TURBULENT SEPARATED FLOWS

A Bump *for* the Road

'I know a guy'

(That's the tiktok version.)

Computational Fluid Dynamics has crossed the event horizon given mind bending advances in intelligence, visualization and computational environments, with advances in analysis, design, simulation, company startups and more already forming. Given the preview though, the road is long still. Fewer are students able and/or wanting to commit the mathematical/intellectual horsepower; outdated and weak the digital form factor and combined with inaccuracies in both physical and virtual model making; specifically in digital model file conversion and transfer, all these emerging resources do not have a rock solid foundation to stand on and build. Though the tools appear to be on line and ready, folks are still struggling/tuning their math and their models ultimately questioning their results, still not able to present whole (CFD) truth strong enough to build with full confidence.

Without question, models accurate to the researcher's specification is paramount, be they virtual or physical in form. As CFD advances, accurate models can be compared to mathematical prediction, better leaving the resulting struggles to shortcomings in software and its application, wind tunnel shape and configuration, team comparison, et al, all the while knowing the model itself is good.

Given advances in both CAD and CAM, combined with analysis software ever more powerful; often open sourced and free of charge, shops such as Scaled Composites and many more are duplicated by smaller teams and private individuals. Scaled is no longer unique. The talent pool is very much expanded, with operating costs often reflecting the size of the smaller operation just as capable. Researchers; themselves to a point limited by the architecture that scaffolds their education, experience and accomplishments, naturally assume/think many of their project requirements as being complex to the point of requiring a large operation, which is not necessarily the true at all.

These thoughts true in my own mind, which may well clash with my contacts, friends and advisors, came to a point where a close contact; a senior Boeing configurator, began work on a research paper covering the development of the Kinetic 100v2, the first unpowered model airplane to exceed 400 mph in sustained dynamic soaring flight. Instrumenting the airframe for strain, crunching large numbers, complex charts and graphs, intended to be a real look from the top of the aero engineering world into dynamic soaring but with a new and fundamental twist; discussion of advanced training, education, experience and exposure in a modern world where small teams and private individuals can meet and sometimes best any skunkworks operation concept to flight, often now at the hobby level:

> '*Given the whole of my training, experience and accomplishments, no different than any of my peers and superiors, it has never even entered my peripheral thinking that it is possible for an unpowered model airplane to exceed 300, 400 and 500 mph in sustained flight. This is not right.*'

Enter the Mouse

And so a pride of true lions, headed by Dr. Philippe Spalart with funding provided by Boeing, working with Dr. Owen Williams at the University of Washington along with a small team of advanced students set out to work with advanced CFD concepts, visualization technique and practices, student education/skills advancement, inter edu level sharing/collaboration and more set out to work with a gaussian 'Speed Bump' model to be fitted in the Kirsten 3x3 foot wind tunnel. Philippe submitted exquisite formula to describe the model, and positioned himself to promote/oversee/observe/critique the project as is typical for him. At the start however a showstopping fault appeared; the model built by Boeings own shop was found too inaccurate for project use, and was rejected outright after incurring costs unknown to me.

In what within my own opinion was an exceptional 'out of the box' thought and approach for a senior distinguished technical fellow sitting on the very point of the aero engineering pyramid, Phillipe suggested a private individual, not a company or team; an individual nowhere near that level but with design and manufacturing history, results and accomplishments already well demonstrated and known, with operations one hours commute away from the Kirsten. The impact was enormous, hidden in plain sight. Since I am not one of them, there is no competition; there is no stack ranking, there are no IP risks, there is nothing in the way of exchanging information in whole and complete, with no opportunity for misinterpretation.

Myself, my role, the manufacturing portion of the program was made part of the project team. As opposed to waiting for a specification to fall from the sky, I was included to begin with after the first model failed. Working with lions in CFD, math, theory, education and more, I become the mouse in their mane from the start. Given their own very limited experience in CAD/CAM and model making, the fit is perfect and very comfortable. Knowing enough, I only need to listen and advise when off (manufacturing) course. I understand the first time, and form up the manufacturing process as they form up their own objectives at the same time. This for me defines 'Agile'; Everybody in, everybody focused on their lane(s), everybody getting the picture correct right from the start.

Dr. Williams converts Philippe's math into a model and submits. No question as to fidelity to the source. At that time I dropped the subject of 'Production Research', that this project can not only be executed on a rapid prototyping lifecycle, it can serve as an example where universities can ask for models and get them quickly and at a fair price, within the class scholastic/quarterly cycle no less.

Again as a result of inclusion from the start, I already know how I will execute. I'm going to machine the model from home made acrylic stone, every bit as dimensionally stable as aluminum for a fraction of the price. A $50k model for $5k, just as accurate and equally as usable for repeated experiments. The model is to be pressure tapped 40 times. The taps will be precision drilled using form fitting precision templates, where the end of the template is machined normal to the 'Bumps' surface at that location. Since the 1/64" drill is flexible by nature, drilling the taps with precision is a non issue; just use the templates end face to bend the drill accordingly.

To prove it all with hope to promote the concept of 'Production Research' from a rapid prototyping environment, a scale model was fabricated in quick time and submitted to Owen. Understanding the manufacturing process in full by holding a scale model, I move to fabricating the full sized artifact.

Both the scale and full sized models were made from a mix of epoxy, ATH powder and colloidal silica in a lost mold process.

The models were carved oversized as female cavities in blocks of 2 pound open cell foam laminated to the required thickness. The epoxy and ingredients were mixed to the viscosity of warm honey, and was evacuated in a vacuum pot to remove bubbles. ATH prevents epoxy from exotherming, so the entire mold was cast fairly quickly. Anchoring the block upside down on the CNC machine, the bottom was machined flat. The result is the models base. The block is then flipped over, located and anchored, and the entire block is carved to remove the foam and reveal the models final shape, accounting for the thickness of the paint. The model was then painted and polished with a random orbit polisher.

The model was submitted to the University of Washington for the visualization programs. Success there, and the model was returned to the shop for precision tap drilling following a map provided by Dr. Williams. Success again, to include repeated experiments at the UW and other facilities where the model was crated and shipped.

All outcomes were more than favorable, and the program clearly demonstrated the concept of 'Production Research'. Current research being conducted by Dr. Williams has a strong chance to see additional models being produced at different aspect ratios.

Steven Seim

Personal commentary

The Kirsten 3x3 tunnel facility is a national historic landmark, funded by Bill Boeing. It is sacred ground. To have my own work there was an honor not possible to fully convey. To even think of the long line of engineers and model makers that have staked their dreams and visions there, and now I join them. I was invited to witness the experiments where each of the 40 taps was read for 8 seconds, and I brought a boxed container of coffee and Makers in a flask. Likely totally inappropriate. What a treat to sip and see it all run at 150 mph tunnel speed.

The gallery link will present photos of the project.