NATO: Leveraging Adams and Luciad to Assess Mobility Characteristics of a Military Ground Vehicle

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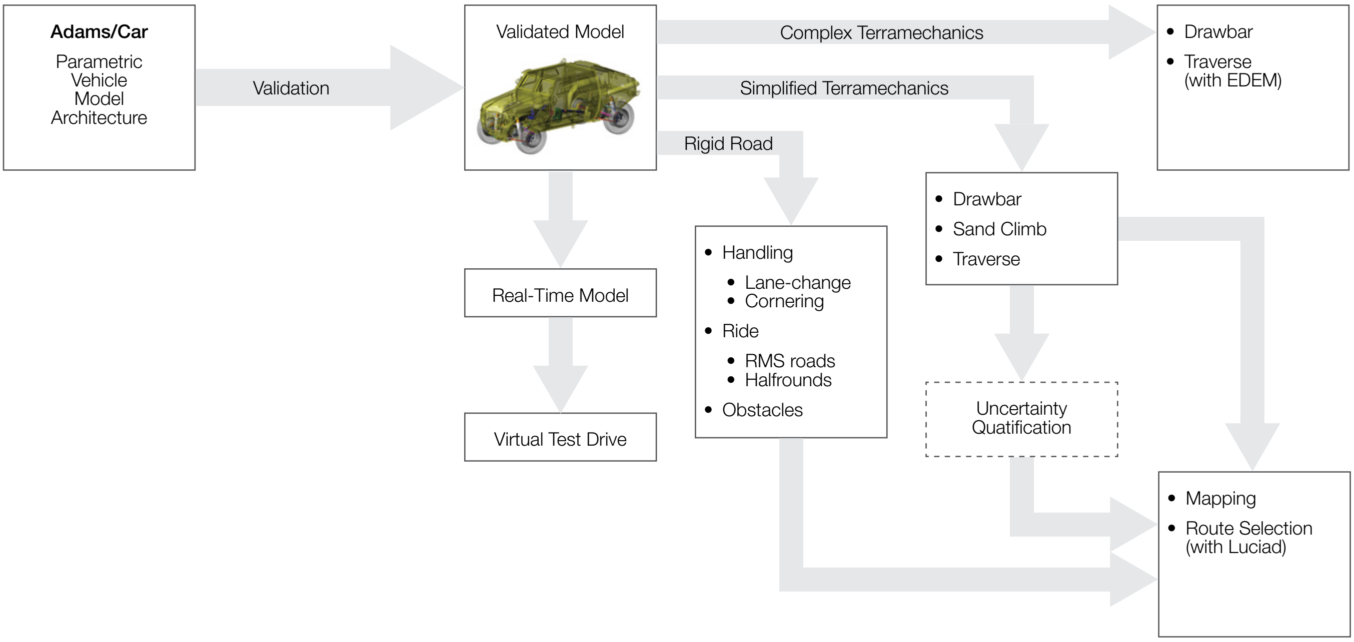

Figure 1 Mobility modeling for the NG-NRMM program

The mobility of a ground vehicle can be the difference between mission success and mission failure on the battlefield. In today's defense environment, there is a need to create rapidly deployable, highly mobile vehicle platforms that operate reliably across various terrain and road types. Vehicle simulation capabilities for assessing performance for different environmental conditions and operational scenarios have increased significantly in recent years.

In support of the Next Generation NATO reference mobility model (NG-NRMM) project for assessing existent CAE mobility analysis capability different facets of the Hexagon product portfolio were used to asses and visualize the mobility of the FED-Alpha, a Fuel Efficient Demonstrator vehicle (Figure 1). Adams models was created and validated against real-world calibration data by a team comprising of Eric Pesheck, Venkatesan Jeganathan, Tony Bromwell, Aniruddh Matange and Paspuleti Rahul Naidu to support this effort. These validated models were then used to accurately predict vehicle performance under a variety of on- and off-road operational scenarios. Select results from these investigations were integrated into Luciad, part of the Hexagon Geospatial portfolio, via a customized application for visualization and mobility mapping. Additionally, real-time compliance of the Adams model to support various autonomous and "Hardware-in-the-Loop" scenarios was demonstrated.

Creating and Validating the Adams Model

Adams Car, a solution vertical in the Adams portfolio focused on the modeling and simulation of vehicle assemblies and sub-systems was used to create a full-vehicle model of the FED-Alpha. Adams Car uses a template-based approach to model building; Reusable parametric templates of sub-systems such as chassis, tires, powertrain etc. can be populated with vehicle data and integrated to create a full vehicle assembly as shown in Figure 2. Typical model data includes design hard points, part mass properties, and component compliance characteristics. Adams Car allows detailed component representations, such as flexibility, friction, or frequency-dependent behavior where warranted. The level of fidelity and detail employed in the model was based on the simulation intent and available design data.

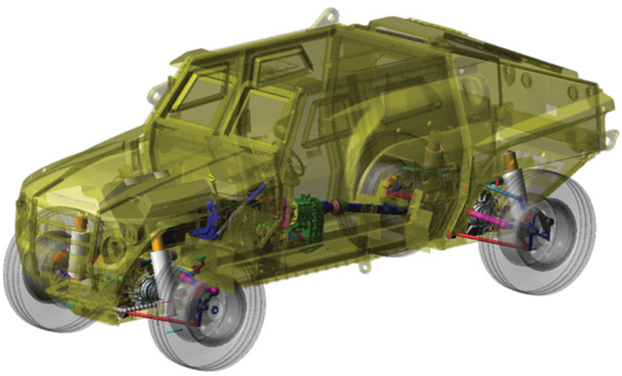

Figure 2 FED-Alpha Vehicle Assemble in Adams

The accuracy of the model was validated by comparison against data gathered from various vehicle test events. Metrics related to vehicle behavior, dynamics and ride quality were compared for model validation.

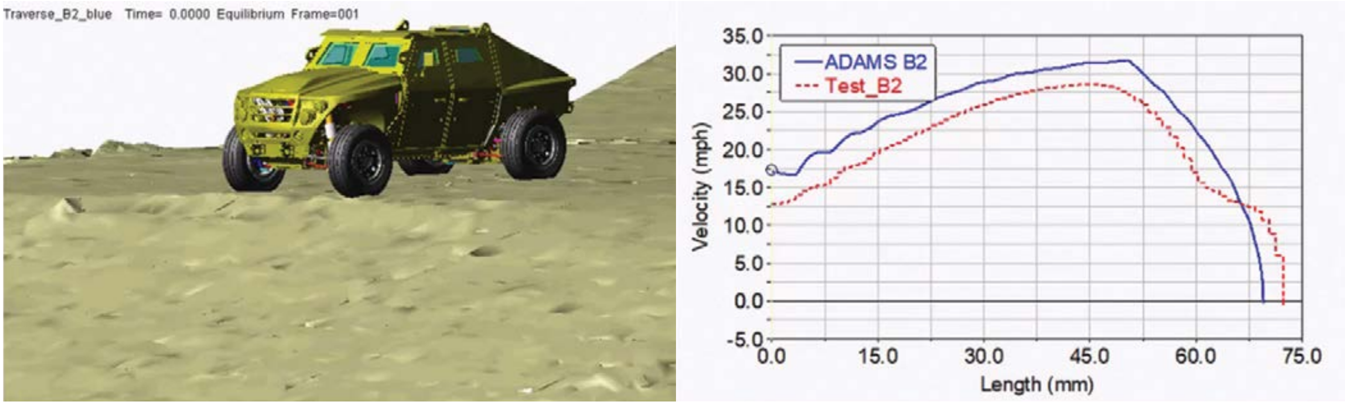

Figure 3 Adams Model Validation against Test Data

Predicting Vehicle Performance Using the Adams Model

The validated Adams model was then used to simulate various vehicle events to evaluate vehicle performance and mobility. These events consisted of both on and off road usage to mimic real battlefield scenarios. Typical military on-road evaluation events such as double lane change, indicating limit handling performance, half rounds, indicating ride quality, and step climbs, indicating obstacle navigation ability, were stimulated, with good agreement to test.

Evaluation of off-road performance is critical since achievement of certain mission objectives could require operation over unprepared terrain. Of crucial importance in off road modeling are the representation of the terramechanics; the soil properties and the interaction between the tire and the soil surface. Simple and detailed models for the description of the terramechanics were utilized in this initiative. Simple terramechanics models use empirical relationships, based on experimental measurements, to predict the response of deformable terrain to vehicle operation. These methods are computationally efficient, and were used to assess vehicle performance for well-defined draw-bar and hill-climb analyses. In addition, these methods were applied to scanned terrain geometry for more generalized off-road performance analyses.

In addition, the computational efficiency of this method facilitated the support of stochastic analysis approaches, where uncertainties due to variations in model and terrain inputs were also accounted for, statistically. These stochastic simulations represented hundreds of potential soil characteristics, and allowed prediction of vehicle performance over a statistical range of soil and terrain properties and resultant development of confidence intervals for vehicle performance.

Higher fidelity approaches, where the soil properties emerged from simulated particle interactions were also employed. This was accomplished using a co-simulation between Adams and EDEM, a Discrete Element Method (DEM) based simulation offering from DEM solutions. In the DEM method, the material is represented by a collection of interacting particles with simple shapes (typically based on circles and spheres). The typical co-simulation workflow between Adams and EDEM is as shown in Figure 3. Potential EDEM contact is defined for designated vehicle parts. The displacement of these parts is determined by Adams and provided to EDEM. EDEM then determines the resultant reaction forces, which are passed back to Adams.

Using these approaches, tests such as a drawbar pulls, and sand-bed acceleration were simulated to gauge tractive behavior of the FED under various off-road scenarios. Though computationally intensive, these simulations were proved to add significant fidelity and result in more accurate correlation to test results.

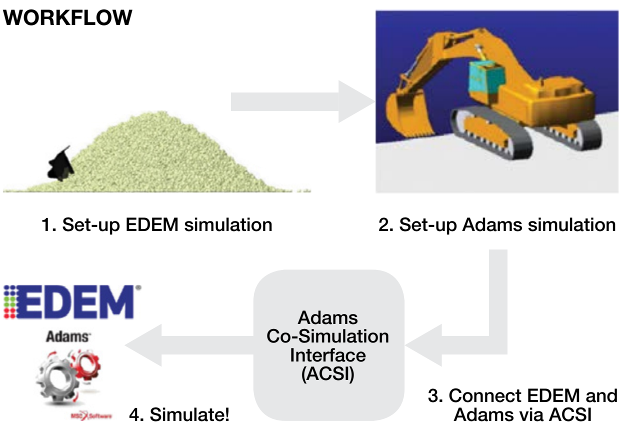

Figure 4 Adams EDEM Co-Simulation workflow

Mobility Mapping

Leveraging the broader Hexagon portfolio (Figure 5), the Luciad Lightspeed technology from the Geospatial Business Unit was used to project the FED Alpha mobility characteristics predicted by Adams onto the test terrain at the Keewenaw Research Center (KRC). The integration of Adams predictions with geospatial mapping technology demonstrates the capability to visualize vehicle speed throughout a mapped domain based upon a combination of soil, grade and predicted vehicle performance data. Additionally, optimized routes can be computed based on selected route endpoints.

Additional operational data such as side-slope predictions and obstacle information can be incorporated into the above framework, thus creating a platform for comprehensive mobility assessment on an actual terrain using simulated vehicle performance data.

Real-Time Virtual Model Performance

To demonstrate the applicability of the full fidelity Adams models used for mobility assessment, to adjacent Hardware in the loop (HIL) and ADAS applications, a reduced order, real-time compliant variant of the full-fidelity model was created. The ability to derive vehicle dynamics modeling variants of varying fidelity, to support a specific simulation intent allows users to deploy a single modeling solution without costly, error-prone model translations between various tools. Furthermore, with the Adams Real-Time approach, the user has additional freedom to retain model features of interest. Typically, real-time vehicle performance may be achieved with a few simplifications of select component and connection representations, depending on the analysis and integration requirements. In this case, only the anti-roll bar model was simplified. The real-time model was tested in the VTD (Virtual Test Drive) analysis environment to demonstrate capability. In addition, the numerical accuracy and efficiency of this model was assessed relative to the baseline full-vehicle performance.

Adams has had a long standing presence in the area of on-road analysis. This effort demonstrates how these models can be extended using the broader Hexagon portfolio and reused for off-road analysis in the context of road terrain representation, real time analysis and operational mapping.

Learn more about Adams:
www.mscsoftware.com/adams

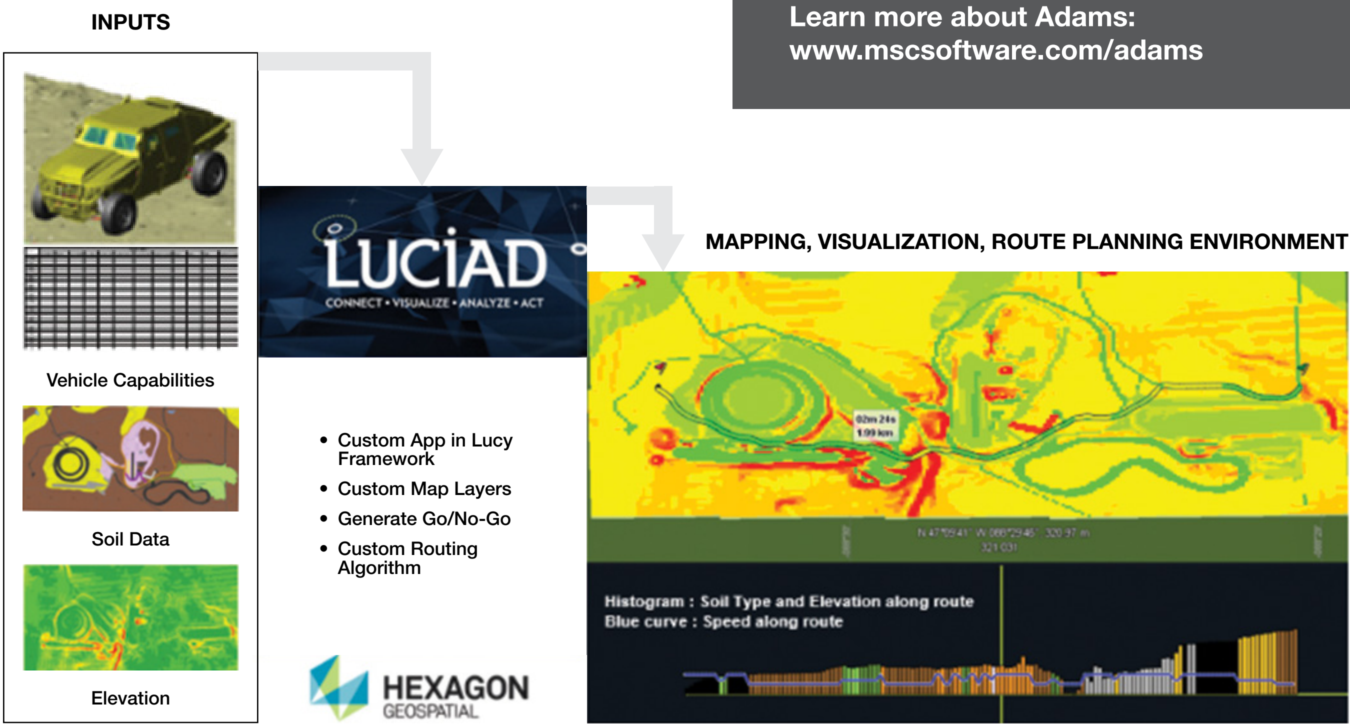

Figure 5 Mapping workflow, showing speed made good and route prediction