TECHNICAL DOCUMENT

DIGITAL TRANSFORMATION FOR MOBILE MACHINES THROUGH SYSTEM SIMULATION

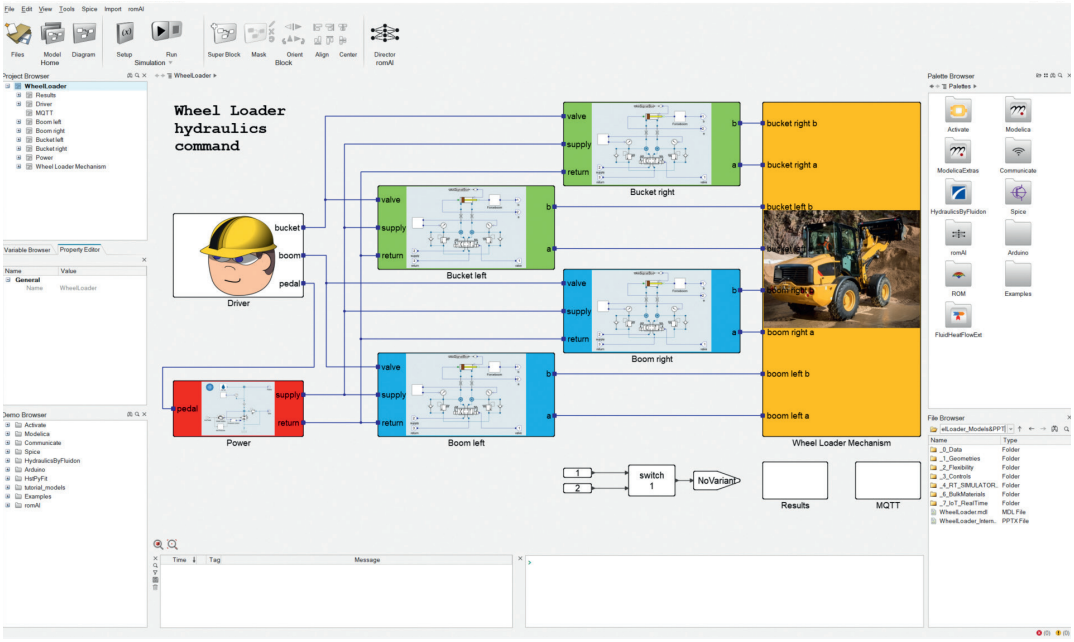
When developing mobile machines, manufacturer focus is twofold:

1) Increasing a machine's productivity and operator comfort
2) Improving its energy efficiency.

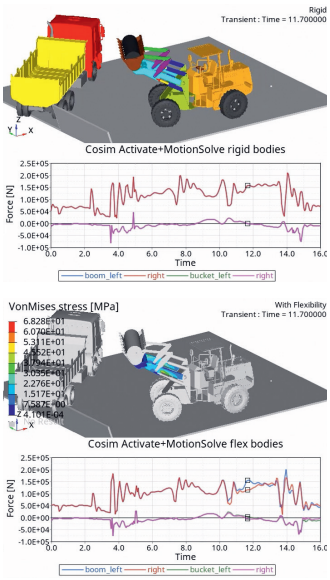
To achieve these objectives, it is crucial to have an optimized system-of-systems and seamless interaction between subsystems. But how can manufacturers design components from varied disciplines like mechanics, electronics, and hydraulics to create a holistic overall system having optimal performance? The answer is digital transformation.

Many Tools – One Flexible Solution from Altair

Most manufacturers already use various simulation tools to develop their mechatronic, hydraulic, or control subsystems – but these tools can't address every development question. For the times when these tools reach their limits – as is the case when coupling the actuated mechanisms with a multibody simulation (MBS) – Altair offers an effective solution using a holistic simulation approach: While performing a system-of-systems simulation, engineers reuse existing simulation models and, for example, study and optimize the hydraulics of the system including its components.



System of systems – wheel loader model



Depending on the desired level of detail, rigid or flexible components can be used in the MBS model.

Modeling 3D Multibody Subsystems at Varying Levels of Detail

Altair bases its approach on an integration platform that lets an overall system model communicate with various external environments, such as with real-time training simulators as well as with methods for collecting and visualizing sensor data. The main element is a simulation model of an overall system created in Altair Activate® that enables interactions between components and subsystems.

The system-of-systems simulation can use 3D MBS models at varying levels of detail. For instance, when a conceptual-level assessment is desired early in the product development cycle, modeling the multibody system using open standards such as Modelica enables a more rapid and sufficiently accurate simulation.

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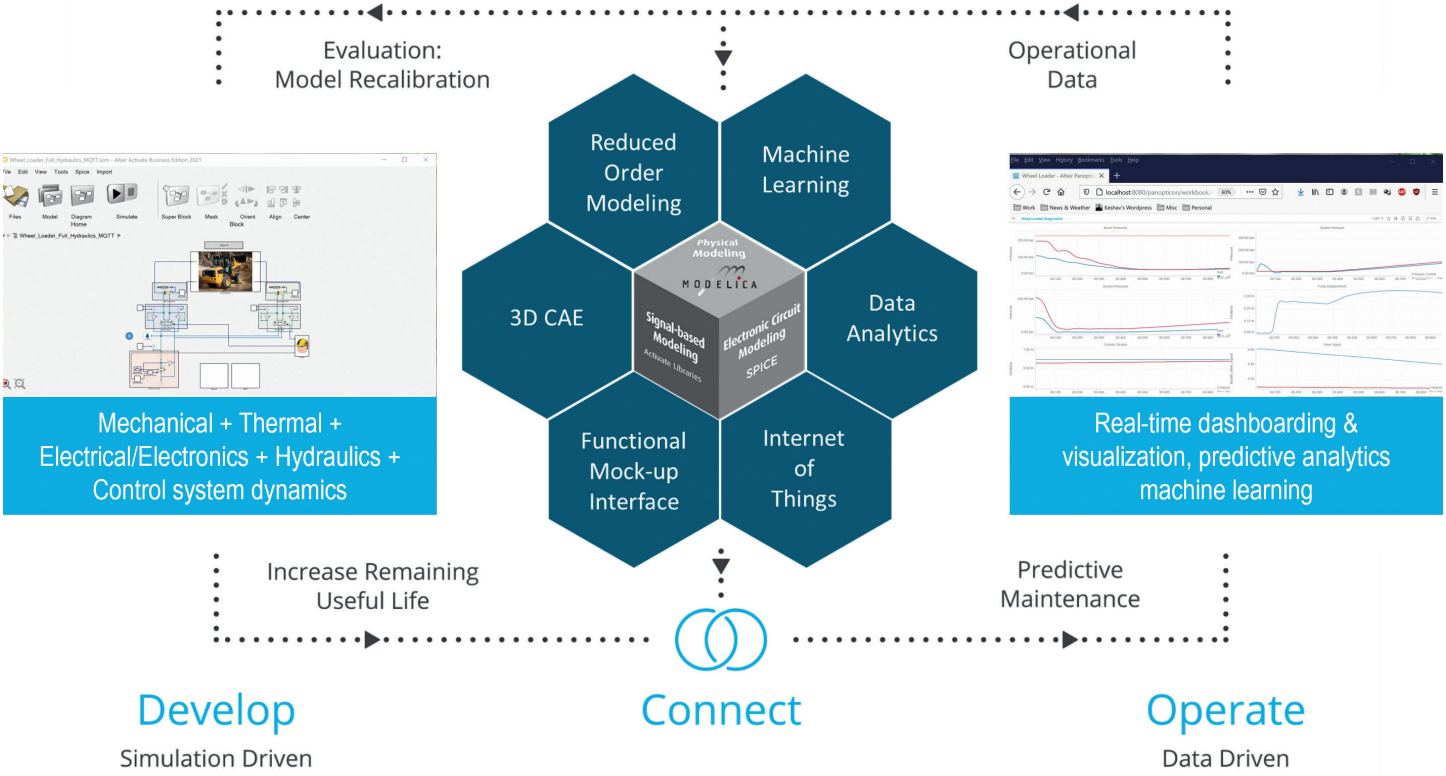


Later, when a more detailed assessment is desired, coupling Altair Activate with Altair® MotionSolve® is recommended because, while this approach is more time-intensive, it will also provide higher-fidelity results – for example, to evaluate stresses or deformations in the mechanical components.

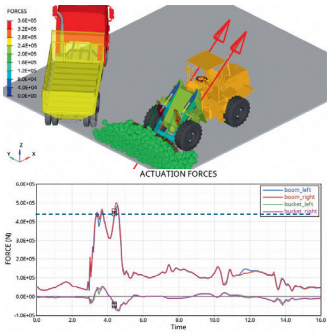
The user benefits from this flexible combination of 1D and 3D models of varying detail partly because existing models can be reused directly. Using a simple interface and a broad spectrum of modeling options, users select which level of accuracy they need and balance that against the amount of modeling & simulation time they can afford. Different levels of model detail can also be used when communicating with other environments such as an IoT platform or when enabling human-machine interfacing (HMI) via a joystick.

Early Insights into the Overall System – Toward the Digital Twin

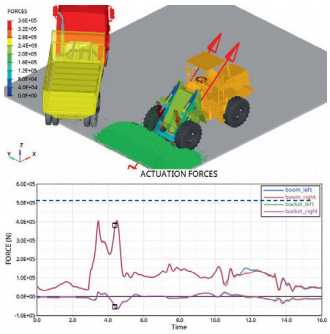
This flexible approach provides important insights as early as the concept phase, eliminating expensive follow-up costs later in the development process. At the concept level, it lets users make important decisions about component dimensioning since the effects on the overall system are apparent.

Using the available geometries and masses, it is then possible to study the effects on the force and stress curves in the detailed design. Depending on the desired level of detail, rigid or flexible components can be used in the MBS model. Here, MotionSolve or Altair® Inspire™ identifies even the smallest deviations by including higher-fidelity flexible bodies versus only rigid bodies in the 3D MBS model.

With the same data set, the developer can study the vibration phenomena of the mobile machine to identify possibly undesirable system eigenmodes and make design changes to shift them to non-critical frequency ranges. Finally, the model offers insights into the mobile machine's behavior during bulk material handling: With the help of Altair® EDEM™, Altair's Discrete Element Method (DEM) Software, the impact of volume and granularity on the actuating forces are determined to avoid over- or under-sizing hydraulic units and actuators as different kinds of material are handled (such as coal versus iron ore).

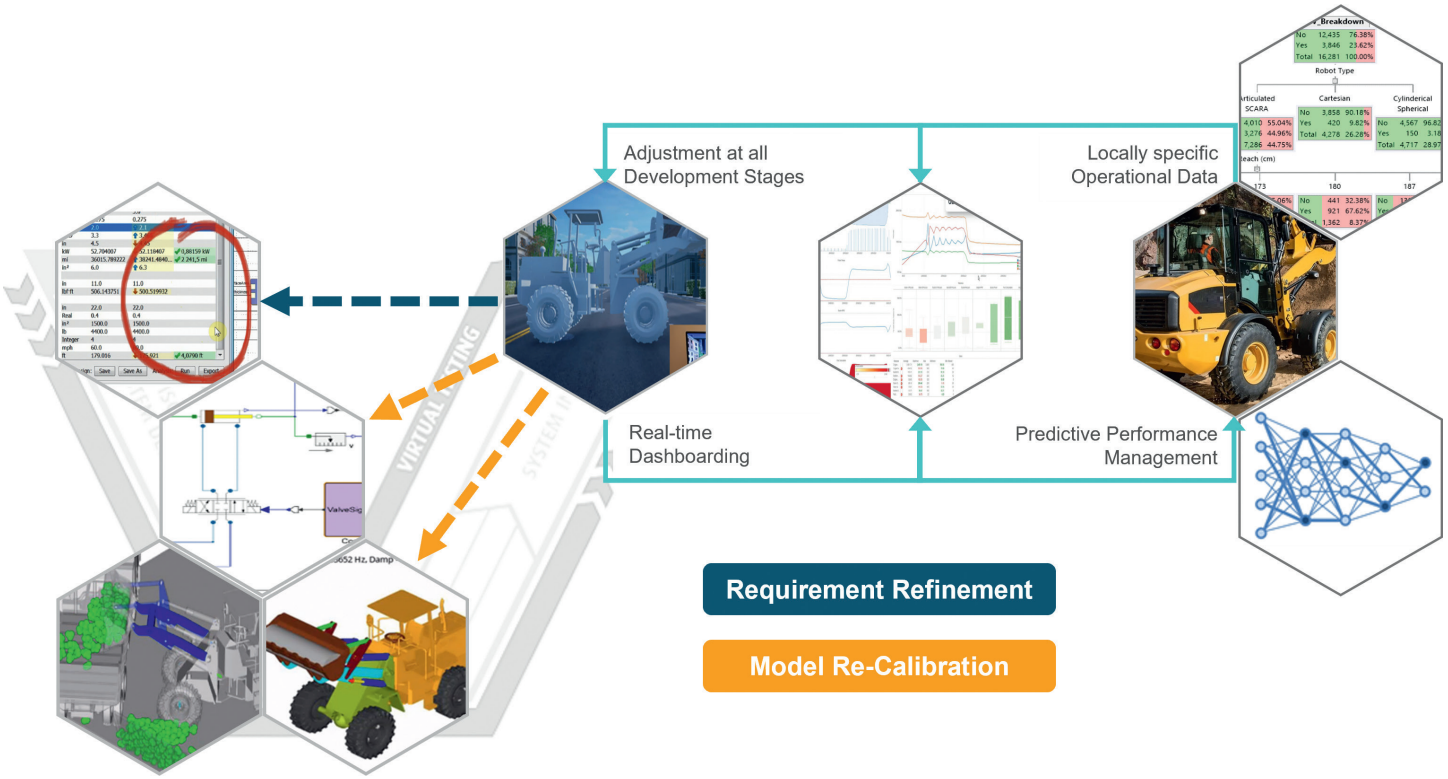


Granular Material Type #1



Granular Material Type #2

The discrete element method makes it possible to determine the influence of the degree of granularity on the actuating forces.



Live Experience: Virtual Reality

Because access to measurement data is not always available, and because it is cost-effective, virtual testing and virtual reality are playing an ever-increasing role in the run-up to the physical prototype phase. The system simulation model is exported from Altair Activate via the Functional Mock-up Interface (FMI), together with the existing geometries, to a visualization environment where it is controlled in real time to test machine behavior, train operators, and run through misuse scenarios, for example.

Consistency Through to the Final Product and Beyond

Also, after the initial development, the overall system model offers as a digital twin the possibility of further system optimization by collecting real data through measurements on the machine already in operation – to enable predictive maintenance. Real data and simulation data can be converged through the same IoT platform and can be visualized, for example, using the Altair® Panopticon™ data visualization solution. Based on real operating data, the model is refined which gives product developers useful insight and ideas about future product design improvements.

Additionally, by training neural networks based on transient measurement data, it's even possible to integrate additional subsystems that couldn't initially be modeled in the overall system simulation – for example, the charging and discharging processes of batteries within electrified systems.

Not only a powerful simulation platform, but also a high level of engineering expertise is crucial to set up such a process. The Altair team provides this expertise to its customers which allows those companies to sustainably strengthen their competitiveness while saving costs in the medium- and longer-term.