

## **SimGen**

SimGen makes it easy for you use computational and semi-empirical aerodynamic prediction and analysis codes to generate a flight simulation model. But you may be wondering about the quality of the data that SimGen generates. How does it compare to wind tunnel data, to flight data? How accurate will it be for my project?

Unfortunately, the question of accuracy is not simple to answer. Each method is based on assumptions and each has limitations. All have strengths and weaknesses. Often the quality of the data is dependent on the specifics of the aircraft configuration. Therefore, it is crucial that users develop an understanding of the capabilities and the limitations of the methods supported by SimGen.

This paper will discuss some background of the methods currently supported by SimGen version 1.x and will offer additional resources to help you assess the capabilities of these methods and determine if they suit the needs of your project.

## **Computational Aerodynamic Methods**

SimGen was designed to utilize strip methods, lifting line methods, vortex lattice methods, and semi-empirical methods. These methods are based on fundamental aerodynamic theories and use basic geometry information such as wing area, relative position of airframe components such as the wing and the tail, wing and tail airfoil camber and thickness, and other inputs, including flight conditions, surface roughness, and the position of control surfaces, to predict aerodynamic data.

These types of methods are not CFD – computational fluid dynamics – which are high-level codes that use numerical methods to solve systems of partial differential equations on grids taking the shape of the vehicle or the volume around the vehicle. There are, however, several advantages to using non-CFD methods to generate flight dynamics simulations for use in vehicle design and flight control development. First, the methods used by SimGen are fast and efficient. They are not computationally expensive and they require much less effort and expertise to use. An entire non-linear simulation database can be generated in minutes. Second, for prediction of control power and dynamic derivatives, the methods used in SimGen can be as accurate as, and in some case more accurate than, CFD.

The computational methods currently supported by SimGen are described in the following paragraphs.

### **HASC2002**

HASC2002 stands for High Angle-of-Attack Stability and Control and features a vortex lattice method coupled with a semi-empirical strake/wing vortex method. It has been successfully used to predict the non-linear stall and post-stall longitudinal characteristics of air vehicles with delta wings, leading edge extensions, and strakes.

HASC is a FORTRAN console software application developed over several years by Lockheed Martin, Nielsen Engineering and Research Inc., and Consulting Aviation

Services Inc. to fulfill a need for non-linear aerodynamic prediction methods suitable for conceptual/preliminary level design and evaluation work. The code is now primarily an integration of two routines:

- VORLAX - a generalized vortex lattice program by L.R. Miranda
- VORLIF - a semi-empirical strake/wing vortex analysis code developed by C. Dixon

Commonly, the code is run in a mode where only the vortex lattice portion of the code is utilized. In this mode, HASC is very robust but is not capable of predicting non-linear behavior. Currently, the SimGen HASC plug-in module limits the execution of HASC to the VORLAX-only mode of operation. Thus, simulation aerodynamics models created using the HASC Module are linear aerodynamics models.

VORLAX is based on linear lifting surface theory and has the same prediction limitations as other codes based on this theory. These include:

- Linear aerodynamics only
- Induced drag prediction only
- Geometry must be planar and represented by quadrilateral panels which maintain span-wise and chord-wise consistency such that trailing vortex elements do not overlap panel control points. It is possible that certain air vehicles may be difficult or impossible to fully represent.
- "Louver" control deflections. Lattice panel deflections are by rotation about the panel center rather than an arbitrary hinge-line and this might lead to an inaccurate prediction of control power.

Comparisons of HASC generated data to wind tunnel data for the F-16 and other fighter aircraft are contained in the 1992 and 995 HASC user reference manuals:

Albright, A., Dixon, C., and Hegedus, M. Modification and Validation of Conceptual Design Aerodynamic Prediction Method HASC95 with VTXCHN. CDAP-10. November 1995.

Adler, Charles, Dixon, Chuck. High Angle-of-Attack Stability and Control – Prediction Methods and Code. WL-TR-92-3050. October 1992.

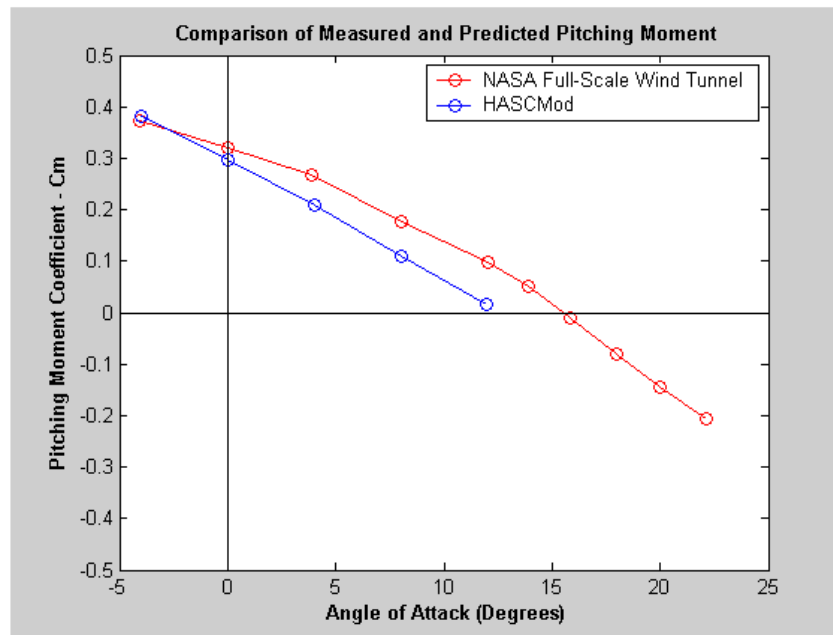
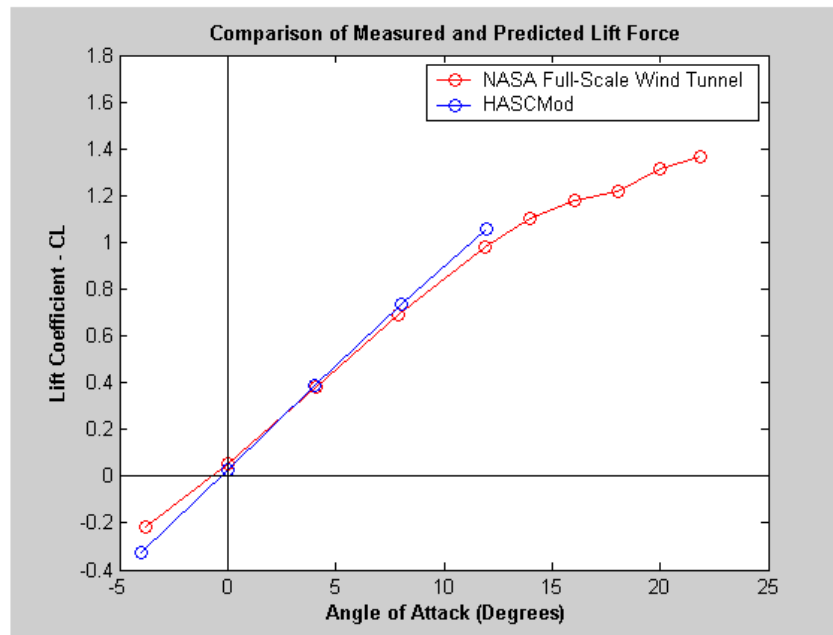
The accuracy of vortex lattice methods has been addressed in several papers. Some work toward validation of stability and control parameters is contained in these references:

Razgonyaev, V., and Mason, W.H. An Evaluation of Aerodynamic Prediction Methods Applied to the XB-70 for Use in High Speed Aircraft Stability and Control System Design. AIAA 95-0759.  
[http://www.aoe.vt.edu/~mason/Mason\\_f/AIAA95-0759.pdf](http://www.aoe.vt.edu/~mason/Mason_f/AIAA95-0759.pdf)

Kay, J. Mason, W.H., Durham, W., Lutze, F. and Benoliel, A. Control Authority Issues in Aircraft Conceptual Design: Critical Conditions, Estimation

Methodology, Spreadsheet Assessment, Trim, and Bibliography. VPI-Aero-200. November 1993. [http://www.aoe.vt.edu/~mason/Mason\\_f/VPI-Aero-200.pdf](http://www.aoe.vt.edu/~mason/Mason_f/VPI-Aero-200.pdf)

As part of the HASC Method Module tutorial in SimGen, a general aviation aircraft, the Navion, was modeled. The data generated by SimGen was compared to wind tunnel obtained from **NASA Technical Note D-5857** by Shivers, Fink, and Ware.



**Note:** Available test data is for a tail incidence angle of 5 degrees. The comparison above was made with HASC data run with the top view tail surfaces with 6 degrees incidence.

## Missile DATCOM

Missile DATCOM is a widely used semi-empirical datasheet component build-up method for the preliminary design and analysis of missile aerodynamics and performance. It has been in continual development for over twenty years. The fundamental purpose of Missile DATCOM is to provide an aerodynamic design tool which has the predictive accuracy suitable for preliminary design, and the capability for the user to easily substitute methods to fit specific applications.

The computer code is capable of addressing a wide variety of conventional missile designs. A conventional missile is one which is comprised of the following:

- An axis-symmetric or elliptically-shaped body.
- One to four fin sets located along the body between the nose and base. Each fin set can be comprised of one to eight identical panels attached around the body at a common longitudinal position. Each fin may be deflected independently, as an all-moving panel or as a fixed panel with a plain trailing edge flap.
- An air-breathing propulsion system.

Missile DATCOM is a non-linear method and is capable of predicting forces and moments as a function of angle-of-attack beyond stall. While it was developed to predict missile aerodynamics, it has also been successfully used to model various aircraft configurations.

A complete listing of the origins of the data and methods used in Missile DATCOM is contained in the user manual:

Blake, William B. Missile DATCOM User's Manual: 1997 FORTRAN 90 Revision. AFRL-VA-WP-TR-1998-3009. <http://www.uscrpl.com/notes/AFRLTR98-3009.pdf>

The accuracy of Missile DATCOM has been addressed in several recent papers including,

Abney, Eric. McDaniel, Melissa A. High Angle of Attack Aerodynamic Prediction Using Missile DATCOM. AIAA 2005-5086.

Sooy, Thomas J., and Schimdt, Rebecca Z. Aerodynamic Predictions, Comparisons, and Validations Using Missile DATCOM (97) and Aeroprediction (AP98). AIAA Journal of Spacecraft and Rockets. Vol. 42 No.2, March-April 2005.