Hodges Transportation, Inc.
Nevada Automotive Test Center
N00178-14-D-8052

System Engineering and Analysis/Advanced Technology Support

Technical Capability

The Nevada Automotive Test Center (NATC) is a family owned, independent, small business engineering firm providing test and evaluation, research and development services with its headquarters located 30 miles east of Carson City, Nevada. NATC utilizes land and water areas totaling approximately one million acres. A branch office is located in Quantico, Virginia, to provide services at close proximity to the U.S. DOD, U.S. DOT and other Federal Government agencies. NATC also operates a Winter Test Facility at West Yellowstone, Montana, for timely response to customer needs.

Although primarily dedicated to ground vehicle systems, NATC conducts vehicle component evaluations and certifications, and weapons systems and ammunition tests. Since its founding in 1957, NATC has continuously served commercial, federal and defense organizations in the United States and foreign countries. Throughout the years, NATC has contributed to the development of wheeled and tracked vehicle systems. NATC has logged more than 40 million vehicle test miles and evaluated more than 1,000 different vehicle systems from motorcycles to Class 8 trucks to earth moving and agricultural equipment.

On-site resources include two full-sized vehicle environmental test chambers and two component-sized chambers for fungus and corrosion tests; a railroad transportability test area; skid pads for vehicle dynamics evaluations; a large tilt table; established slopes, fording pits, and obstacles; fabrication and repair facilities including engine and electronic system rebuild; approximately 3,000 miles of test courses; and on-site ranges for direct-fire weapons systems.

The NATC facility is situated in a rural portion of northern Nevada, but it has access to all major transport systems. Rail and air cargo facilities are located within 60 miles at Reno, Nevada.

Standard engineering and testing services include translation of customer needs into specific performance requirements, followed by development of the design and test criteria and scheduling of associated test courses, facilities, ranges, and instrumentation to best satisfy these requirements. NATC provides support during the development of requirements and standards to verify performance; and the bulk of testing at NATC is on prototype and developmental equipment.

NATC recognizes the need for a broad range of services immediately available at one location. From structural analysis to prototype fabrication to production hardware certification, NATC meets these needs throughout the entire vehicle development cycle. NATC combines more than 40 years of ground vehicle system development and test experience with analytical testing and practical, real-world solutions to create tailored test programs.

The following list provides a synopsis of areas in which NATC has significant experience in providing need-based services to its customers.

- Design of structures/components to improve performance and reliability
- Development of onboard data acquisition systems
- Vehicle mobility optimization
  - Tires, suspension, traction, braking, durability
- Integration of ballistic protection systems into vehicles
- Prototype development
  - Virtual Prototyping and Validation
- Hybrid electric vehicle testing
- Hybrid electric vehicle system integration
- Modeling and simulation of vehicle systems
  - Handling, stability, ride traction, structural and failure analysis/prediction
- Rail transportability (impact) test
- Unique understanding of specialty vehicles
  - Emergency response vehicles: ambulance, fire trucks, airport fire and rescue trucks, safety and law enforcement vehicles
- CSC container certification
- Life cycle cost analysis
- Safety analysis
- Failure Analysis
- Operational training
- Logistic support and analysis of alternatives

History and Facilities

After heading the Detroit Arsenal's test facility at Camp Bullis near San Antonio, Texas, Henry C. Hodges moved to the Carson City area in 1957 and started the Nevada Automotive Test Center as a division of Hodges Transportation, Inc. The site was chosen based on a 1950s U.S. Army Corps of Engineers study which indicated that nearly all of the terrain types found around the world could be accurately represented in northwest Nevada.

Based on its years of experience with on- and off-highway vehicle performance testing, NATC has designed an efficient and productive facility for total vehicle evaluation. Terrain analogs have been established for representative areas in Turkey, Israel, and other locations in the Middle East; for China, Indonesia, Pakistan, Malaysia and other areas in the Far East; and terrain representative of the North German Plain and central Europe. These areas are all within the contiguous test boundaries of NATC. The amount and variation of terrain is extensive, and virtually any required terrain configuration can be simulated naturally without major construction cost. Test course conditions are controlled to provide year-round consistent and repeatable input.

The continued monitoring, measurement and maintenance of these test courses has enabled NATC to develop a virtual proving ground which directly correlates to a wide range of user

environments. The use of the virtual proving ground as a development and testing tool has significantly improved the efficiency of OEMs and the development of prototype vehicles in terms of reducing both development time and cost.

These extremes in terrain and temperature allow testing under conditions similar to those which exist in many parts of the world as formidable obstacles to wheeled and tracked vehicles.

Engineering, System Engineering and Process Engineering Support

NATC has a broad understanding of United States Marine Corps (USMC) and other government agencies needs relative to vehicle platform performance requirements and has developed performance specifications for vehicle platforms ranging from light tactical vehicles to heavy combat support vehicles against applicable mission requirements.

Through its work with electronics systems, vehicle dynamics and handling, and driver/vehicle interface, NATC has developed a vast body of knowledge applicable to Anti-lock Braking Systems, Traction Control Systems, Stability Control Systems, Central Tire Inflation, active and semi-active suspensions, electronic engine and transmission control optimization and onboard power management and control.

In addition, NATC has worked extensively in systems integration. Only when a new technology is actually integrated into a complete vehicle package can a valid study of total performance be made. NATC has the capability to perform full vehicle integration, and then evaluate the complete vehicle, exploring, for example, the interaction between ABS and engine exhaust brakes on large vehicles, the relative effects of tire type, size, and loading on ABS systems, and the lateral traction considerations of ABS and TCS as they affect total vehicle system performance. NATC has developed and validated computer simulations (ADAMSTM) and performed instrumented tests for both on-road and off-road ABS and TCS applications.

NATC has developed parameters and performed trade studies of vehicle components and systems including engines, drive train, suspensions, tires etc. NATC has compiled a library of reference vehicle technologies, design aids, and hardware sources. NATC has also conducted full-vehicle trade studies in which multiple combinations of requirements are weighted, prioritized, combined, and iterated within a computer simulation code to converge toward a solution of maximum utility. Through the tradeoff studies and vehicle systems analyses, NATC continues to develop vehicle systems that meet present requirements while being adaptable to future demands to meet evolving threat levels and theaters of operation.

NATC has developed, fabricated, and optimized a variety of independent suspension systems on heavy-duty and off-highway vehicles. Active and semi-active suspensions have been fabricated and evaluated in a variety of both on- and off-road vehicle systems using pneumatic, hydraulic, and mechanical structure subsystems. NATC also has researched, developed and tested numerous CTI systems and applications. NATC has implemented J1939 electronic mobility

control systems which integrate the CTIS, ABS, suspension ride height, transmission, and differential lock settings onto a common operator terrain/payload control interface.

NATC has full awareness of current threats as applicable to vehicle mobility in hostile environments. NATC is currently conducting several evaluations of add on and integrated design of armor protection for a range of tactical vehicles.

NATC has open-air ranges at the main proving ground facility suitable for tests involving munitions with aggregate explosive weight of up to 100 pounds TNT or equivalent.

A dedicated arena is available for explosives testing and evaluation of both bare charge and shrapnel/fragmentation charges on vehicles and armor. This area can be used for stationary detonation of explosive devices and artillery shells up to 155mm. There are bunkers and protective areas for technicians and photographic equipment.

NATC has the capability to evaluate both active and passive armor protection against most major direct and indirect fire weapons, as well as fragmentation grenades and fire bombs. Evaluations can be made of materials/armor arrays proposed for a system, and as delivered with a system. In addition to analysis of armor protection against conventional weapons and explosives, NATC can also assist in analysis of armor protection against unconventional hostile threats and actions such as the use of jelled gas, homemade shape charges, and other types of devices designed to destroy or disable a system.

NATC has two large DOD and BATF approved bunkers, each capable of storing up to 1,000 pounds of high explosive. In addition, there are two magazines for storage of self-initiating explosives and detonators.

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Reliability, Maintainability, and Availability (RM&A) Support
Human Factors. Performance and Usability Engineering Support
System Safety Engineering Support
Interoperability, Test and Evaluation, Trials Support
Measurement Facilities, Range and Instrumentation Support
Logistic and Training Support

The above listed functional areas are part of NATC's test and evaluation services. NATC testing and evaluation services include development of duty cycles/mission profiles, performance requirements, program goals and work/test plans, conducting a range of tests, providing engineering measurement and analysis/recommendation and report. The services include, but are not limited to, instrumented measurements of vehicle performance parameters and analysis, mode of failure determination/prediction, accident reconstruction, input parameter identification and dynamic simulation of ground-vehicle systems.

NATC has the on-site capability to evaluate all aspects of ground vehicle operations and performance. The broad variety of terrain at NATC allows simulation of any type of terrain condition from paved roads to severe cross-country. The NATC courses are used to certify performance and reliability, Availability, Maintainability and Durability (RAM-D) requirements of prototype and production military vehicles. Mobility test areas range from soft mud (.7 cone index) to sand (10 square-mile live dune) to snow and ice. Commercial test environments include ride and handling course, paved tracks for operational sustained speeds up to 180 mph, salt troughs and cobblestone roads.

The main complex facilities are designed to support the full range of requirements for vehicle development tests. Large shop areas with mobile cranes, machine shops, and fabrication facilities are designed for the immediate response required in field test situations.

A complete range of performance tests conducted in accordance with ISO, SAE, FMVSS, DOT, ASTM, NAV-SEA, FMCSR and Military Standards can be performed. The proving ground's capabilities are not limited to these standard tests. NATC has the flexibility and experience to design special tests to meet a client's specialized testing needs. NATC has specifically developed a duty cycle of the North American user environment representing various regions with different topography, road conditions and climate.

In addition, instrumented tests can be conducted virtually anywhere in the world. NATC has conducted tests in Mexico, Canada, Brazil, Peru, Chile, Algeria, Egypt, Tanzania, Mozambique, Saudi Arabia, Israel, Turkey, France, Italy, Germany, Great Britain, Sweden and China. NATC has an in-depth understanding of technologies used and operational issues in countries around the world.

Based on international experience, NATC has developed test routines representative of specific geographic areas. Examples include:

- European Simulator
  Includes high-speed operation, paved secondary roads, cobblestones, mountainous terrain, snow, soft soil, humidity, rain and blowing rain, high and low temperature, salt fog

- Middle East Simulator
  Includes paved roads, unimproved roads, sand courses, basaltic rock, blowing sand and dust tests, high temperature, solar load

- China Simulator
  Includes paved roads, unimproved roads, basaltic rock, soft sand, mud, blowing sand and dust tests, high and low temperature, rain and blowing rain, solar load

- Russia Simulator
  Includes high-speed operation, paved secondary roads, unimproved roads, degraded paved roads, basaltic rock, snow, frozen tundra, mountainous terrain, high and low temperature, rain and blowing rain, blowing sand and dust, humidity, solar load.

Durability and Specialized Test Courses

Test courses include representations of the U.S. Army's Aberdeen and Yuma Proving Grounds, and Twentynine Palms MCAGCC. These simulators include APG's Perryman, Churchville and Munson Road Courses, APG Shock and Vibration Courses, YPG Truck and Tank Courses and MCAGCC 50-mile and 200-mile loops. NATC can duplicate any of the performance tests conducted at these military proving grounds. The Munson Road test courses consist of the standard 3" spaced bump course, a 6" washboard course, a 2" washboard course, a radial washboard course and a Belgian Block course. NATC's Munson Road courses have been approved for MIL-STD validation and certification.

Environmental Chamber Test and Certification

NATC operates three complete-vehicle environmental chambers capable of MIL-STD-810 certification. Two of these chambers are situated end-to-end and can be operated independently or interconnected for a total length of 88 feet. One chamber is 16 feet high, 16 feet wide, and 56 feet long; the other is 21 feet high, 20 feet wide, and 32 feet long. The third chamber, which is used primarily for humidity and corrosion testing, is 40 feet long, 18 feet wide, and 14 feet 8 inches high.

Natural breathable atmospheres are generated from - 60°F to +160°F, obviating the need for man packs, and relative humidity is controlled between 5 and 100 percent. Conditioned engine make-up air is available at a rate of up to 900 cfm. There is heat rejection to 1 million BTU/hour. Solar radiation fixtures simulate the sun's spectral irradiance from ultraviolet to infrared. NATC

conducts salt fog, blowing dust, blowing sand, humidity, rain, solar radiation, high- and low-temperature storage and operation, and other environmental certification tests.

Commercial testing of air conditioning systems, defrosting/ defogging systems, engine cold and hot starting, tire aging and extreme temperature characterization, vehicle full and road load cooling, and vehicle paint and rust protection coatings can be performed. Sensors and data acquisition equipment are available to measure and record virtually any quantity, frequency and type of test parameter of interest, including (but not limited to) engine, wheel and fan speeds; manifold, coolant and hydraulic line pressures; vehicle component, reservoir, exhaust and surface temperatures; exhaust gas emissions; fuel, air, lubricant and coolant flow rates. Dedicated data acquisition systems allow up to 200 channels of simultaneous data collection and analysis.

Fungus Chamber

NATC has devoted one environmental chamber to use in studying the effects of fungus on components and complete vehicles in either storage or operational scenarios. This unit is 8 feet wide, 8 feet high and 19 feet long, accommodating most full-size, light-duty vehicles. Conditions within the chamber can be maintained at temperatures ranging from ambient to 165 °F and humidity from 5 percent to 98 percent. Typical fungus spores can be maintained at 75 to 88 °F and humidity from 90 to 100 percent.

Corrosion Chamber

The Nevada Automotive Test Center's dedicated corrosion test chamber was designed and constructed to accommodate full-vehicle tests in accordance with a variety of commercial and military standards. Specific test methods such as General Motors Procedure GM9540P, MIL-STD-810E, and simulators for severe high-humidity, high-corrosion environments such as China, Vietnam, and Central America have been preprogrammed into the chamber to allow automatic, repeatable and representative test conditions. The chamber is configured to allow integration of corrosion tests with vehicle durability as part of an overall accelerated life test. Chamber ambient temperature is measured at multiple locations throughout the structure, and separately controlled fans ensure uniform heat and humidity conditions. Chamber relative humidity is monitored and controlled from sensors located in the return air plenum. Computer controlled nozzles automatically inject moisture in the chamber plenum to maintain proper uniform humidity levels. Salt fog nozzles are similarly computer controlled and are positioned throughout the chamber to ensure uniform concentration delivery to all test components and reference coupons.

Instrumentation, Data Acquisition and Analysis

NATC has an instrumentation department to support and conduct instrumented evaluations of ground-based vehicles and weapons firings. NATC has the on-site capability to install and calibrate each over 1,000 sensors available for vehicle instrumentation. Specific installations are designed to capture information needed on vehicle handling, performance, fatigue, and life cycle.

NATC provides the turn-key solution for sensor selection, installation, data collection, and data processing.

A wide variety of transducers is used to measure many different system performance parameters for vehicles and weapons systems. NATC has the ability and experience to design and construct load and strain measurement instruments based on design and FEA analysis. Examples include accelerometers, strain gages, single and triaxial load cells, and thermocouples.

All of the equipment necessary to condition and record the signals from the transducers is available. Systems for recording over 150 channels simultaneously are available; however, typical commercial and military applications on vehicles use approximately 32-64 channel configurations. This equipment is currently on-site and available for test support.

Modeling, Simulation, Stimulation, and Analysis Support
Prototyping, Pre-Production, Model-Making and Fabrication Support

The Nevada Automotive Test Center recognizes that modeling and simulation are valuable tools in vehicle development to optimize design and minimize program risk and duration. NATC offers a full range of Computer Aided Engineering (CAE) capabilities including full vehicle dynamic modeling/simulation, Controls Systems modeling and integration, Finite Element Analysis (FEA) with fatigue prediction capability and Computer Aided Drafting (CAD).

Vehicle Model Development and Validation

Coupled with our established worldwide and North American duty cycles, data acquisition and advanced engineering analysis and prototype fabrication capabilities, NATC provides the customer with one-stop solutions from design to product verification. Utilizing simulation tools including ADAMS, MATLAB, and several finite element analysis codes.

NATC understands customer expectations and the demands placed on the vehicles they use. From USMC OMFTS to commercial public utility to standard vocational and over-the-road trucks, we have developed validated dynamics models which include tire-soil interface parameters necessary to provide the level of simulation accuracy necessary to make design decisions.

NATC has design and drafting capabilities required to produce engineering drawings in pen and ink or through the use of AutoCAD. NATC maintenance and fabrication personnel work closely with NATC engineering personnel. Fabrication drawings are developed in-house.

Vehicle Model Development and Validation

NATC can aid the customer in the structural design of vehicle assemblies with original finite element models or in the validation or modification of a customer provided finite element or dynamic analysis. Finite element models can be fine tuned at NATC with modal analysis techniques and controlled loading tests in our laboratories.

Often, data from one of NATC's instrumented vehicles, the Dynamic Force Measurement Vehicle (DFMV), are correlated with vehicle dynamics results to trace the attenuation or gain of energy through the vehicle. The combination and correlation of road surface data and vehicle dynamics data are used in NATC's accelerated life testing methodology for accelerating vehicle fatigue. The longer wavelengths from the road survey are used to understand drive train inputs and power demands for vehicles.

Predictions of vehicle response and durability with widely varying ground surfaces and operational modes can be useful to the customer before and during the initial design phase and in the design modification process. NATC can develop mathematical simulations of the stochastic and deterministic elements of ground surface trends and irregularities in elevation and other spatially dependent properties. NATC has the expertise to develop continuous dynamic models of multi-body systems, especially relating to vehicle suspensions and sub-assemblies, and can simulate the force and displacement inputs of the ground surface model to the vehicle system model.

NATC also has the expertise and resources to apply this technology to active and semi-active suspension systems in both developmental programs and evaluation of existing systems.

The engineering center at NATC has in-house computer aided drafting capabilities to transfer original engineering designs and suggested modifications to the customer. Coupled with our test courses, data acquisition and advanced engineering analysis abilities, NATC can provide the customer with the complete services necessary to see a product through to a successful design for the required performance.