Using Tornado, Didactics in the Aeronautical Education at KTH

Tomas Melin – Royal Institute of Technology (KTH), Sweden

Introduction.

In the undergraduate aeronautics education, the fundamental phenomena that are being addressed requires both mathematical rigor and, equally important, an artistic panache in their description in order to provide the students with a good mental model.

From this viewpoint, the academic and industrial objective differ in the sense that in education the final product is a mental model while the industrial product often is a more packaged model in the form of compiled software, technical reports or a physical product.

To accommodate the scholastic demands a set of goals as presented below serves as a guideline in finding the appropriate methods in the learning problem.

Goals.

- Communicate the physical principles behind the aerodynamic phenomenon.
- Create an understanding of the available methods of analyzing aerodynamics.
- Give working knowledge with the numerical implementations of the methods.
- Provide a large number of handles towards adjoining disciplines.

In essence, the student should leave a class with more unanswered questions than the student had before class. Provided of course, that these are new questions.

Methods.

In order to work towards these goals the aerodynamics division at KTH utilizes programming exercises with the students as course work. Because of the complex problem formulations the students are provided with a number of aerodynamics tool structures. The selected platform is MATLAB due to its: platform independence, intuitive user interface, and standard syntax.

One of the applications provided in the tool structure is the vortex lattice method

Tornado

Tornado is a 3D-vortex lattice program that supports a wide variety of planforms with a infinite number of lifting surfaces. The wake is allowed to skew to accommodate the free stream. In the current version the outputs are: force vector acting on each panel, pressure distribution plots, aerodynamic coefficients in both body and wind axis. Stability derivatives with respect to angle of attack, angle of sideslip, angular rates and rudder deflections.

As the source code is open and available under the GNU General Public License, the students are encouraged to make their own modificatios, and/or add functions to the basic program in order to accommodate their sought results. This approach relives the student of some the drudgery work usually accompany programming. Especially with the aircraft geometry definition functions, that correspond to half to two thirds of the total code volume.

As Matlab is very generous in providing easy plotting functions in a vide variety of forms, the students can follow the numerical model graphically in a step by step fashion. This means that the time required to master the input interface of Tornado is minimized. Figure 1 shows two different geometries used in Tornado, a Boeing 747 and a Cessna 172. Figure 2 shows sample results of an alpha sweep on a oblique wing with 20 degrees of sweep.

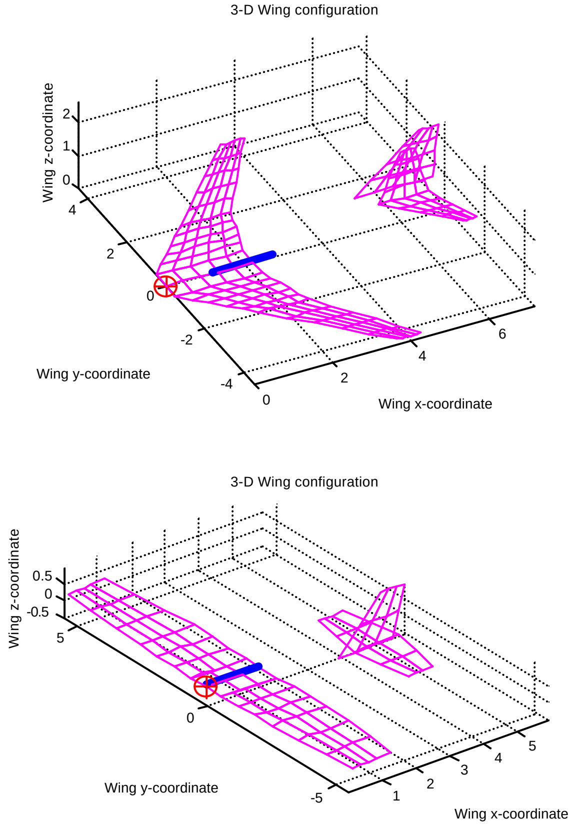

Figure 1 Different example aircraft geometries in Tornado

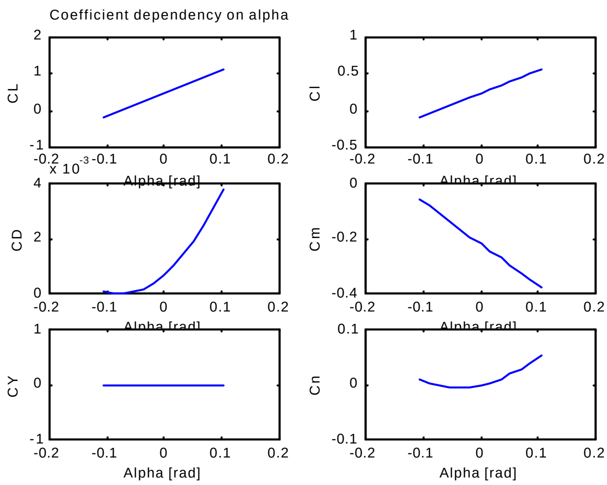

Figure 2 Sample alpha sweep output

Worldwide response.

Tornado has also become popular at other research establishments, such as Virginia Tech in the USA. Tornado is used in the undergraduate education there, where the students are currently working with developing supersonic module. Tornado can be downloaded from the Internet at:

http://www.flyg.kth.se/Tornado/htm/tornado.htm