ECATS SARC conference 2020-10-14

Harmonic Forcing From Distortion in a Boundary Layer Ingesting Fan

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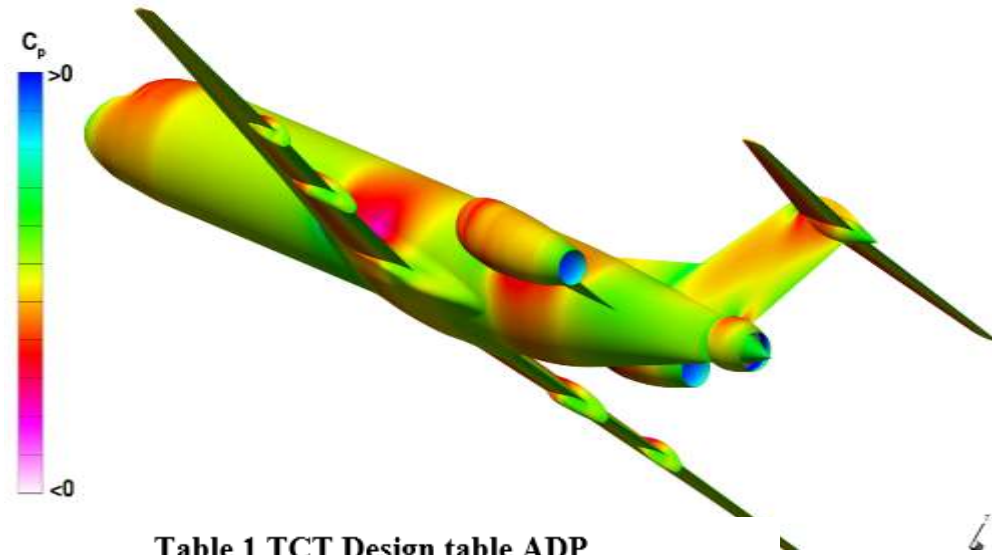
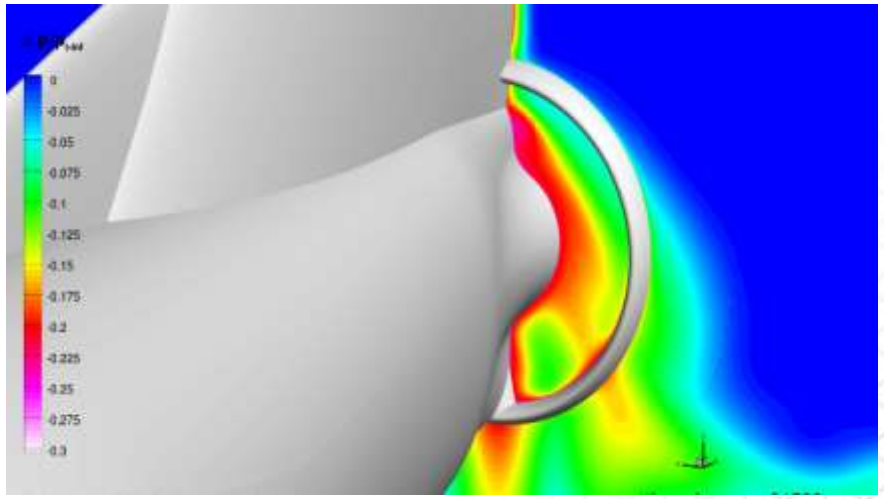
F100 Whole aircraft CFD results used for realistic BC





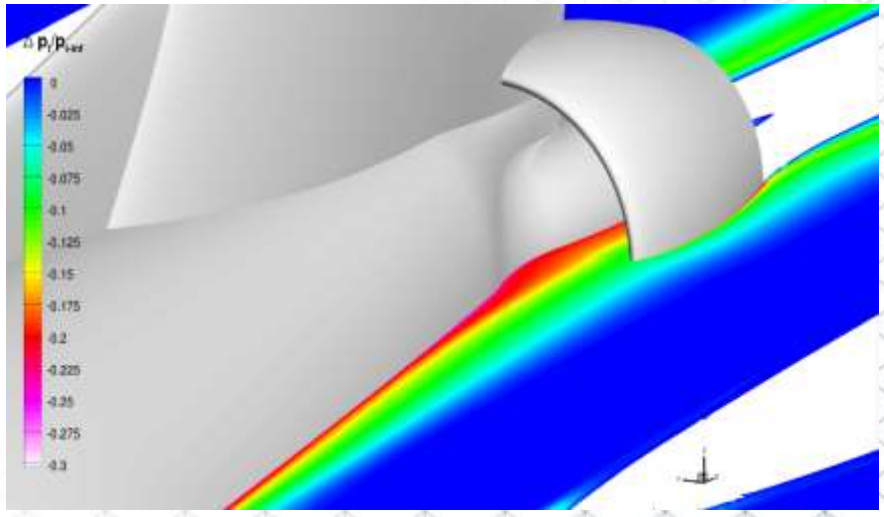
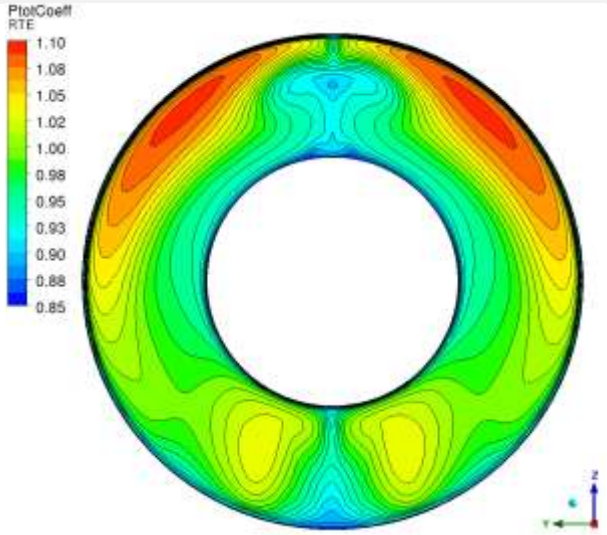


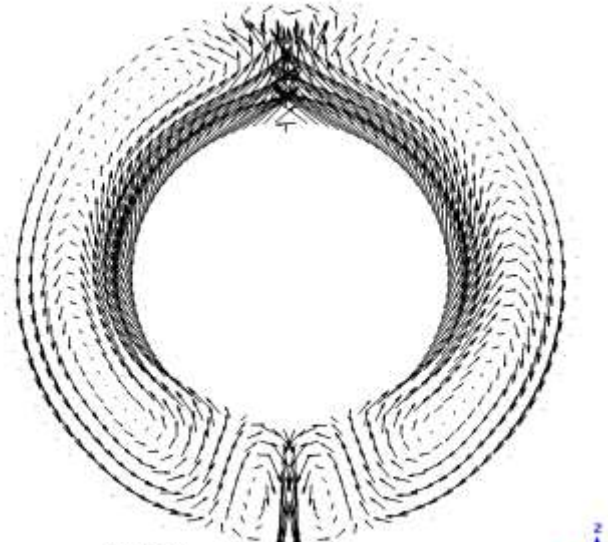
Table 1 TCT Design table ADP

Diameter	[m]	1.2
Shaft speed	[rpm]	4419
PRTT	[-]	1.3
Fan efficiency	[-]	90%
Electric power target	[kW]	1000
Altitude	[ft]	35 000
Flight speed, Ma	[-]	0.74

Performance presented in GT2020-2487, with M.Laban, NLR

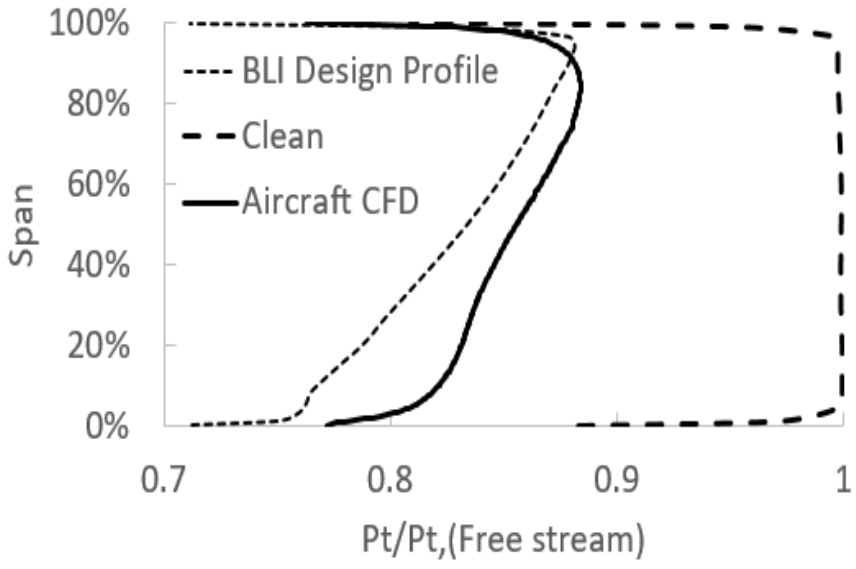
Computation set-up for the fan, 360 unsteady model in CFX

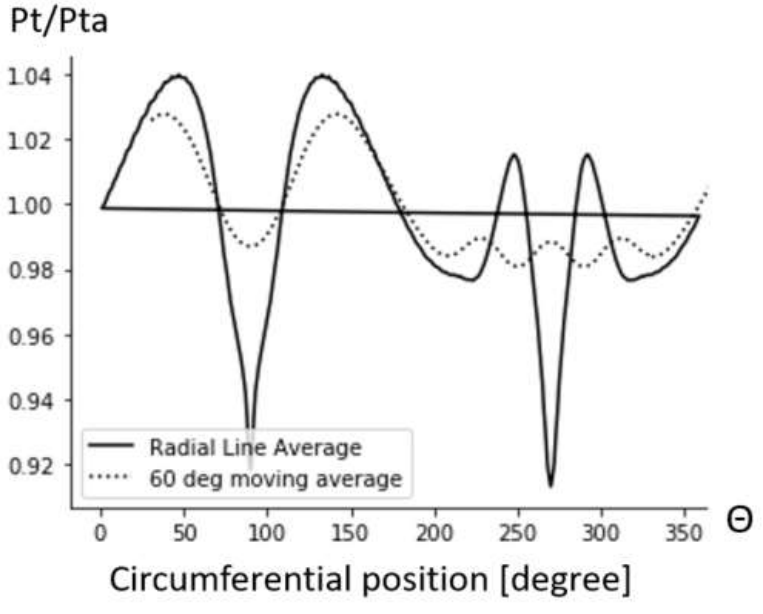


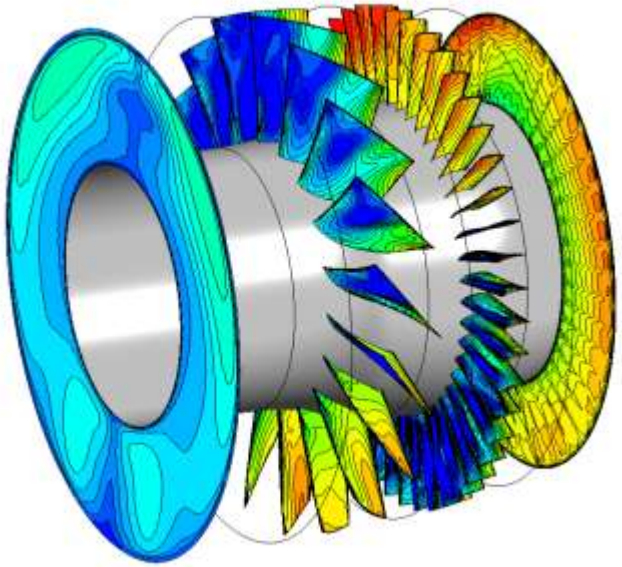


Inlet field Total pressure and swirl velocity vectors mapped from whole aircraft CFD

$$DC_{60} = \frac{P_{t,60} - P_{t,ave}}{P_{t,ave} - P} = 12\%$$

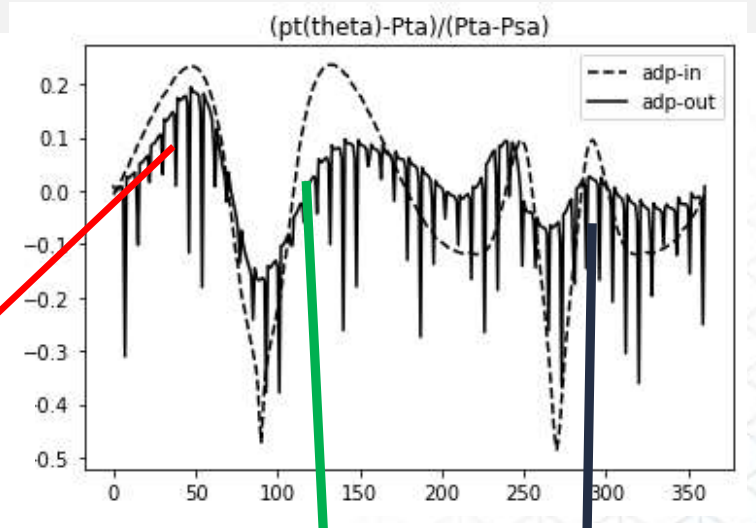


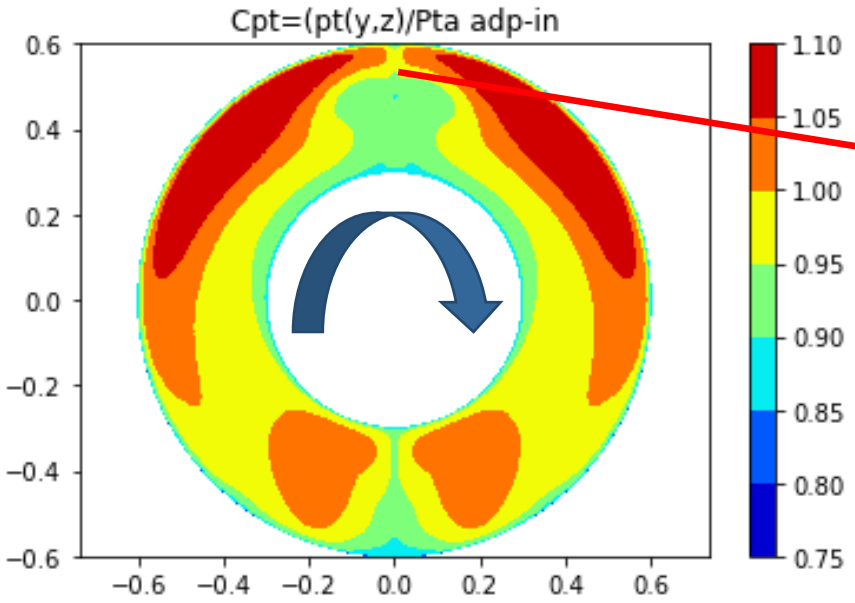


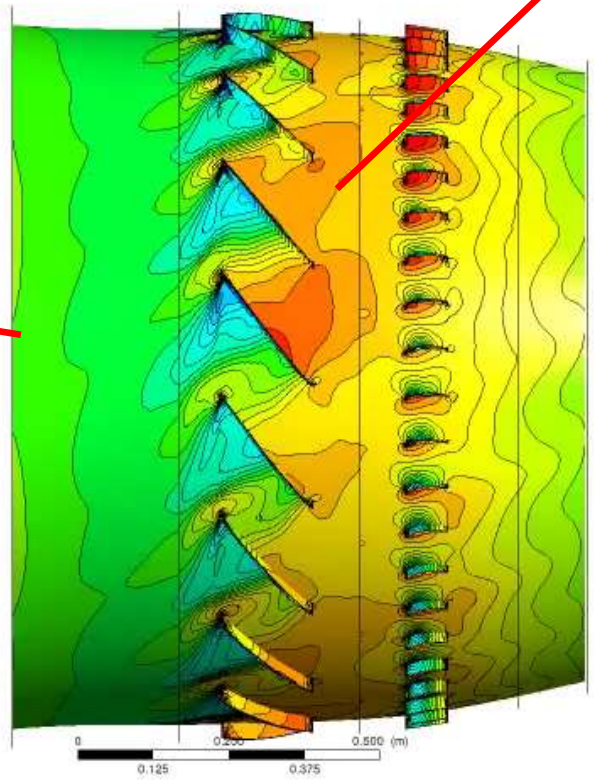


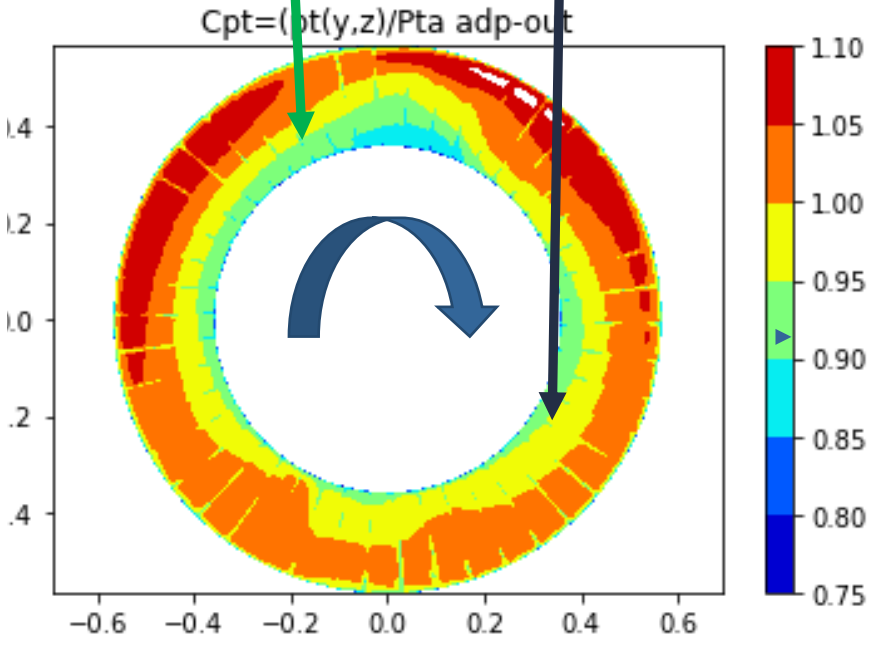
Attenuation and unsteady pressure field

Distortion is attenuated by the blade load increase coming through the low P0 region







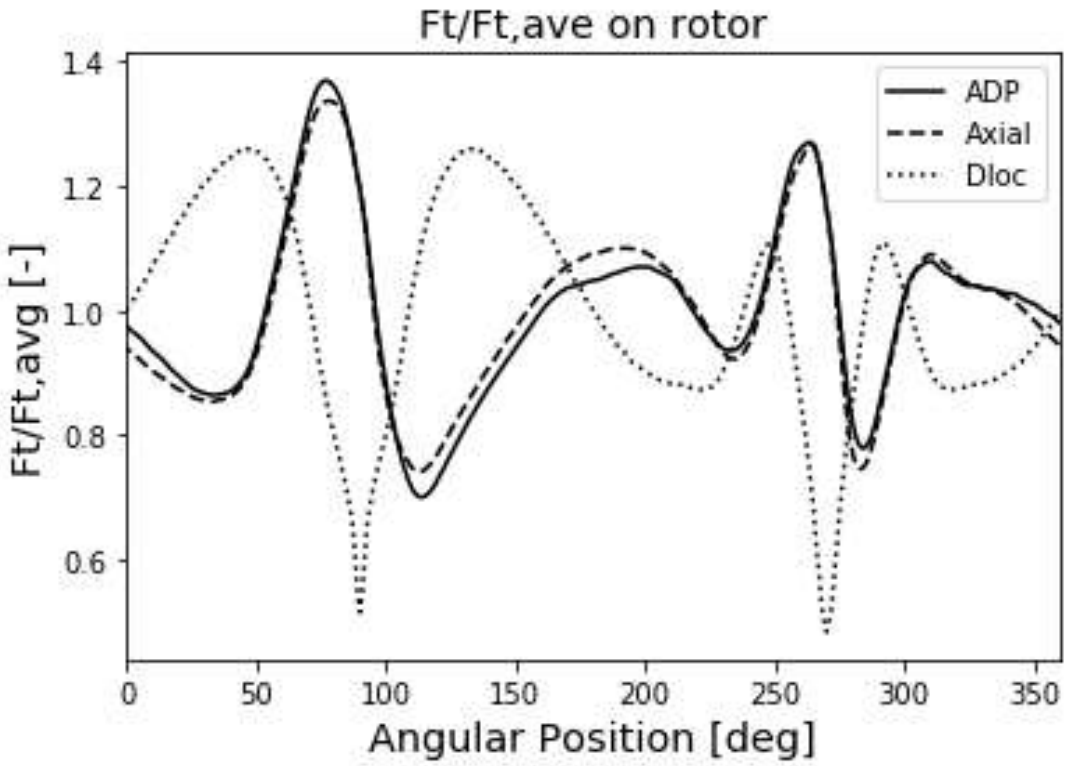


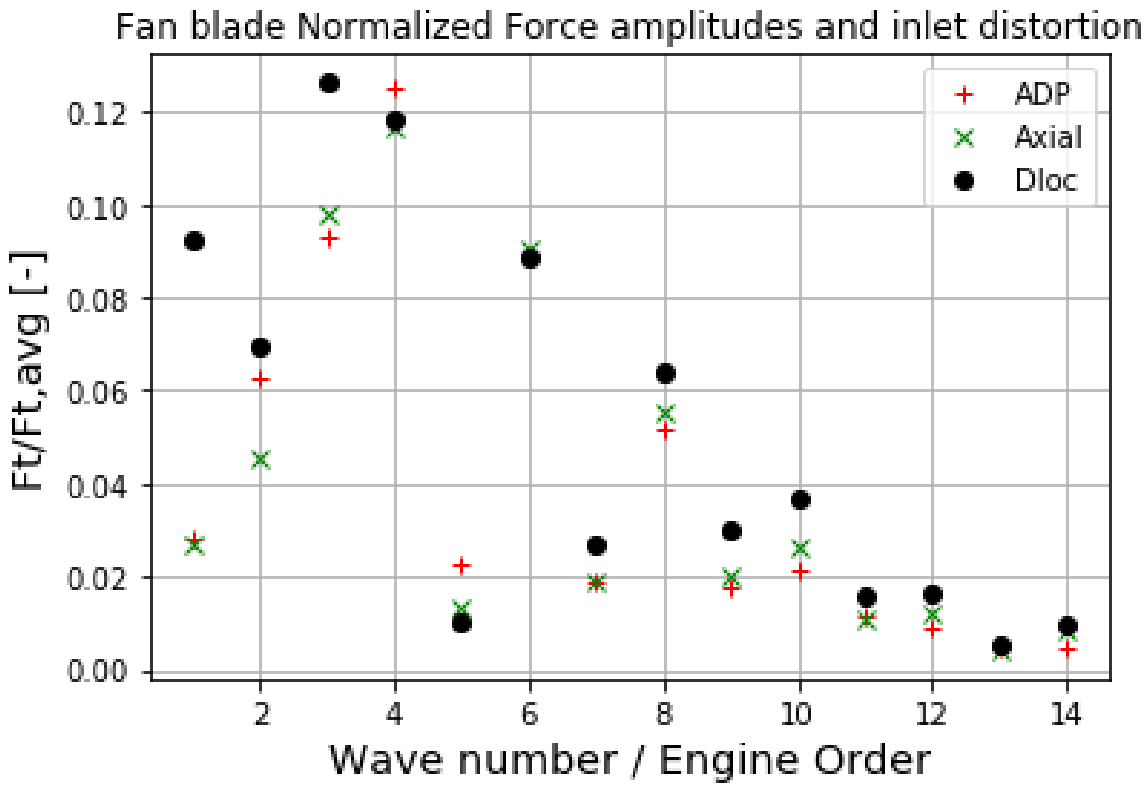
Forcing and distortion correlation at ADP

Good correlation with Fourier components of P0 variation, but a large force amplitude

The swirl velocity components contributes marginally

At 10 EO the forcing has dropped off, odd EO earlier

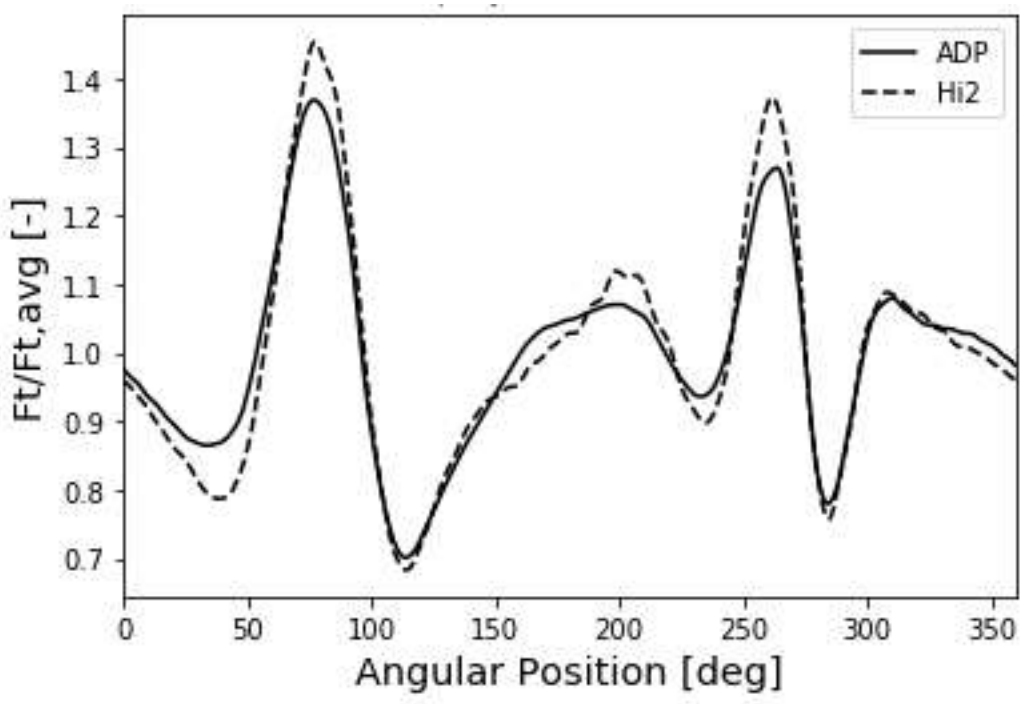


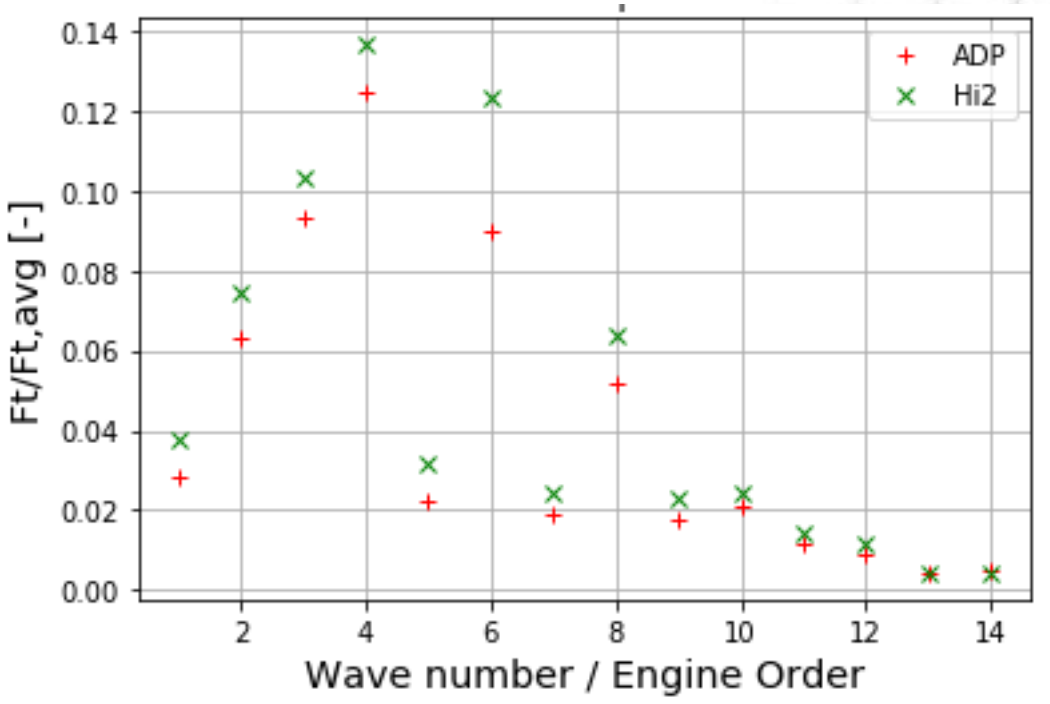


Off-design effect on forcing

Reducing the mass flow 91 % of ADP with the inlet BC

- increases normalized forcing moderately

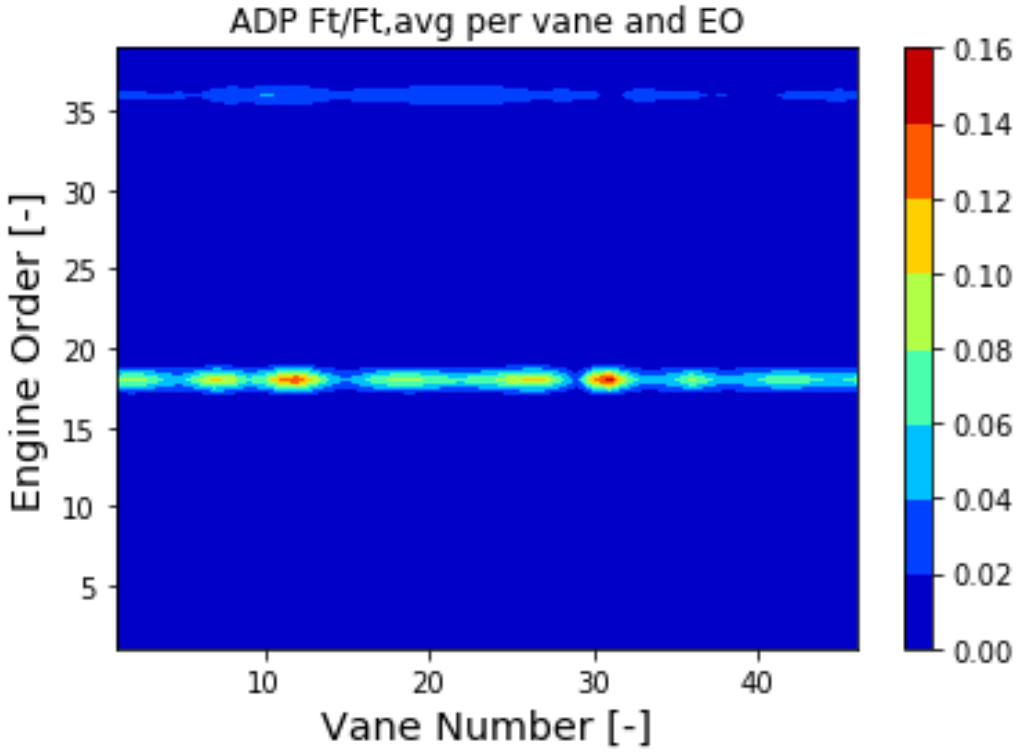


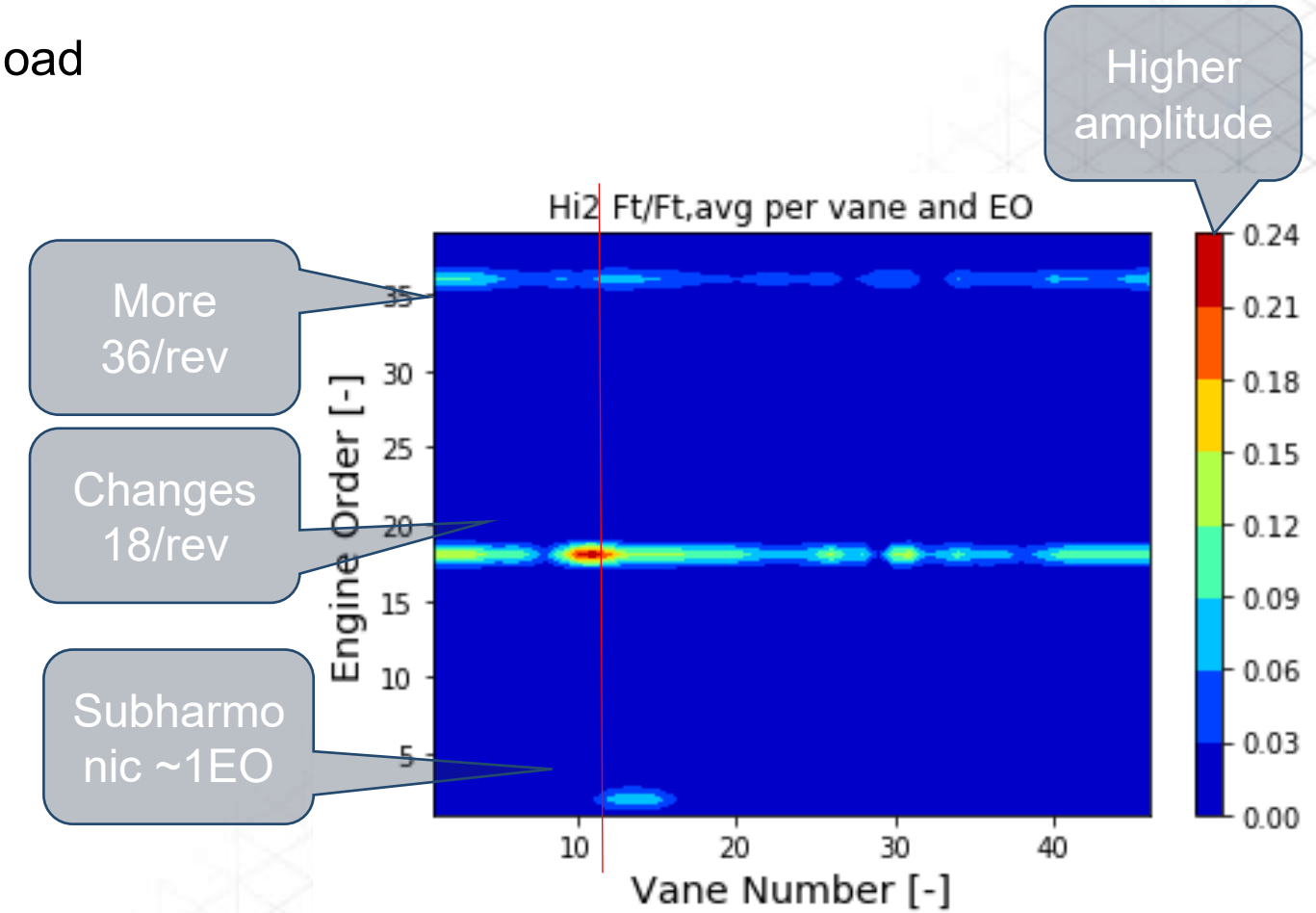


Vane harmonic response

Vane responses at 18/rev, 36/rev vary with position and load

Some low EO response occurs at the higher load

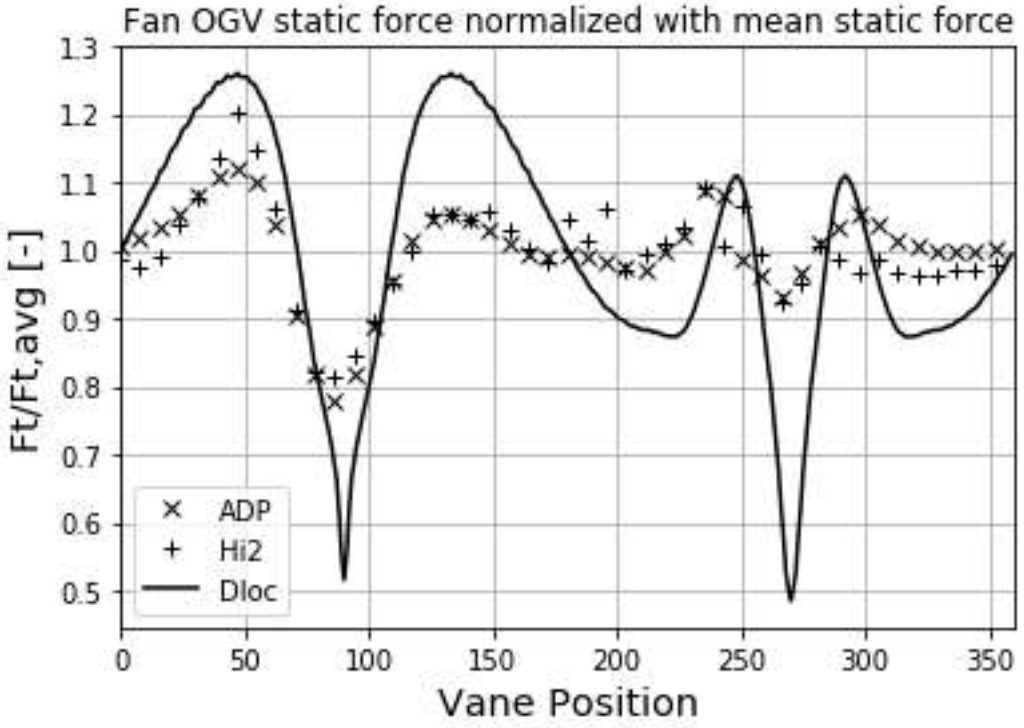


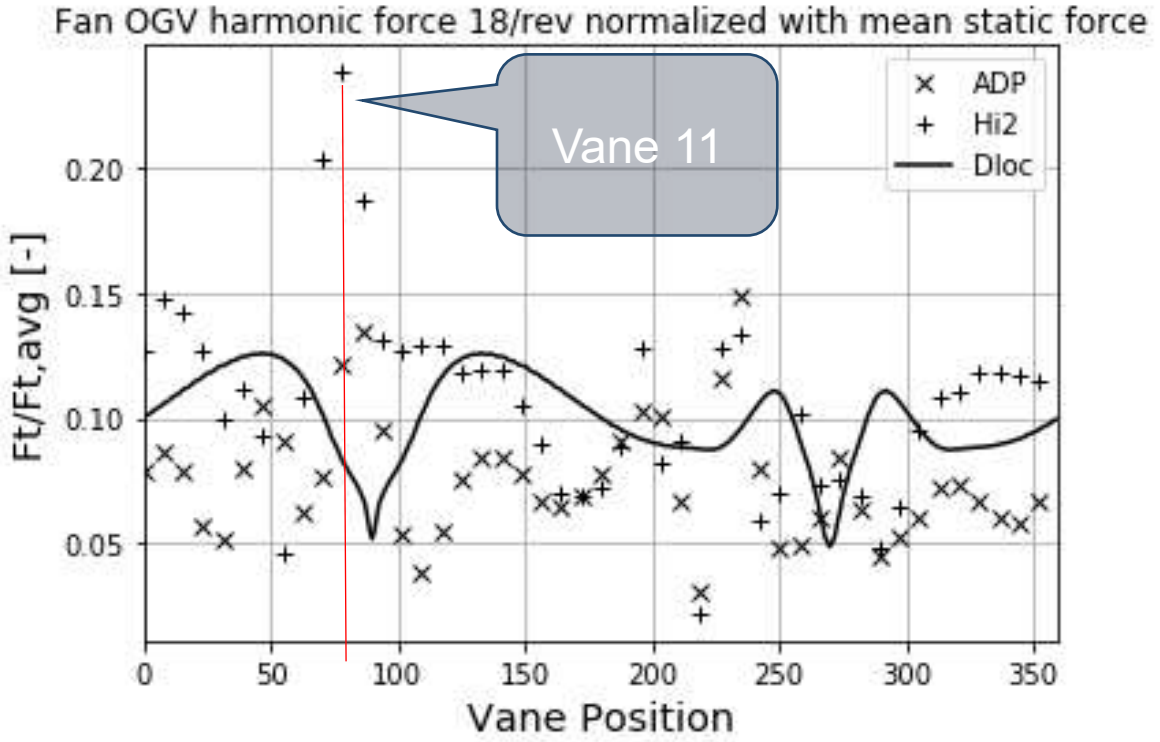


Vane response

Static forces are clearly correlated to the distortion pattern

At a lowered mass flow vanes in the highly loaded sector shows higher response





Summary and Conclusion

In this case – Pt distortion dominates, swirl effects are small

Rotor harmonic forcing correlates well with the distortion parameter for most wavenumbers.

A larger variation of loading on the stator is observed

Results suggest that blades aerodynamics copes with this level of distortion, but also that improvements may be made to the design