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New Developments and Applications of the γ-Re_Θ Transition Model

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ABSTRACT

Modelling of laminar-turbulent transition processes has gained increased attention in the turbulence modeling community in recent years. While highly specialized models for specific applications have been in use for several decades, there was for many years a gap in the modeling of transition processes in complex and industrial applications. This means that the community had failed in the formulation of models, which where generic enough for usage in general-purpose CFD codes. The requirements for such models are that they have to be independent of the geometry, of the orientation of the flow, the topology of the numerical grid and other applications specific information. These requirements are typically met by models based on so-called single point closure formulations – meaning models based on transport equations with local source terms. For the longest time, single point closure transition models where solely based on low-Reynolds number models, with the hope that the viscous damping terms would also provide acceptable transition capabilities. However, it turned out in many test over many years, that this was not the case, and that the resulting pseudo-transition was not reliable as a design tool. More promising where models, which considered transitional effects during the formulation of the damping terms, and thereby had a built-in calibration for transition under specific conditions. However, these models suffer from the intrinsic combination of transition and viscous sub-layer damping terms. It is therefore very difficult to calibrate the one without affecting the other. In addition, some of the model even showed a hysteresis, resulting in different results if the solution was initialized fully laminar or fully turbulent.

Considering the complexity of transitional processes, resulting from an interaction of linear and non-linear physical processes, a new family of transition models was proposed by the current author and his co-workers. The principal idea was to combine local transport equations with experimental correlations. The concept was termed "**LCTM** – Local Correlation-based Transition Modeling". In LCTM, the physics of the transition process is contained in a set of encapsulated correlations, whereas the transport equations are used as a means of coupling the correlations with the mean flow solver. This has the advantage that the complex, and often not well understood transition processes do not have to be modeled, but can be included through the correlations. The resulting model features two transport equations, one for the turbulent intermittency and a second one for the transitional Re number.

The presentation will re-iterate the original formulation of the γ-Re_Θ model and some newer modifications aimed at reducing the models complexity as well as including some additional

physical effects. The relation between the model and some of the proposed alternatives will also be discussed.

In the application section, a number of generic and industrial applications will be shown. These cover flows in turbomachines, flows with rough walls, flows over wind turbine blades and flows around appendages of Yachts for the Americas Racing Cup, where the current model was used by all major teams.

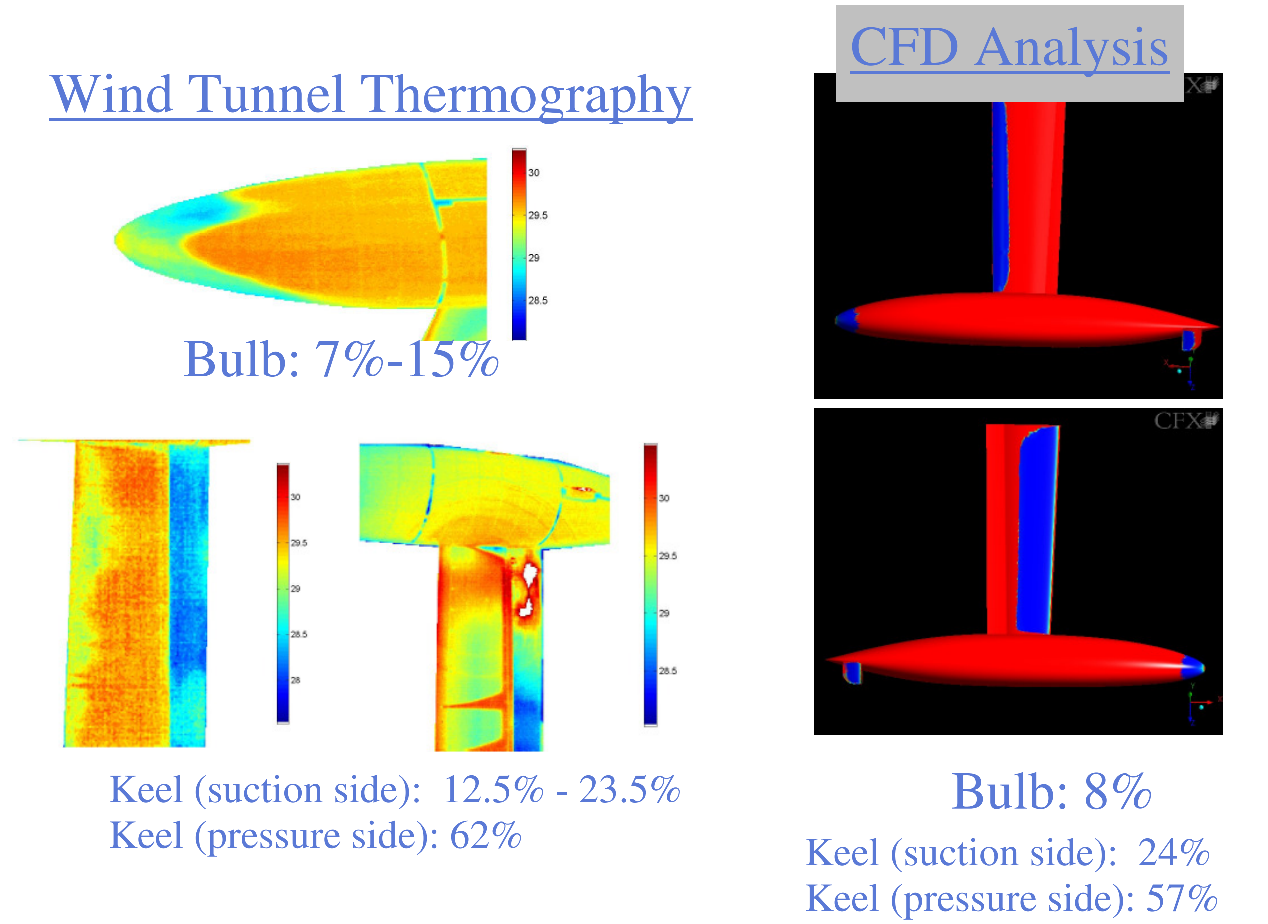

Figure 1: Comparison of experiment and simulation for appendages of team Alinghi's Americas Yacht.

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