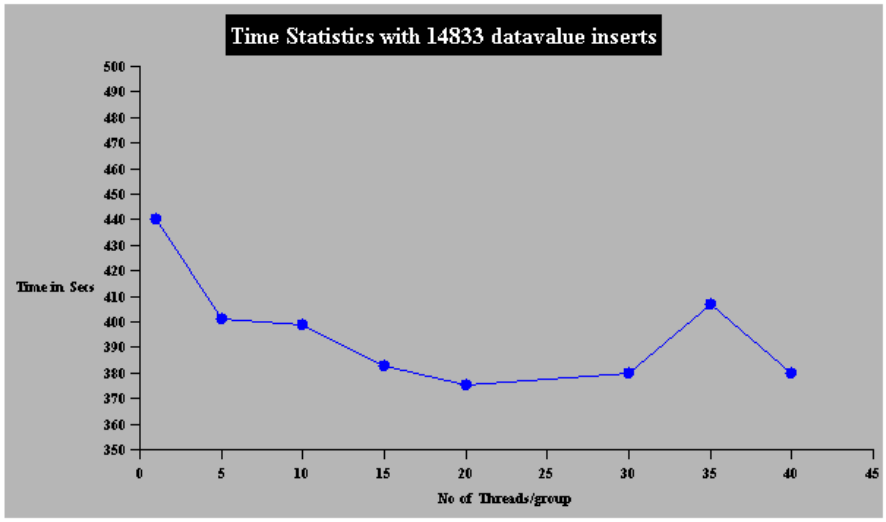
The Intelligent Dot – A Progressive Search Engine



The figure below shows a typical search page. The way the progressive search engine works is as the user selects parameters from the windows, starting at the top left window, the subsequent windows get refreshed revealing only data the is available give the selected parameter(s). This ensures that once all requested parameters have been selected the only data left will correspond to these parameters. Gone are the days of entering search criteria in the hopes of finding some useful information, but getting nothing. Too often user have to relax their search parameters because the either couldn't find any data or found too much data. The Intelligent Dot ensures that the right information is located the first time.

FASTDat – Ultra-Fast Data Transfer

FASTDat is a capability of utilizing grid computing technology for uploading and downloading large data sets much faster than current single stream approaches. Grid computing has been used extensively in the Computer Aided Engineering (CAE) industry for many years, and is more recently gaining ground throughout the database community in order to populate large databases quickly and efficiently.



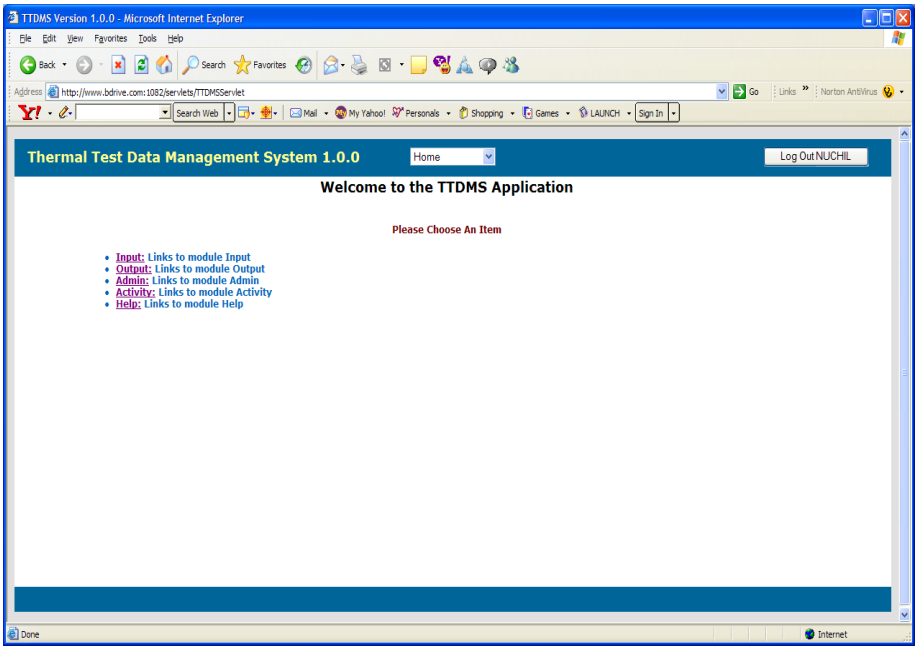
BDrive has used this technology for many years in its experience dealing with large datasets that are typical of the test community. By applying grid computing technology to the upload of data, dramatic improvements in data transfer time can be accomplished. The figure below show the results of one such upload showing the time saving based on the number of threads per group. As you can see a significant time savings is achieved using this technology.

6 Application Showcase

The following screens show the users view-ports as they progress through the application, and the various elements.

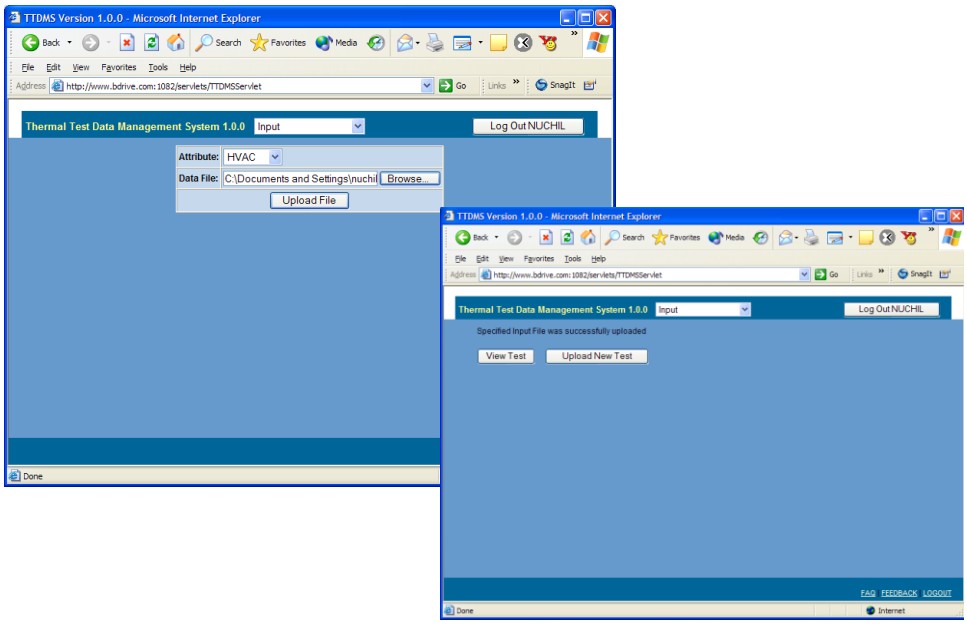
Application Home Page

The screen shown above represents an Administrators view. Based on login parameters, a typical user's view will automatically change to display only the output field.



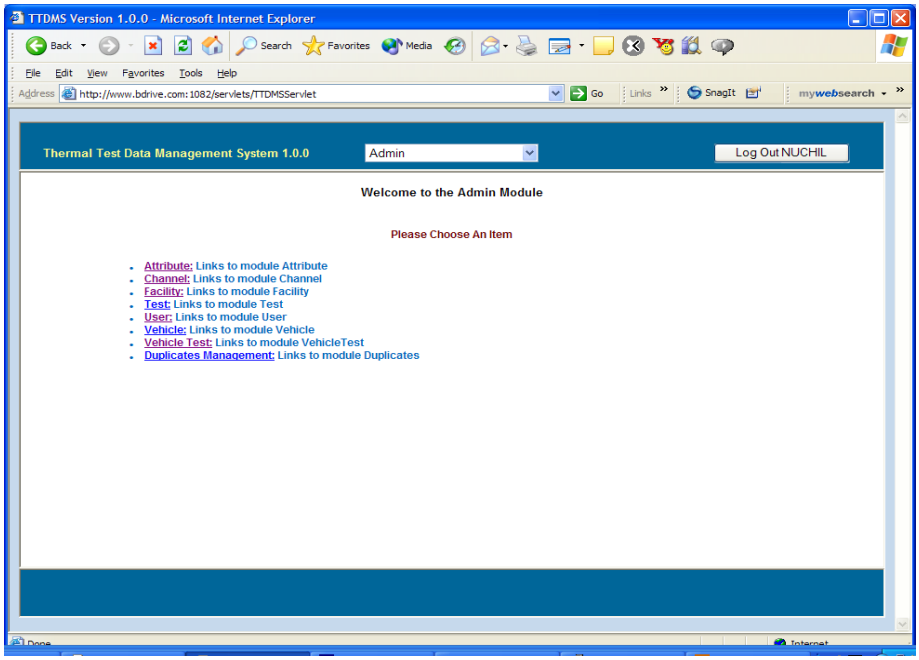
Data Upload

The data upload capabilities will only be made accessible to a select group of gatekeepers within the organization. This will assure that the database does not get populated with arbitrary or inappropriate information.



Administration Page

This page is accessible only by approved administrators, and provides for management of the metadata entities as detailed below.



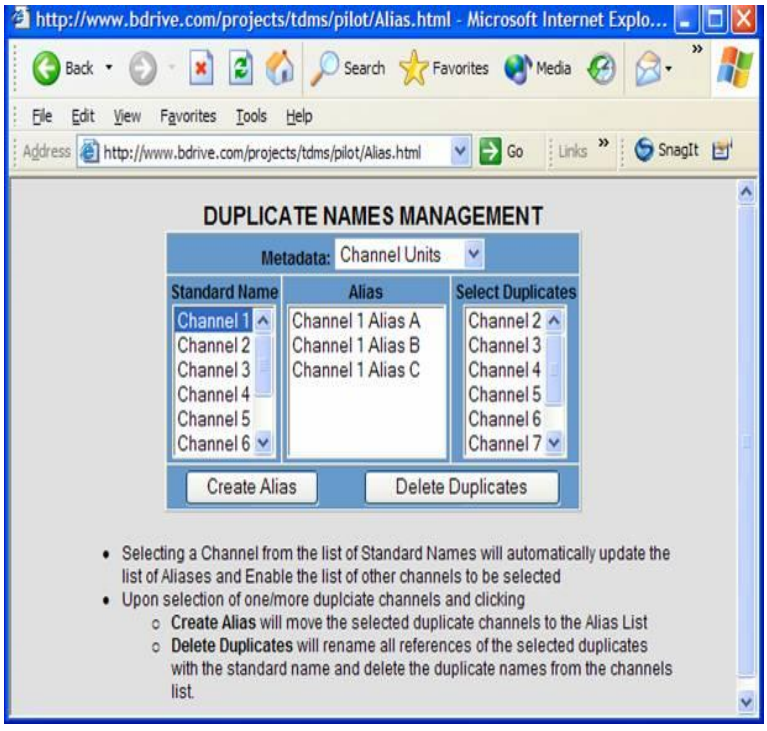
The metadata entities that are capable of modification and customization are grouped under the following classifications:

- Attributes
- Channels
- Facilities
- Tests
- Users
- Vehicles
- Test Information

As mentioned earlier, each attribute can be searched independently or via modifications under the Administration Module, combinations of two or more attributes can be selected to narrow search parameters or better understand the data source location. This capability facilitates faster results retrieval and is ideal if users are searching across several disparate systems or global intranets where particular datasets are not relevant or when connections speeds are inconsistent or slow.

Managing Aliases

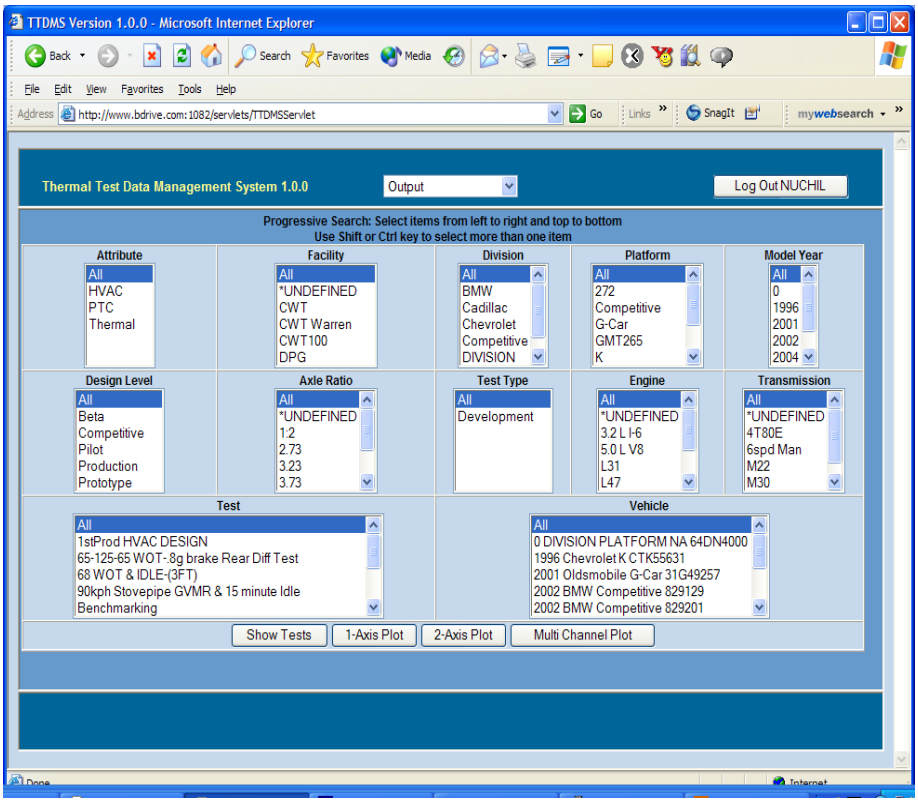
In addition to the attributes mentioned above a unique feature of the Administration Module is the ability to manage multiple or redundant names throughout the metadata entities. It is not uncommon for each test technician to develop unique names for given channels based on their own personal preferences. Likewise, engineers often repeat these same errors during their analysis of the data re-naming channels for their own personal preference and use. If this issue is not carefully tracked databases quickly get out of control with superfluous names that hinder users efficiency and propagate errors though the application. It then takes an administrator an excessive number of hours to clean up the names and reset the database. For this reason it is the objective of every corporation to develop and use a consistent naming convention, and while this is an objective, it is unlikely that you will ever find one that is perfect.



In order to eliminate this problem for administrators and users we have developed functionality for allowing multiple names that represent the same data to coexist. Also termed aliases, these names are captured and maintained by the administrator to quickly clean up databases and ensure that they stay orderly regardless of the names users like to use. This feature is saves considerable time in maintaining databases and reduces the likelihood of errors being created and propagated throughout the system.

Data Output & Visualization

Below is the main search screen that was displayed earlier. This is the starting point for users as they collect data for further visualization. As mentioned previously, BDrive proprietary progressive search engine will ensure that the right data is located quickly and efficiently. Please review the previous section for further information on how this technology works.

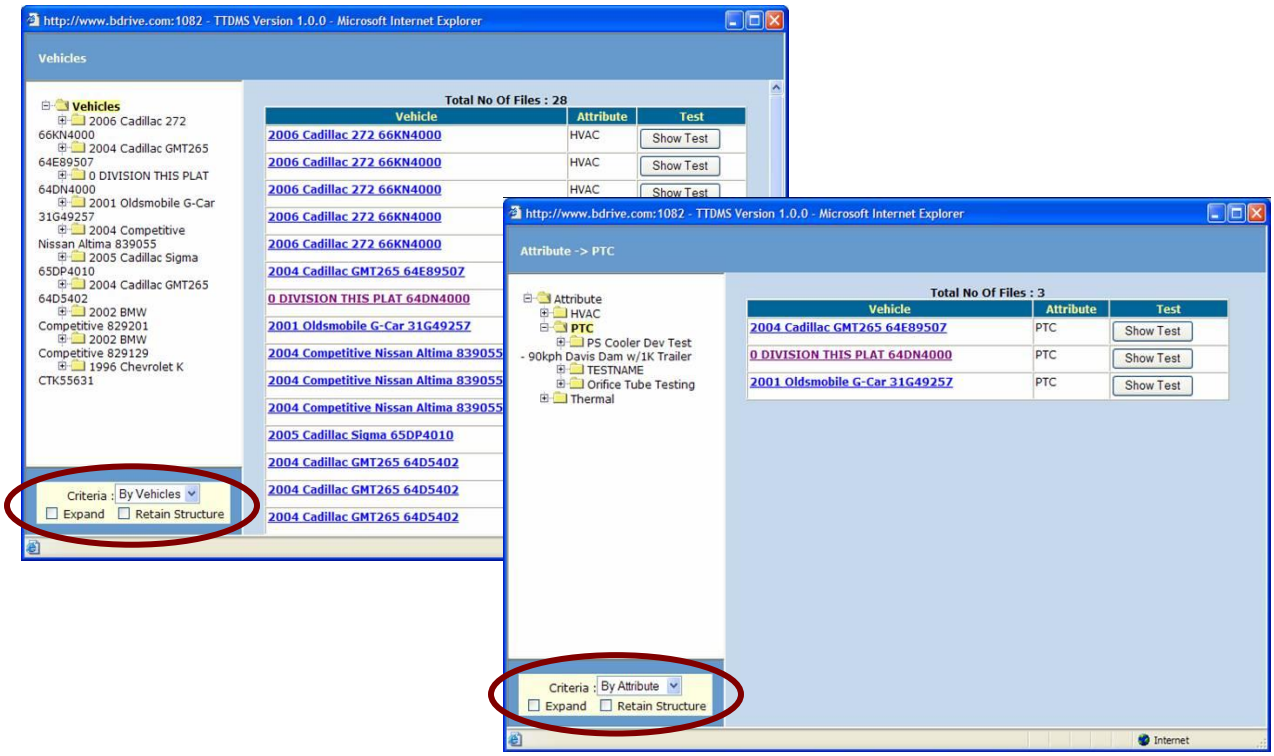


Once they have selected their search parameters they can select one of the following next steps:

1. Show Tests
2. Axis Plot
3. Axis Plot
4. Multi-Channel Plot

1. Show Tests

The two screens below show the output from the search based on a given set of parameters. As noted below the resulting tests can either be classified by attribute or by vehicle. If information about a specific vehicle line is desired, this feature facilitates searching for particular data corresponding to that vehicle line. If general attribute specific test data is desired then the attribute parameter can be selected, and the resulting data will be available for all vehicle models. Once the desired test is selected the user can then click to view the actual data set.



2. 1-Axis Plot

Once a test is selected the data can be view as a single axis plot. Additional features to select specific channels and to clean sensor errors from the display are also included.

3. 2-Axis Plot

Once a test is selected the data can be view as a 2-axis plot if warranted. Additional features to select specific channels and to clean sensor errors from the display are also included.

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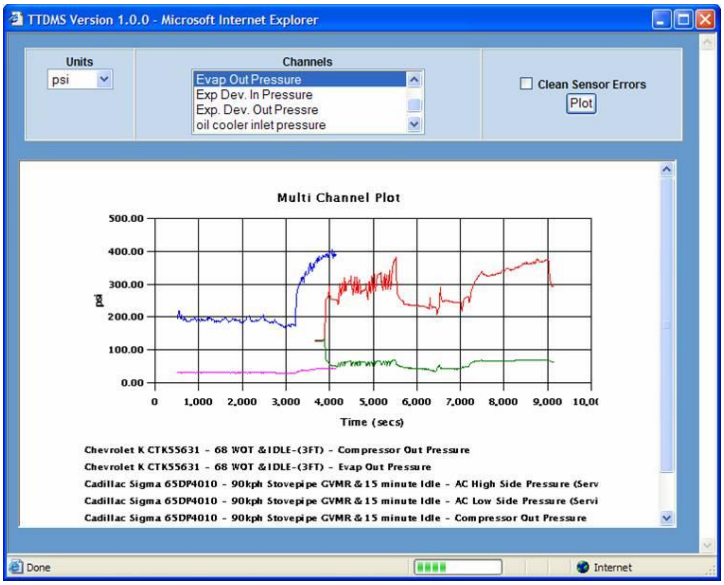
4. Multi-Channel Plot

Once a test is selected the data can be view in a Multi-Channel plot. Users will first select a unit value from the pull-down menu. Once selected the channel list will automatically update to display only channels corresponding to unit value selected. User will then select as many channels as desired for plotting. Additional features to clean sensor errors from the display are also included.



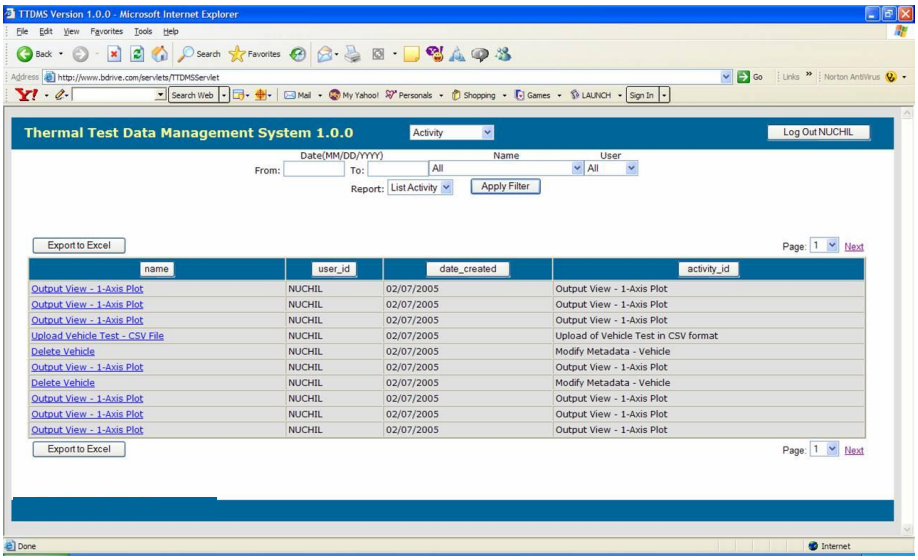
Activity Log & Metrics

System activity and metrics can be visualized to understand how the application is being used and by who. These features help administrators improve the system either from a performance standpoint or from a feature and usability standpoint. Furthermore, the Metrics page provides useful information regarding the application specifics which can be use for future planning purposes, expansion to other groups, and forecasting hardware storage requirements. These features help IT professional better manage their existing IT infrastructure. By planning for future additions rather than having new hardware requirements thrust upon them, IT groups can make changes and/or additions at the right time and for the right cost.

Below are several screens showing the typical application statistics that are monitored.

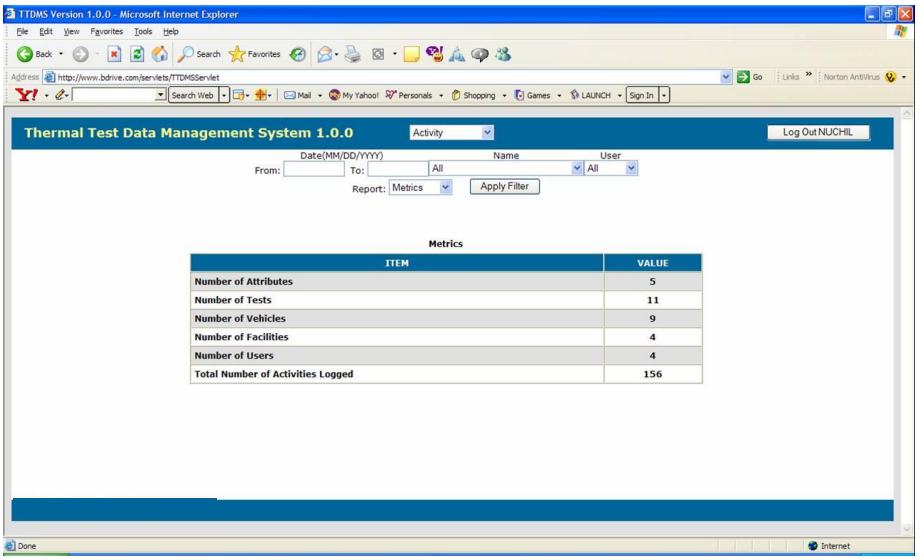
Activity Log

The screen to the right shows the latest activity of the application. Statistics such as recent users and their activities are listed and can be sorted, filtered and searched.



Application Metrics

The screen to the right shows the application metrics. This screen documents the statistics of the application with respect to number of records, size per record, total space requirements, etc. This information can be used by IT departments to better manage their system requirements, allowing them to plan for enhancements and upgrades and to make more informed decisions regarding the system needs.



7 Next Generation Applications

The current T-TDMS application provides a solid foundation on which to build. Providing a central assess point to relevant data is one of the most burdensome challenges that companies face today. Having this foundation in place makes the development of next generation applications much easier, and faster to deploy.

Next generation applications can be quite varied and unique. Some may span outside the engineering department and across the organization including sales forecasting, financial reporting, or warranty analysis. Many of these applications, which can be very beneficial, have a much higher level of intricacy and require a much larger commitment since they span multiple departments. Therefore, for the purpose of this paper we will focus on three applications fully within the typical engineering department domain: Intellectual Knowledge, Expert Systems, and Correlation.

Intellectual Knowledge

Corporate intellectual property (IP) is always challenging for companies to capture and manage. It is typically an after thought, thus making it burdensome and costly to collect, yet it is highly coveted and incredibly valuable. The T-TDMS system is an excellent example of how companies can begin to capture, manage, and disseminate corporate IP. If you recall the T-TDMS application is intended to not only store raw test data, but finalized data analyses and reports. Having this foundation in place, engineering departments can utilize the information in numerous ways. In its simplest form as a historical reference, that can be searched; as teaching aides to younger or less experienced engineers; or for design studies for future concept designs.

Expert Systems

Expert systems are an example of how companies can use the IP that they captured and re-use existing data. By putting this data to use again, companies can quickly develop new design based on historical data that has been proven successful. Likewise, these systems help to highlight poor design choices so that errors are not propagated or repeated. These systems have the potential to dramatically shorten new product development cycle times, improve product quality, improve time to market, and reduce development expenses.

Additionally, expert systems make excellent teaching aides. The expert systems that BDrive has developed are fully documented and provide on-line help at the click of a button. These systems walk users through the process of conducting design studies thus allowing them to fully understand the interactions of the physics at work. Furthermore, they teach corporate processes and design methodologies, important skills that corporation needs them to propagate in their daily work.

Correlation

More and more emphasis is being placed on reducing physical testing and increasing virtual testing or computer simulations, also known as Computer Aided Engineering (CAE). Where most of this work fails is in its ability of the results to correlate between the virtual and physical worlds. While improvements continue, correlation is a necessary part of any CAE process. In order for any CAE process to be successful a strong understanding of how parts are tested is required.

As we have discussed previously, one of the most important aspects of the T-TDMS system is that it provide access to test data that was previously difficult to locate. With the T-TDMS system engineers can now quickly located the correct test data, but they have to conduct their own analyses of that data manually on their local machine. BDrive has developed systems for other clients that automate this process. Gathering both the CAE and test data in one central location, BDrive applications then compute the statistical process control algorithms to determine how well the datasets match. From here engineers can ascertain whether the results of their CAE analysis can be used, and with what level of confidence. Additionally, any abnormalities can be investigated to understand root causes, whether they occur from broken test fixtures, or poor modeling assumptions.

8 Conclusions

Like many companies these days the global pressures of competition and the need to control costs are having profound effects on the way companies do business. Luckily, the advances in hardware and software technology are keeping pace and continue to provide robust methodologies for streamlining business processes and increasing corporate efficiency. BDrive is a company in this field with leading-edge tools and methodologies, providing robust solutions to our clients most intricate and important business problems.

The T-TDMS application is just one example of how BDrive is working with its clients to increase data re-use, promote standardized tools and processes, and increase communication through the product development community. The T-TDMS application replicates a current manual process that is inefficient, error prone, and slow. The new system communicates globally, establishes standards for visualization and reporting, and dramatically reduces the time required for processing thermal test data.

Typically, engineers would order tests to be conduct not knowing that data already existed because they either didn't have access or they couldn't find the information. Another tangential benefit of the T-TDMS application is its ability to reduce the demand for new redundant tests thus decreasing the testing burden and testing costs.

The T-TDMS application provides an excellent foundation for building next generation applications that can profoundly affect the product development process. By building off of existing historical data, teaching aides and concept design tools can be built quickly and efficiently. These tools can dramatically reduce new product development time, reduce costs, and increase design quality.

About BDrive

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We have been providing Knowledge Management, Process Optimization and other IT infrastructures to the product development community and finance departments for the past 7 years in the areas of:

- Benchmarking
- Futuring And Target Setting
- Test OLAP
- CAE Integration
- Verification
- e-Learning
- Expert Systems
- Manufacturing Assessment
- Sales Forecasting
- Financial Consolidation

We have a system of reuse and application development that will further reduce our application build time and use state-of-the-art IT Technology (J2EE, XML and RDBMS) that enables seamless collaboration of information between people and processes.

In the process of building applications we have created our internal development platform. Called MANTRA IDP, it seamlessly steps thru the process of building applications in a web enabled framework using XML binds to manage the entire creation, deployment and maintenance. This is a pure Java application that we are integrating with WebLogic, WebSphere and iPlanet servers. Using MANTRA BDrive has been successful in reducing application development time by as much as 50-60%, a savings we pass along to our clients.

Moving Forward

Today, we are in a position to service the needs of the Product Development Community even better: by having a thorough understanding of domain needs, use of the latest technologies, and provide the best solutions possible.

We have a proven and time-tested robust methodology to impact Product Development using the latest state-of-the-art technologies in IT, to make it optimized, collaborative and intelligent. This enables clients to compact their product development lifecycle considerably with a magnitude return on ROI.

To make our applications more efficient we are partnering with service providers like BEA (WebLogic), IBM (WebSphere and VisualAge), SUN (iPlanet), Borland (BAS) etc., and with niche tools providers like Inxight, Visual Mining, Spotfire, Oculus and Visual Numerics. Our interactions with products from companies like KSD (Knowledge Systems Design), Fair Isaac (Blaze Software/Neuron Data) and Visual Numerics is bringing us the expert system/AI toolset intelligence that we embed within our processes and business logic.

For further information about BDrive, its products and services, please contact us via the World Wide Web at www.bdrive.com or you can contact us directly at 248.380.0815

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