11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Overview of transition prediction tools in elsA software

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Key Words: *Transition prediction, RANS code, Transition criteria and transport equations.*

Long term involvement of ONERA in laminar-turbulent transition modelling, and into the development of the elsA software, with major contributions from D. Arnal, R. Houdeville et al. have led to a wealth of transition criteria in the elsA code, routinely used for wing design and quite well adapted for performance prediction. Nevertheless, transition prediction is a difficult task and the prospect of laminar wing design on one hand, and the ever improved design of rotating devices, from high speed propellers to turbine blades, put a renewed pressure for reliability and precision, while the current demand for ever more complex configurations calls for robustness and simplification of the use of the elsA solver regarding transition prediction.
Presently, two categories of tools coexist in elsA. First, a large number of transition criteria, which generally rely on boundary layer integral parameters and may (or not) take into account the boundary layer history. Most important among these, the so-called AHD-GL and C1 criteria, the first one being based on systematic stability calculations of similar Falkner Skan profiles, and the second being one of the few correlations dedicated to crossflow prediction. Also to be mentioned is the Abu Ghannam & Shaw empirical criterion, which may be applied in conditions of large turbulence of the incoming flow, up to Tu = 9%. This first series relies on the concept of transition computation line, to be defined by the user, and along which regions are specified to be laminar, turbulent, or to be computed.
Second, the approach proposed by Menter & Langtry, based on two transport equations for an intermittency γ and a transition Reynolds number $R_{\theta T}$ is also available in elsA, using a closure developed by C. Content. While the transition criterion contained in this approach is rather crude, the ease of application and the fairly good results which may be obtained on turbine blades have made this approach a popular one, at least for given classes of applications.
The above mentioned drivers, reliability, precision, robustness and simplicity, are motivating new developments in two separate directions:

- the introduction of stability based methods to replace transition criteria and improve the first two points, especially concerning 3D configurations and crossflow predictions. The so-called parabola method is seen as candidate, in which case a proper meshing of boundary layers will be required (with around 40 well placed points), together with the use of a low dissipation numerical schemes (Roe or equivalent). Limited extensions will be required, in particular concerning regions of separated boundary layer.
- Work has started on the development of a new method, with the ideas of using transport equations as a mean to follow approximately streamlines and discard the user

defined transition lines, and, at the same time, keeping the use of high fidelity criteria. The objective is not a strictly local approach, but one that will improve the treatment of complex configurations while being compatible with the use of stability based methods.

A few illustrations are given to illustrate these points, first a computation results on a 3D high lift case showing the evolution of C_{Lmax} as a function of the chord Reynolds number, from 1.5 to 15 millions, second an example of the new implementation applied to a simple profile.

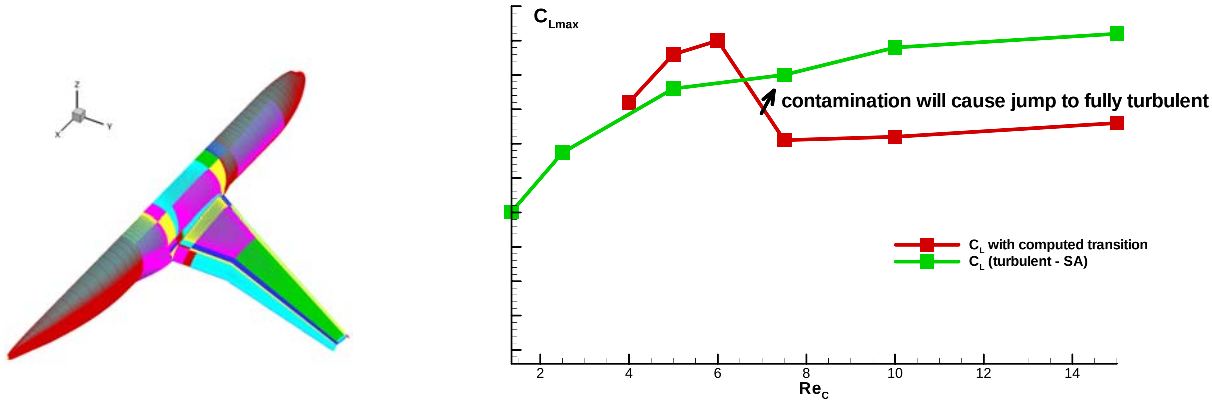

Figure 1 : C_{Lmax} evolution with the Reynolds number

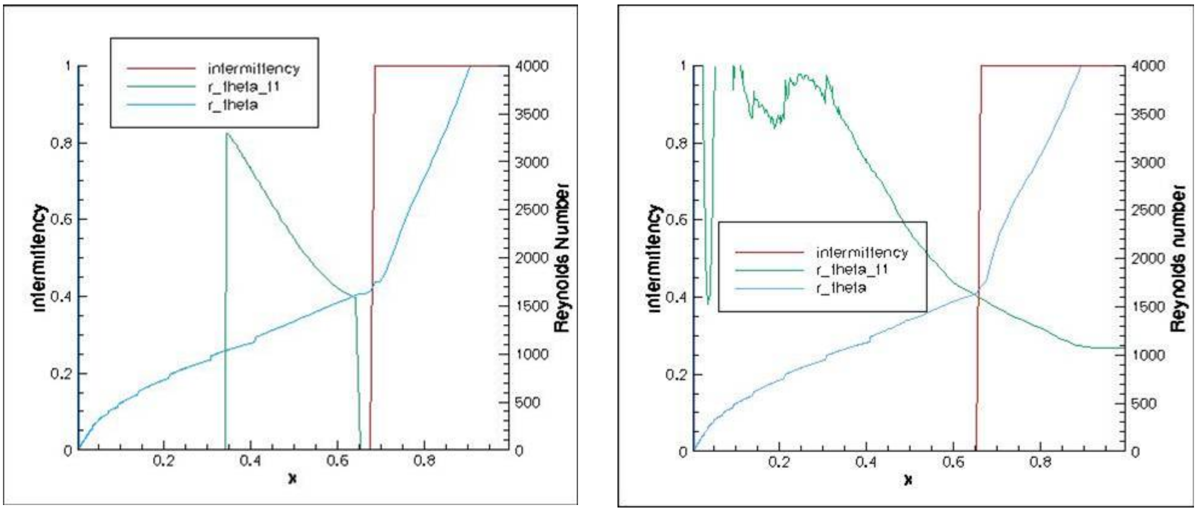

Figure 2 : Application of the new approach on a profile

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