Answers to leftover chat room questions from *Vikram Shyam's* Seedling Seminar presentation *Holistic Concepts for Aeropropulsion,* February 27, 2014

Joel Wagner:
Historically, fluidic control for flow diversion and for generating oscillating flows requires a significantly higher "signal" air pressure source. Has the source and amount of this air been considered?

Vikram Shyam:
Joel, this is an important consideration. We have considered the source flow based on preliminary CFD simulations to ensure we have enough mass flow for control. We are using two types of fluidic valves. The first is a diverter, i.e., a Coanda-type valve that sends the flow off to one of two possible paths with no internal chamber and no feedback paths for oscillatory switching. The second type of fluidic is an oscillator designed by Advanced Fluidics that produces a bifurcated pulse or sweeping motion that functions at even low pressure ratios (we have done bench-top tests to verify this). The latter has an internal chamber and includes feedback paths. The fluidic diverter requires a higher control signal to switch it and responds well to low frequency switching (intended purpose). It also has lower pressure drop across it. As for source flow, either boundary layer ingestion or a small fraction of compressor bleed (0.1%) would be sufficient. Characterizing the effect of signal strength, effects of unsteadiness, path lengths, attenuation etc. are proposed tasks for phase 2.

Joel Wagner:
I am enthusiastic about using fluidics to control main gas path flows. Thanks for conducting the study.

Gavriil:
(On Joel Wagner comment) Indeed.

Vikram Shyam:

Thank you!

George Adams:
Thanks Vik, when I think of bio-propulsion I would think of a squid, it is quite amazing what you found from a whisker, thank again

Vikram Shyam:
Thanks for the interest! We are looking at the propulsion abilities of squid-like marine organisms but not related to this Seedling Fund effort.

Krish Ahuja:
Vik: Have you done some calculations for potential noise reductions or is it just your gut feeling.

Vikram Shyam:
This is based on the gains from 'wake filling' experiments. The idea is that we would be able to achieve a breakdown of the turbulent structures and bringing down the tones with significantly less energy. We are currently obtaining hotwire data in the wake to get a better handle on the actual number.

Krish Ahuja:
The whiskers are like car radio antennas, where the wake shedding can be modified by wrapping a hanger spiral. This makes the vortex shedding along the span incoherent and reduces wake noise. This is used to reduce oscilltaing drag as well. Do you think the same mechanism is in works in your case?

Vikram Shyam:
Krish, the impact on noise is a good point. The European team (Hanke et al.) show that the shedding is basically pushed aft of the body and segregated along the span so that shedding between two adjacent peaks or valleys is out of phase. The result of offset shedding is that the unsteady lift forces on each side of the vibrissa are offset and this is the reason for reduced unsteadiness. The

breakdown of the vortical structures in the wake was shown to be much faster than that off a cylinder. This may prove to be of benefit to us from an acoustic standpoint. At the end of the talk, the Scruton helix was mentioned as a solution for VIV (vortex induced vibrations) that is used for electric cables and antennae and such. The major drawback of that geometry is increased drag. The Seal whisker has a drag reduction of approximately 40% based on the European study. Our implementation on the blade shows a similar magnitude in loss reduction. In phase 2, we plan on detailed flow visualization and wake measurements to better understand the mechanisms at work for the seal vibrissae and for our implementation of it on multiple airfoils.

Milind Bakhle (NASA GRC):
Vik, Thanks for your very interesting research work.

Vikram Shyam:
Thanks for tuning in Milind.

Krish Ahuja:
Thanks for inviting me to participate. Great work.

Vikram Shyam:
Thanks for attending!