TECHNICAL DOCUMENT

ACHIEVING AEROSPACE DESIGN CONFIDENCE WITH MODEL-BASED SYSTEMS ENGINEERING

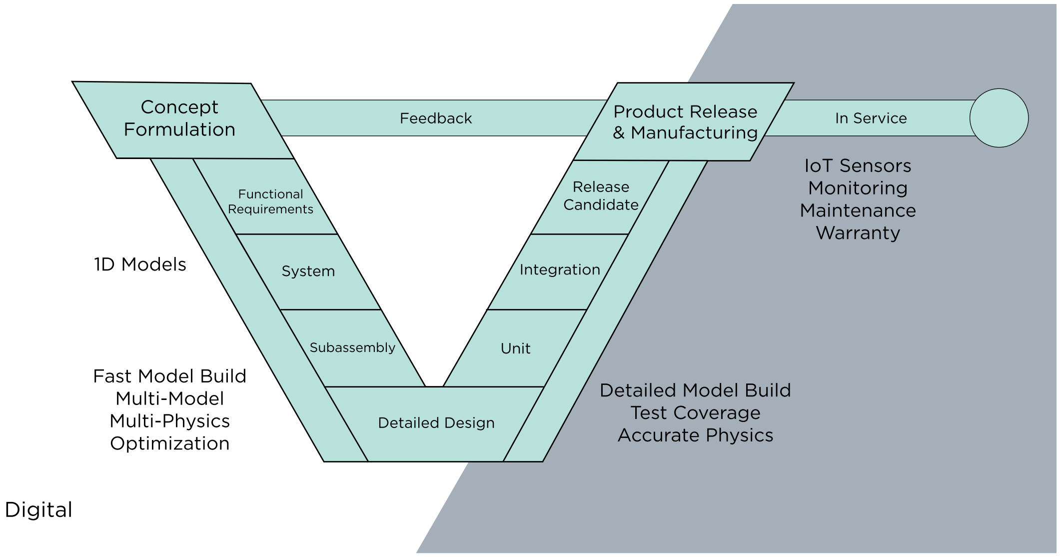
Reducing aircraft design and development time is critical for all aircraft manufacturers, from urban air mobility and electric aircraft startups to military to commercial OEMs. In order to fully understand and optimize the complex systems of systems required in modern aircraft, aerospace engineers leverage a simulation method called Model-based Systems Engineering (MBSE). MBSE allows the evaluation of various types of vehicle systems to determine which best meet the mission requirements.

Applying MBSE in Aerospace Design

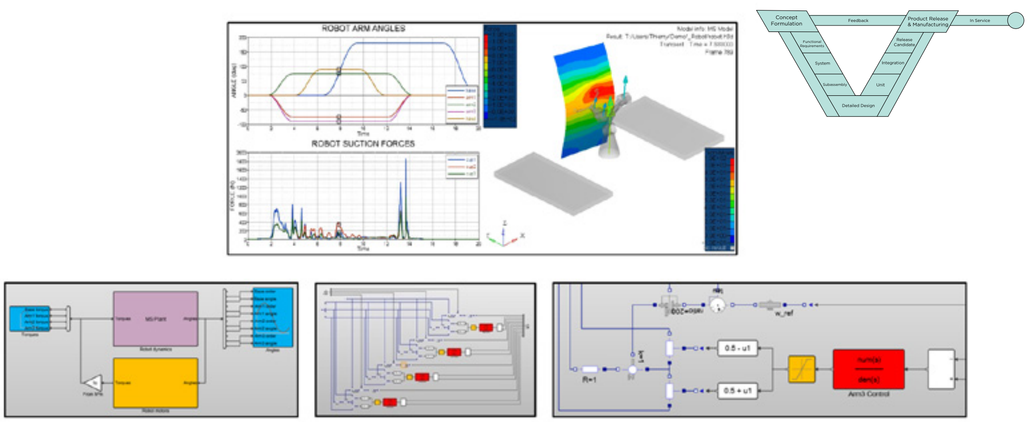
Model-based Design (MBD) is method for characterizing and improving the design of complex systems. The process involves the creation of digital 1D representations of aircraft systems and subsystems. This allows aircraft designers to vary individual system requirements, for instance on the signal processing or controls, and simulate the impact these variations would have on the broader system. With a system model at the center of the development process, a common framework can be established to efficiently model and verify the design will meet mission requirements.

Problems still arise, however, when it comes to data sharing and design collaboration as the model moves through the development process. Most workflows don't provide connectivity between 1D system models and the 3D multiphysics models used in the detailed design phase.

MBSE enhances the efficiency of the MBD process by enabling the creation of a digital thread that can be followed from concept formulation through to product release. This digital representation of the design can be more easily transferred, reviewed, modified, and optimized as it moves through the various stages of the development process. With MBSE, results of multiphysics or data analytics simulation can be used to populate 1D models where such models did not previously exist as well as improve collaboration amongst cross-functional development teams.



The MBSE approach enables designers to simultaneously support parts represented in multiple fidelities, making it easier to transfer results across teams in the format they need. These teams can exist within one organization, or even across multiple government, OEM, or supplier channels. The same part can have several representations in the same model, including 1D, coarse 3D, and fine 3D. The user may select any of these representations at any stage of the design phase depending upon the fidelity needs of a particular analysis.



MBSE at US Naval Air Warfare Center

Government solicitations for proposals, or RFPs, for aircraft and airborne systems require preliminary designs with enough fidelity to accurately predict performance in order to prove the design's ability to meet the aircraft's mission requirements. With the increased accessibility of modern high-performance computing (HPC), aerospace designers can now leverage multi-physics simulations such as computational fluid dynamics (CFD) or structural simulations in these early stages. The results of these analyses can be used to populate 1D models for system level MBD involving multiple interrelated disciplines. These capabilities allow design engineers to rapidly iterate to levels of model maturity and accuracy not previously achievable, resulting in high levels of fidelity between mission requirements and system specifications.

Mission: Collaboration between government and industry in model-based acquisition under System Engineering Transformation framework.

Goal: Execute SET framework to assess, refine, and understand a new paradigm for collaboration in Authoritative Source of Truth.

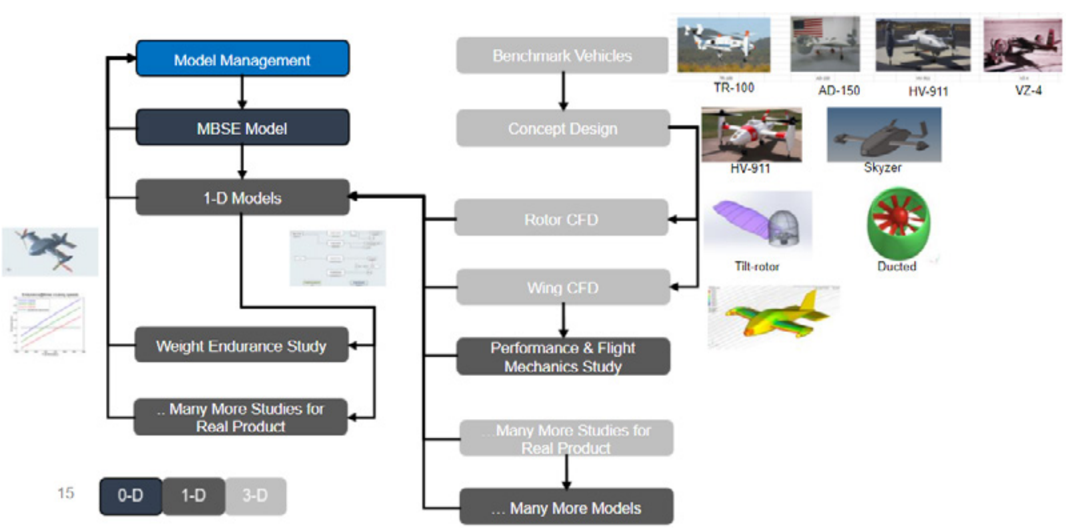
US Naval Air Warfare Center (NAVAIR) utilized Altair MBSE technology as part of their System Engineering Transformation (SET) Initiative. The goal was to transform their acquisition process to a model-based approach, allowing them to evaluate design alternatives and select the right system specifications.

Altair was selected by the US Navy for their Surrogate Pilot Project to both develop this new design process as well as to apply the process on a surrogate system design, an unmanned aerial vehicle (UAV). Multiphysics simulation, including CFD, structural, and multi-body systems simulation were performed using Altair HyperWorks™ 3D analysis tools, which were then captured as 1D block diagrams in Altair Activate™. Additionally, Altair's high-performance computing tools scheduled and managed computing jobs to ensure analysis can be run and delivered efficiently.

A simple proof-of-concept model was created to validate the method, which included modeling of the aerostructure, motor, gearbox system, and propulsion design. While this project included simulation models of multiple systems, real-life models can account for many additional design variables including the dimensions of all aerodynamic surfaces such as wings, flaps and rudder and the size of propeller. The NAVAIR UAV used a turbine engine, but the process could easily be applied to e-propulsion design variables as well, including the number, size and location of batteries, the number and locations of rotors, and the number of motors in each rotor.

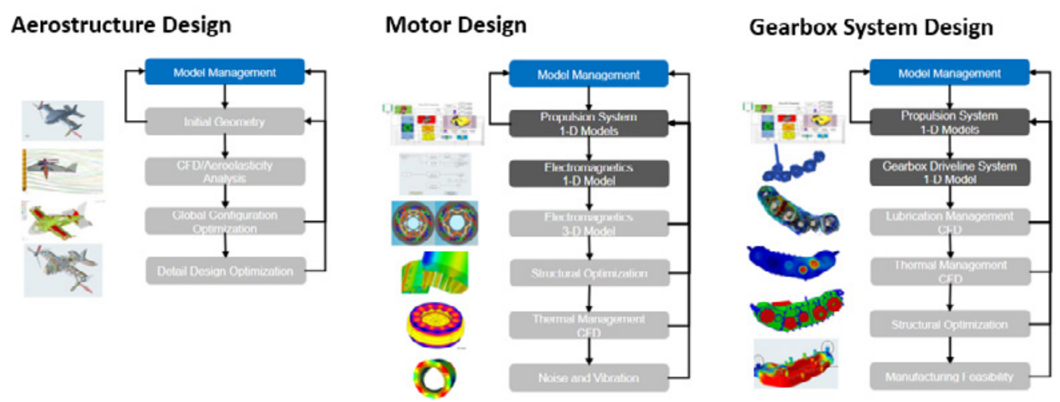
NAVAIR looked to MBSE in order to improve collaboration, achieve seamless bi-directional translation from one phase of the design to another, and ultimately establish an 'Authoritative Source of Truth' in their vehicle development process.

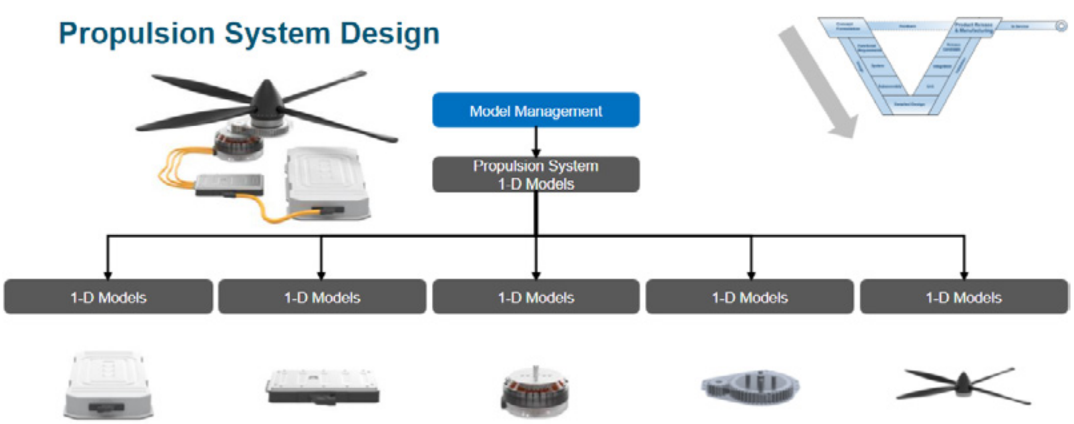
Connecting all of this together is Altair One™, a collaborative platform providing web-based access to simulation and data analytics technology plus scalable HPC and cloud resources. NAVAIR used Altair One to share Altair Inspire™ models and Altair Compose™ scripts with designers and management throughout the development cycle and across the enterprise. This portal connects engineering data to the broader development process, where users can view and collaborate on work orders, low- and high—order analysis results, trade studies, and more.



A system-level study was run with four unmanned aerial vehicle (UAV) design benchmarks to determine which design most closely matched the aircraft's mission requirements. After choosing the benchmark vehicle HV-991 as the starting point, NAVAIR needed to generate 1D models representing the CFD performance of the chosen aircraft concept design. The design was run through a series of CAE analyses including rotor and wing CFD to develop the 1D models for MBD simulations. With 3D simulation providing the necessary data for the 1D models, NAVAIR could then use these models in aircraft-level system study.

Model-based analysis was performed with length, sweep, and taper of the wing as design parameters to meet aircraft mission requirements. The optimized aircraft design parameters form functional specifications for the aircraft. These are made part of the MBSE framework for downstream design and collaboration.





System specifications are now used for designing the aircraft. Details are added as needed to aircraft 1D models to develop 1D models of each system, which are used to optimize each system. The process progresses down to mode detailed 1D models for subsystems and eventually 3D Multiphysics models of subsystems and components. This process is partially depicted for the e-propulsion system design in the sketch above. The digital connectivity provided by the MBSE approach ensures that aircraft system specifications and mission requirements can be evaluated and tracked at all stages of design process.

Want to Learn More?
Watch the Webinar Now

Working with Altair

Aerospace belongs to explorers. Altair has been instrumental in pioneering the establishment of optimization centers at major aerospace OEMs. Our simulation technologies develop complex, high-fidelity finite-element models for the predictive virtual testing of airframes, engines, and aircraft interiors. We accurately simulate impact damage and correlate against vulnerability events. Now, new methods fuse with old for entirely new processes that take us further than ever into the beyond.

Learn More at altair.com/aerospace