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NLR contribution to AEROGUST

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AEROGUST project

Contributions of NLR to objectives of AEROGUST

1. ~~Understanding non-linearities of gust interaction using CFD~~
2. Reduced reliance on wind tunnel data

   ~~T3.1: Initial evaluation of current industrial loads process for gusts~~)

   T3.2.2 Investigation of using multiple flight shape models for aeroelastic corrections

   T3.3.1 Effect of aerodynamic and structural uncertainties on the worst case
3. Adapting the loads process for non-linear and innovative structures

   ~~T5.3.1 Develop comparison methodology~~

   T5.3 Simulations

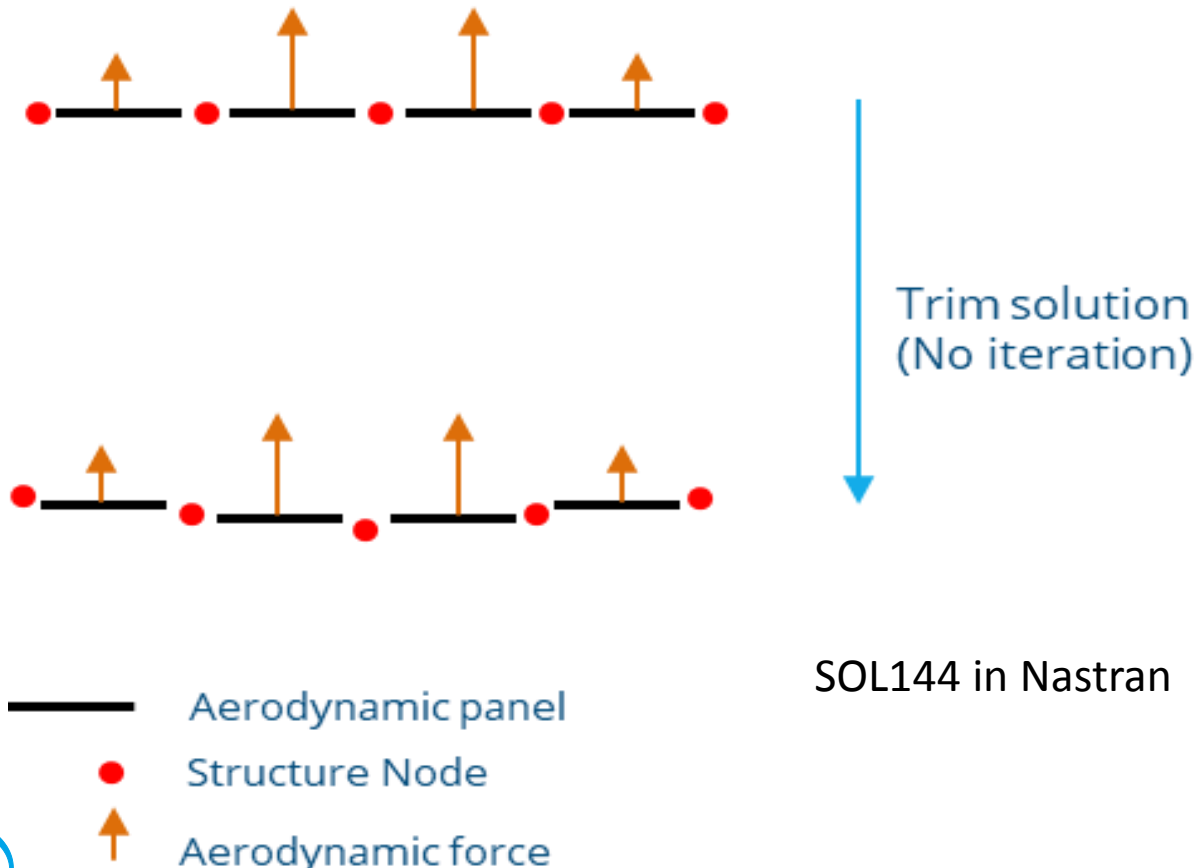
T3.2.2 Investigation of using multiple flight shape models for aeroelastic corrections

The goal is to perform a gust simulation using the DLM method with a *nonlinear pre-stressed* structural flight shape

This flight shape is computed using an iterative process

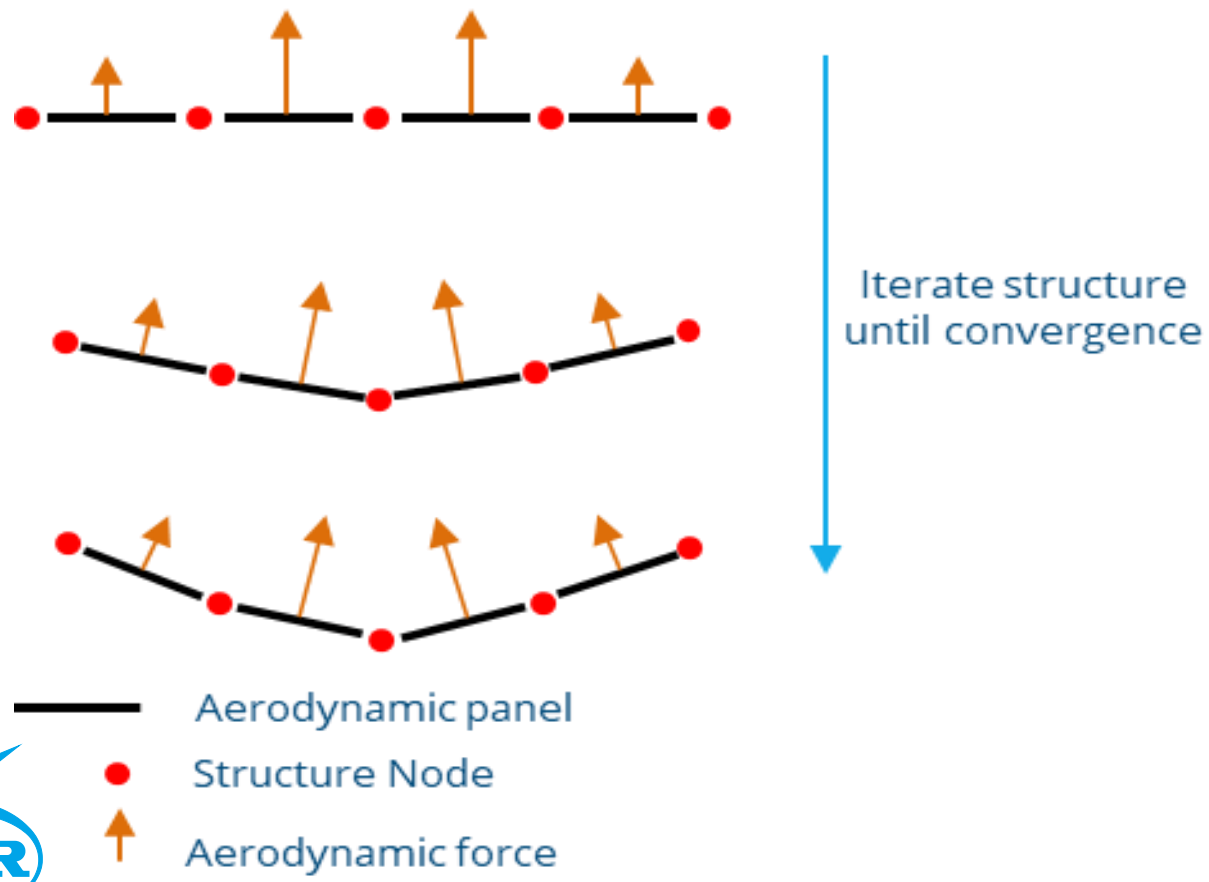
Once this flight shape is obtained one can subject the model to a gust. The gust analysis will be done by linearizing the trimmed state (i.e. prestressed modal analysis).

Default static trim



SOL144 in Nastran

Nonlinear static trim



SOL106 in Nastran: Geometric nonlinearity (follower forces)
NB Restriction is that wing must be constrained

Aero remains DLM (either from Nastran or ZAERO) but the attitude of the panels is taken into account

Status

Implementation coupling with ZAERO has started, nonlinear pre-stressed trim is obtained

For a gust simulation, ZAERO requires both the MGH matrix as well as the (free-free) mode shapes. A NASTRAN DMAP routine exists for non prestressed modal analysis (SOL 103) but this does not work with (nonlinear) prestressed modal analysis

Looking for a solution...

T3.3.1 Uncertainty for 1-cos gusts

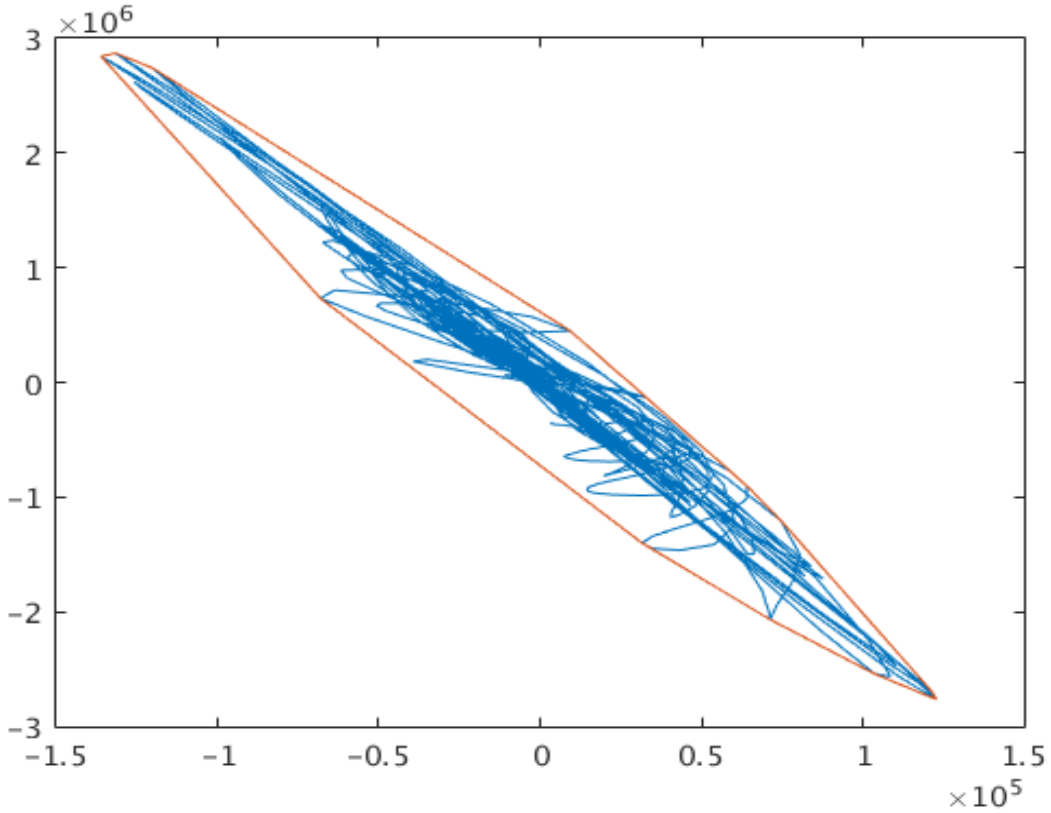
Approach: use Dakota (dakota.sandia.gov) as driver for polynomial chaos expansion of the outcome of a reduced order model

Analysis model is the CRM Nastran model with (corrected) DLM (from UniBristol) – so linear model

- Focus on correlated loads, rather than worst case

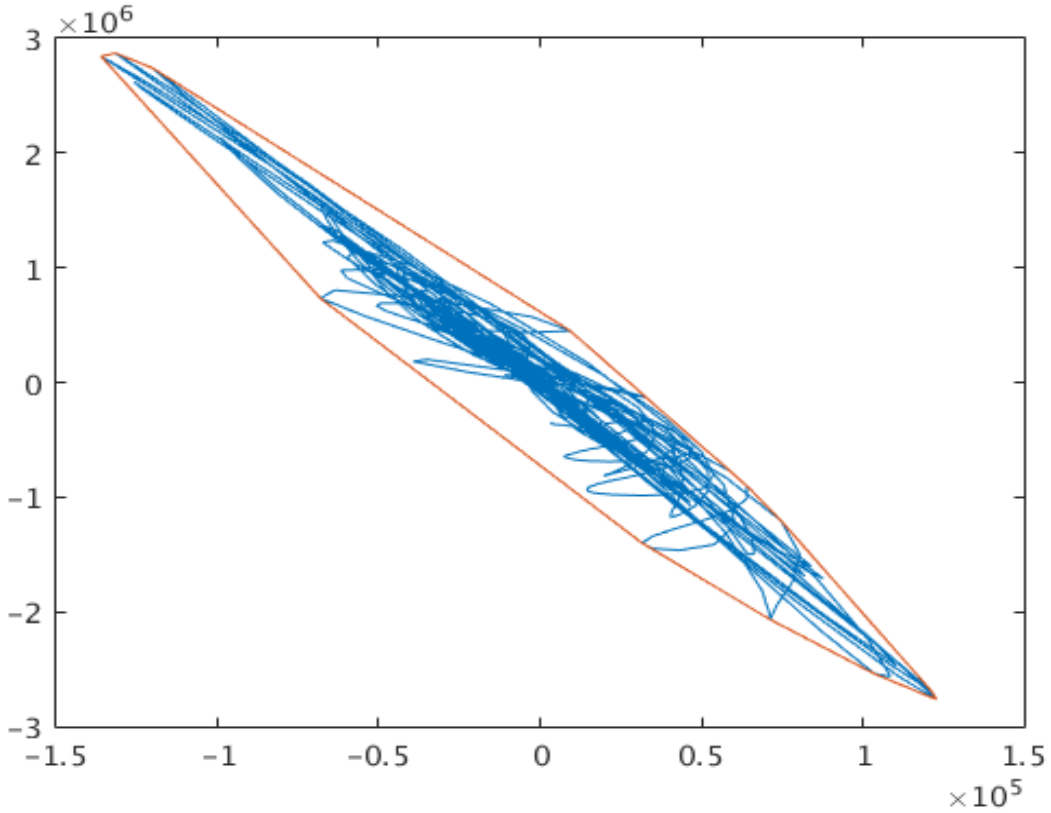
A parametrization of the ‘potato’ plots of correlated loads is proposed, which allows UQ of the parameters

Parametrization of the potato

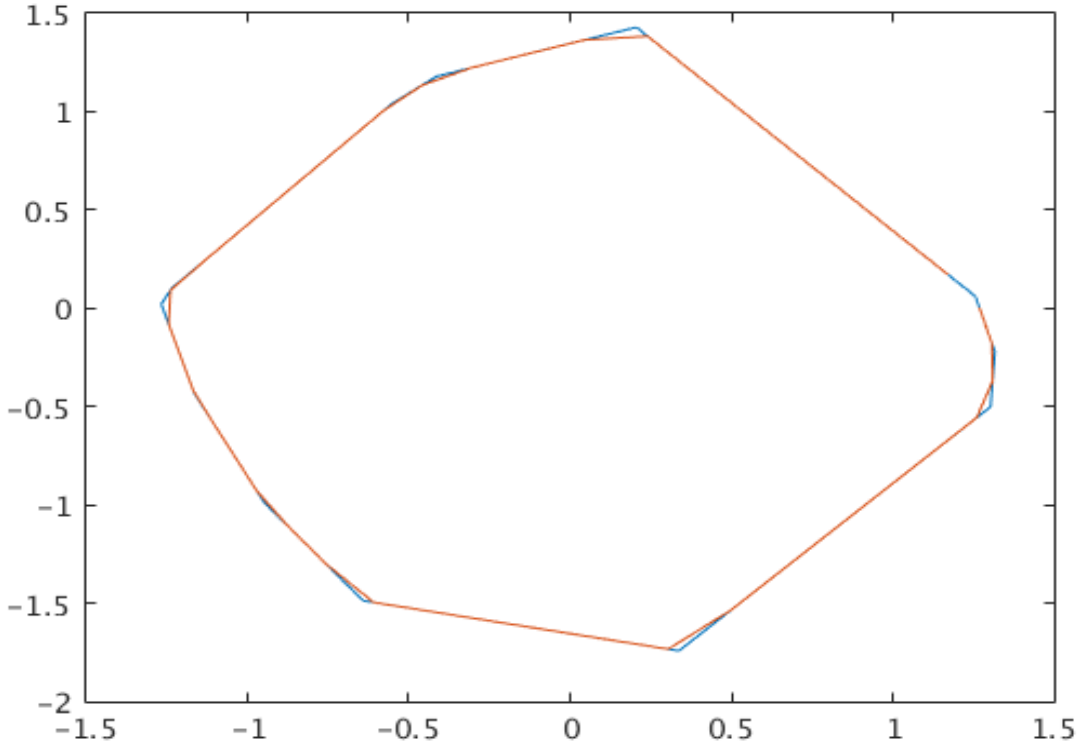


loads en convex hull

Parametrization of the potato

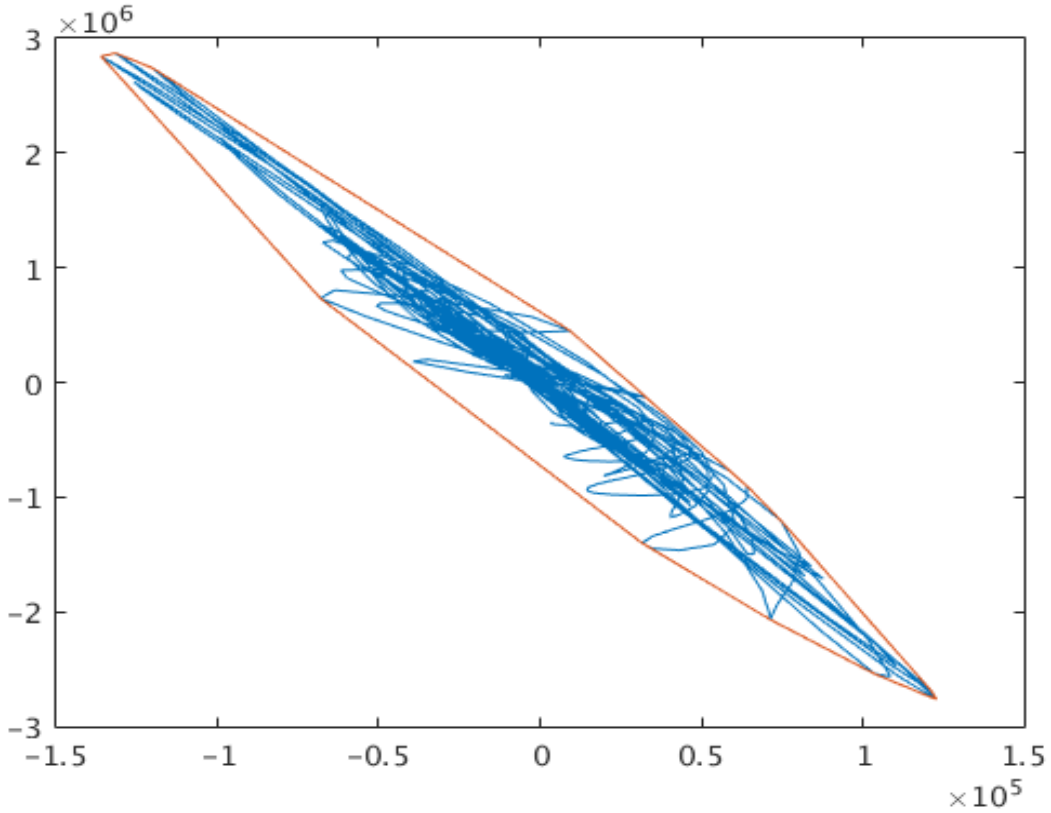


loads en convex hull

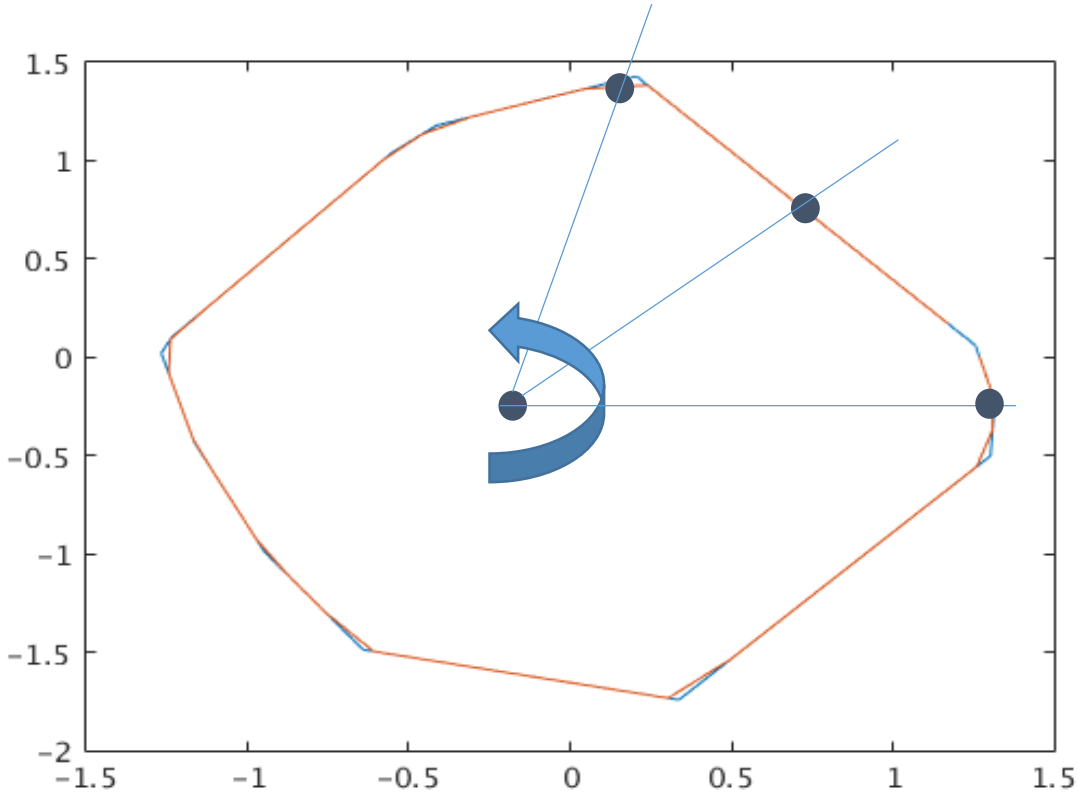


Scaled and rotated potato using PCA

Parametrization of the potato

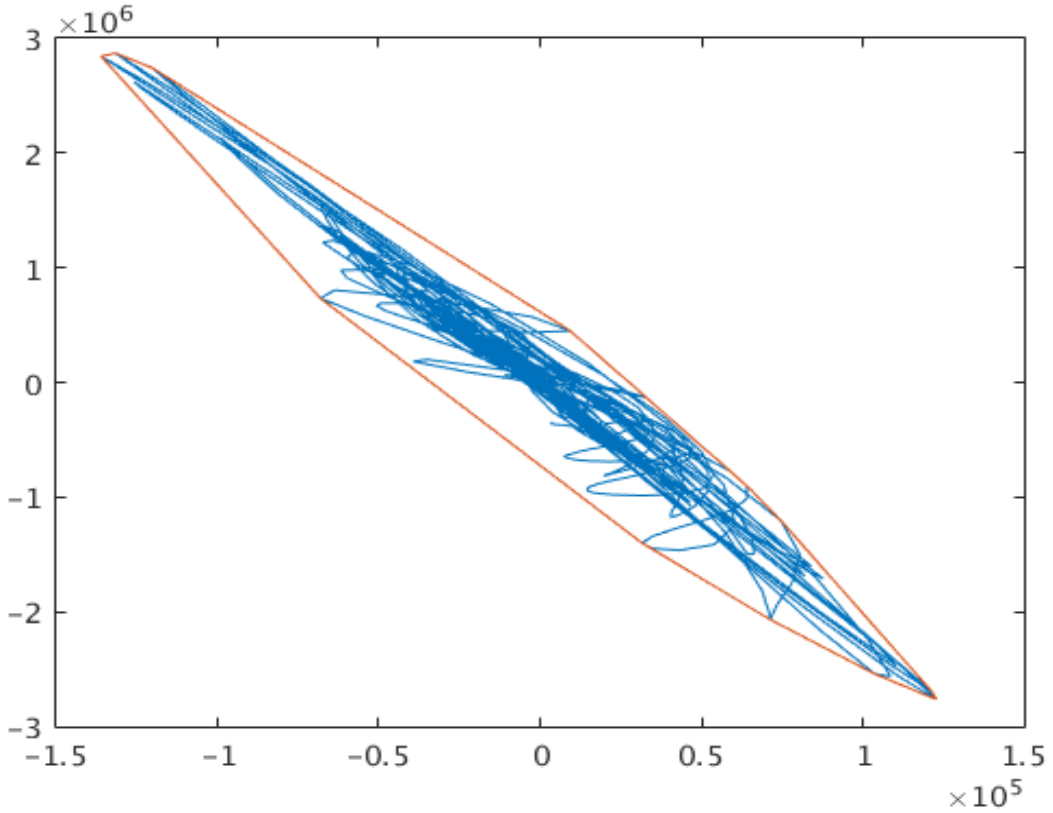


loads en convex hull

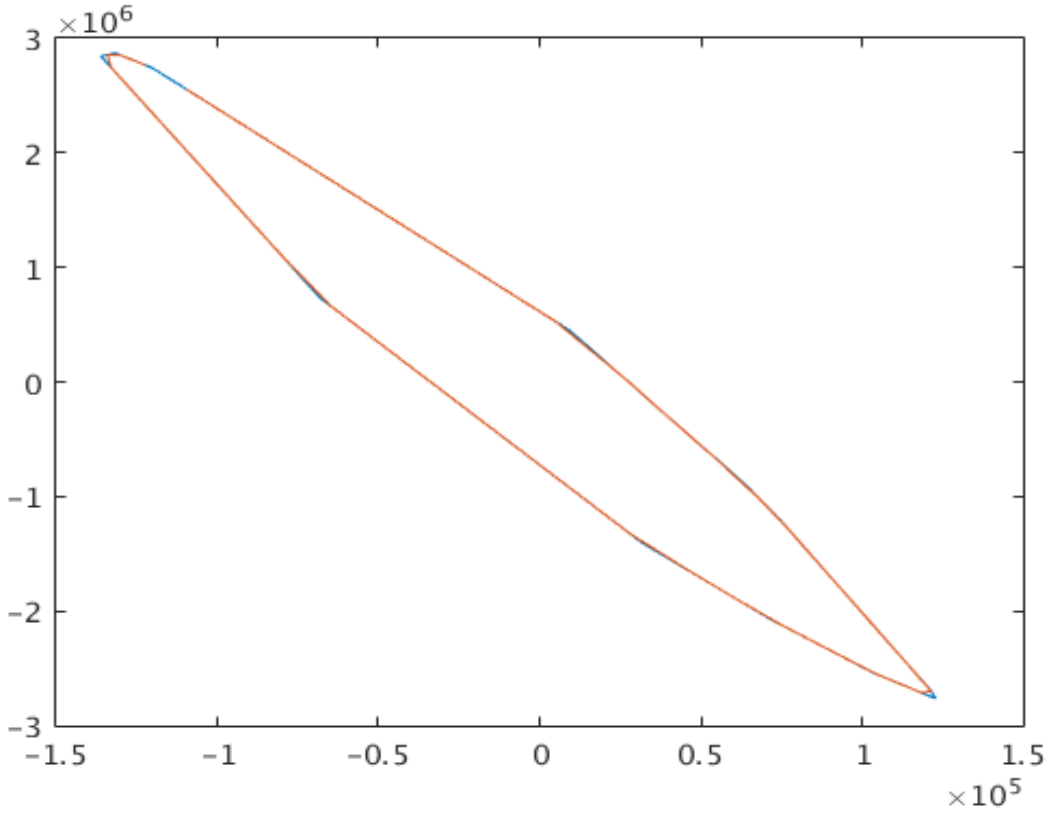


Parametrization of the scaled potato:
Radii at given angles

Parametrization of the potato



loads en convex hull

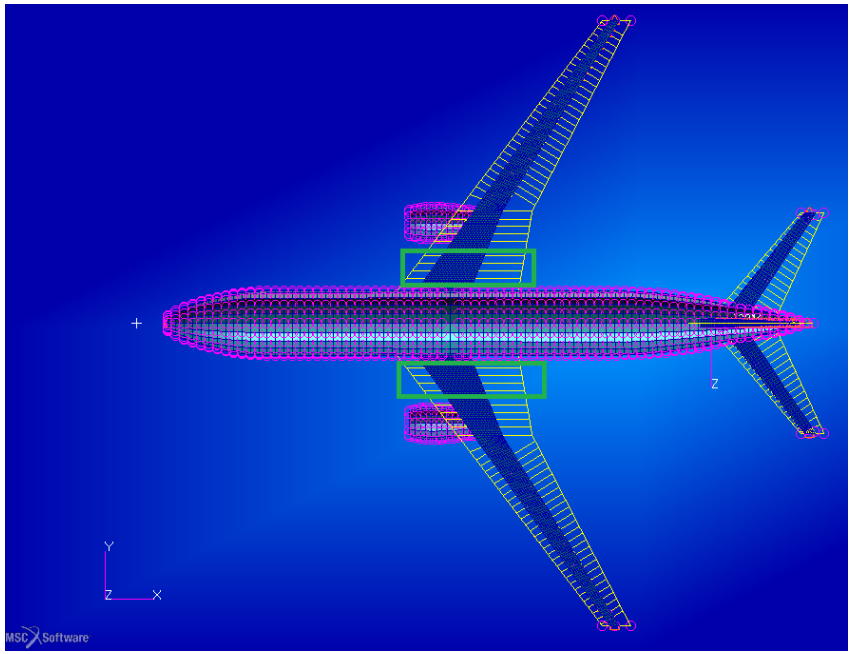


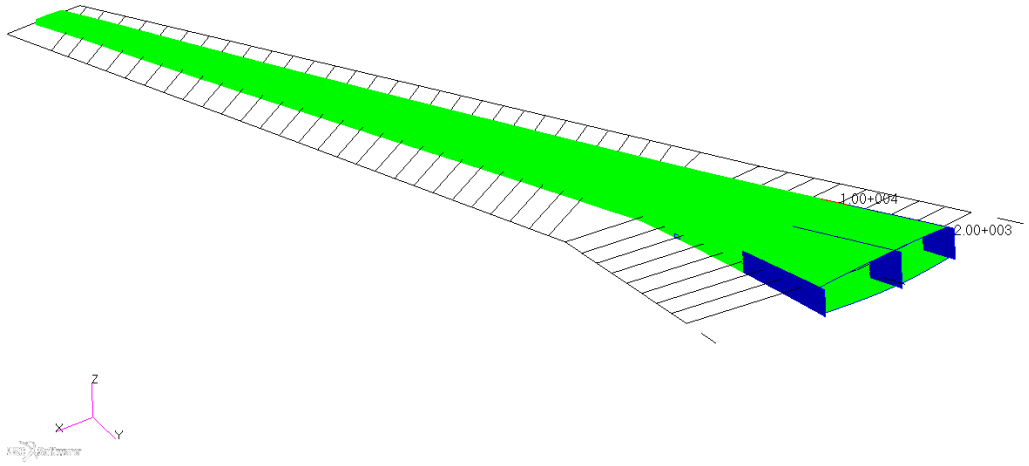
Scaled-back parametrization

Model variations

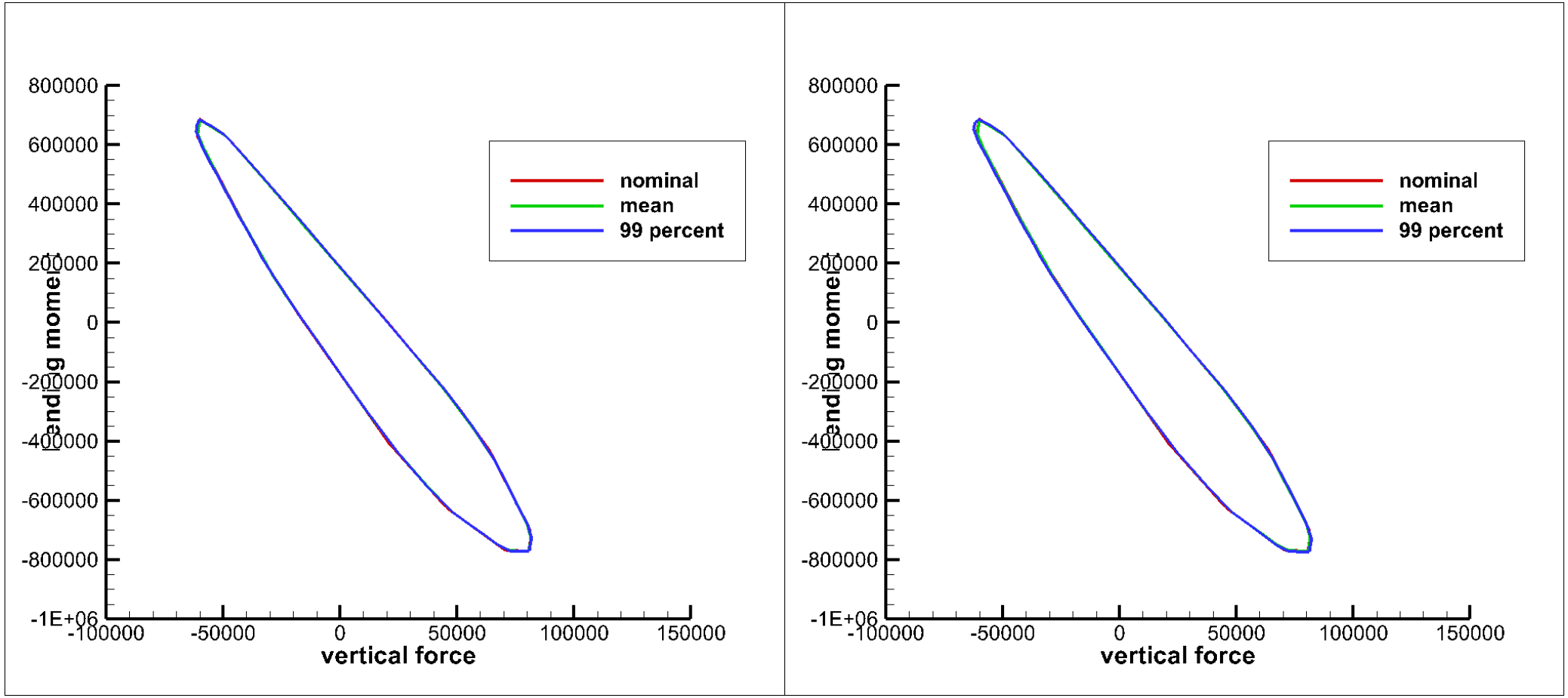
Young's modulus is varied in the three spars at the root of the wings

Normal distribution is assumed (10% or 20% standard deviation)





Results with PCE



10% standard deviation

20% standard deviation

Next steps

Agree with Bristol which structural parts of the model to vary

Possibly replace the linear process by using multiple flight shapes (nonlinear pre-stressed trim)

Contribute to joint paper with Bristol and Numeca

T5.3 Overview of calculations

configuration	weight	flow condition	flexible	rigid
CRM	heavy	H	√	√
		F	√	√
	light	H	x	x
		F	x	x
UAV	-	P	√	√

x: running as we speak

Overview of calculations

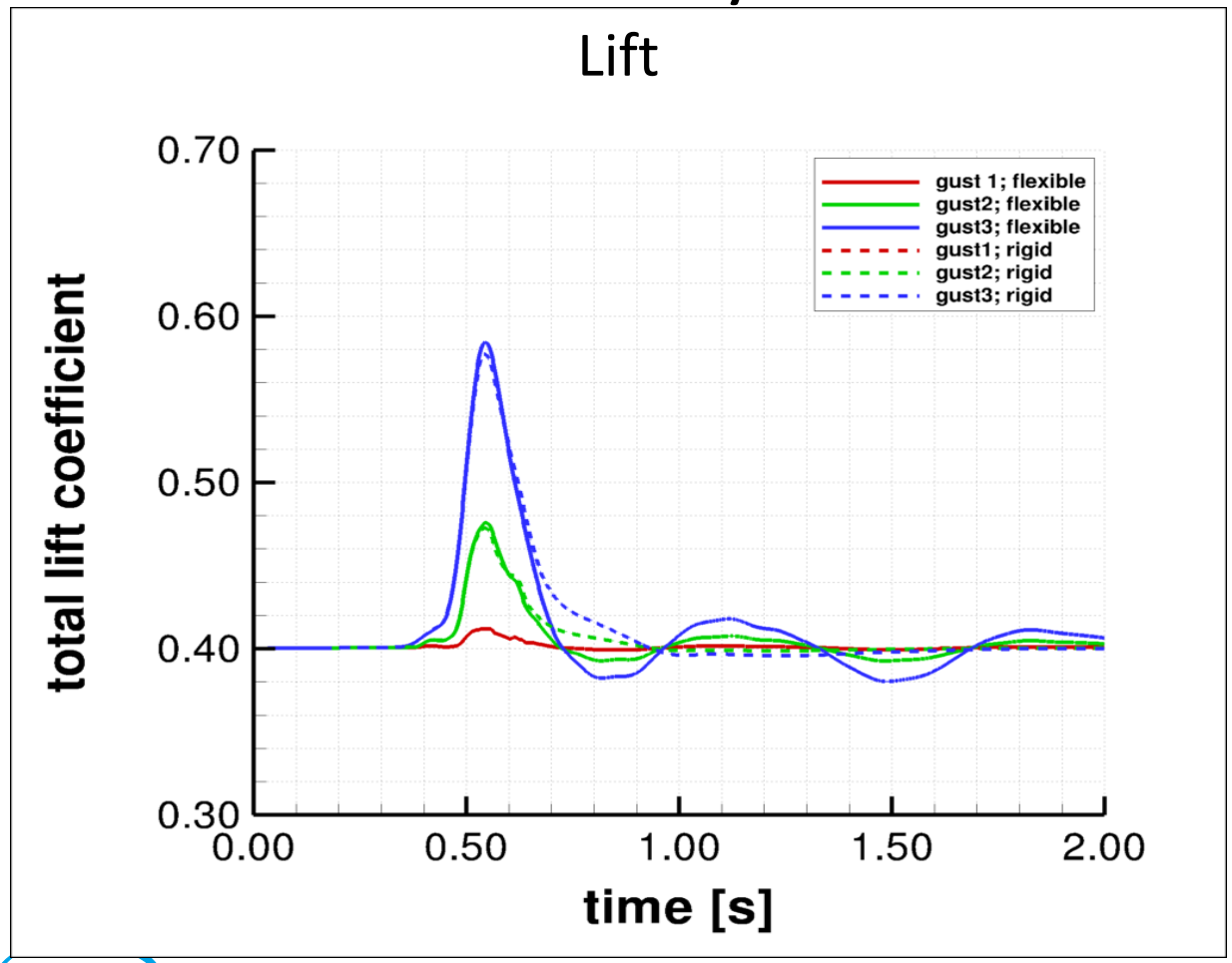
Gust	H		Ug	
	[ft]	[m]	[ft/s]	[m/s]
1	30	9.1	37.18	11.33
2	150	45.7	46.62	14.81
3	350	106.7	56.00	17.07

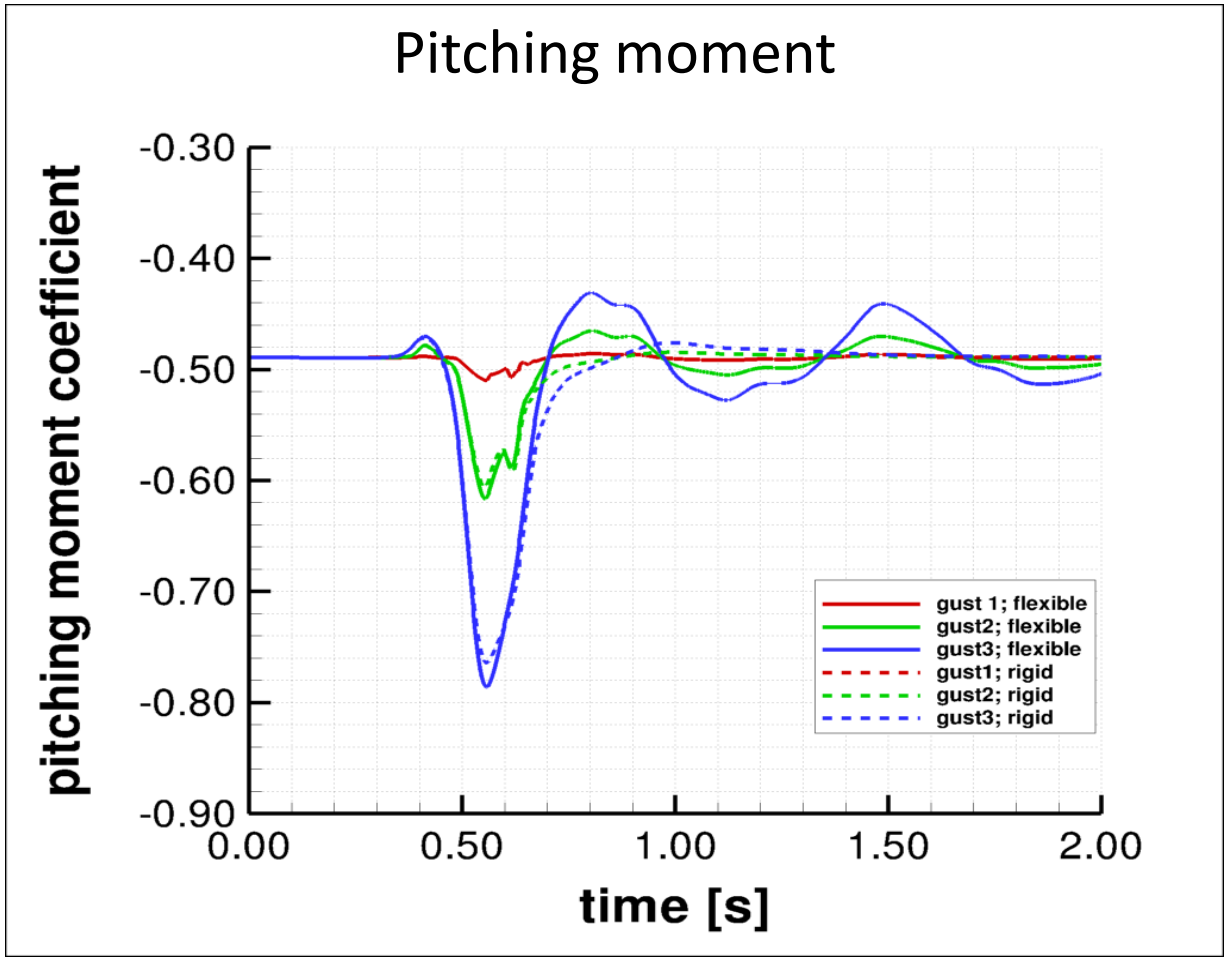
In calculations, location of gust peak is prescribed

Calculation details	
Timestep (t*Uref/Lref)	0.05
Turbulence model	EARSM
#modes	CRM: 24; UAV: 5

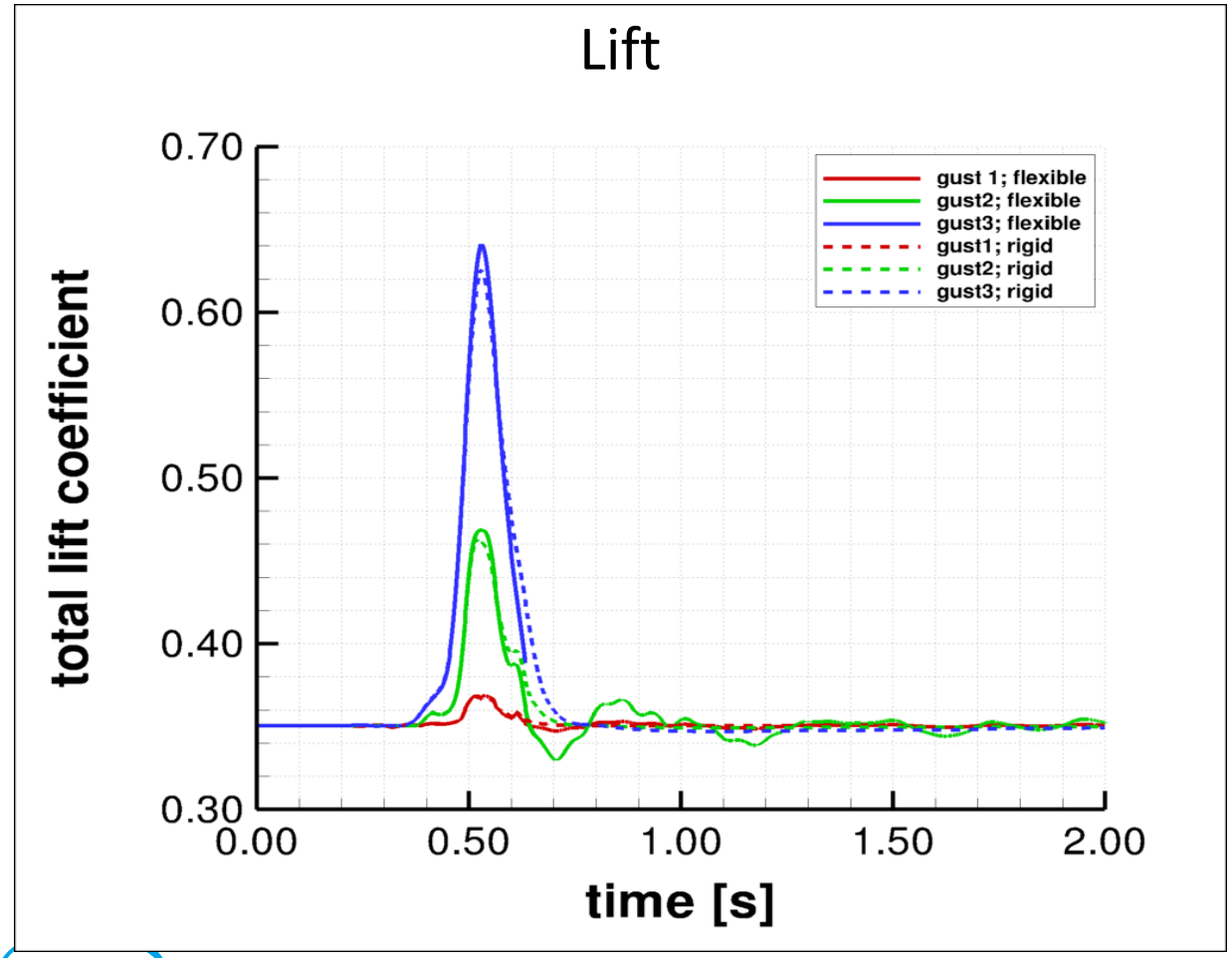
NLR

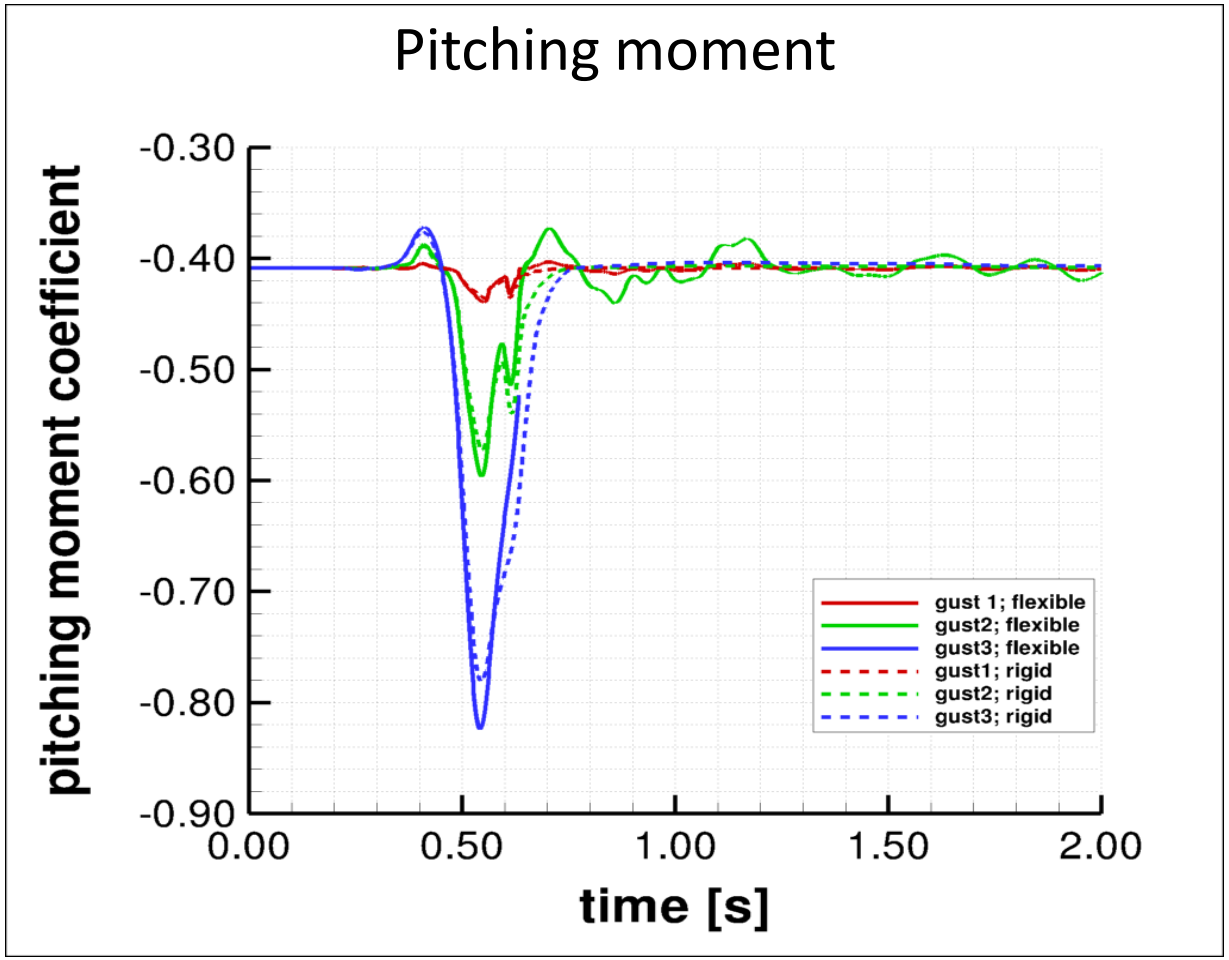
CRM – heavy – flow condition H





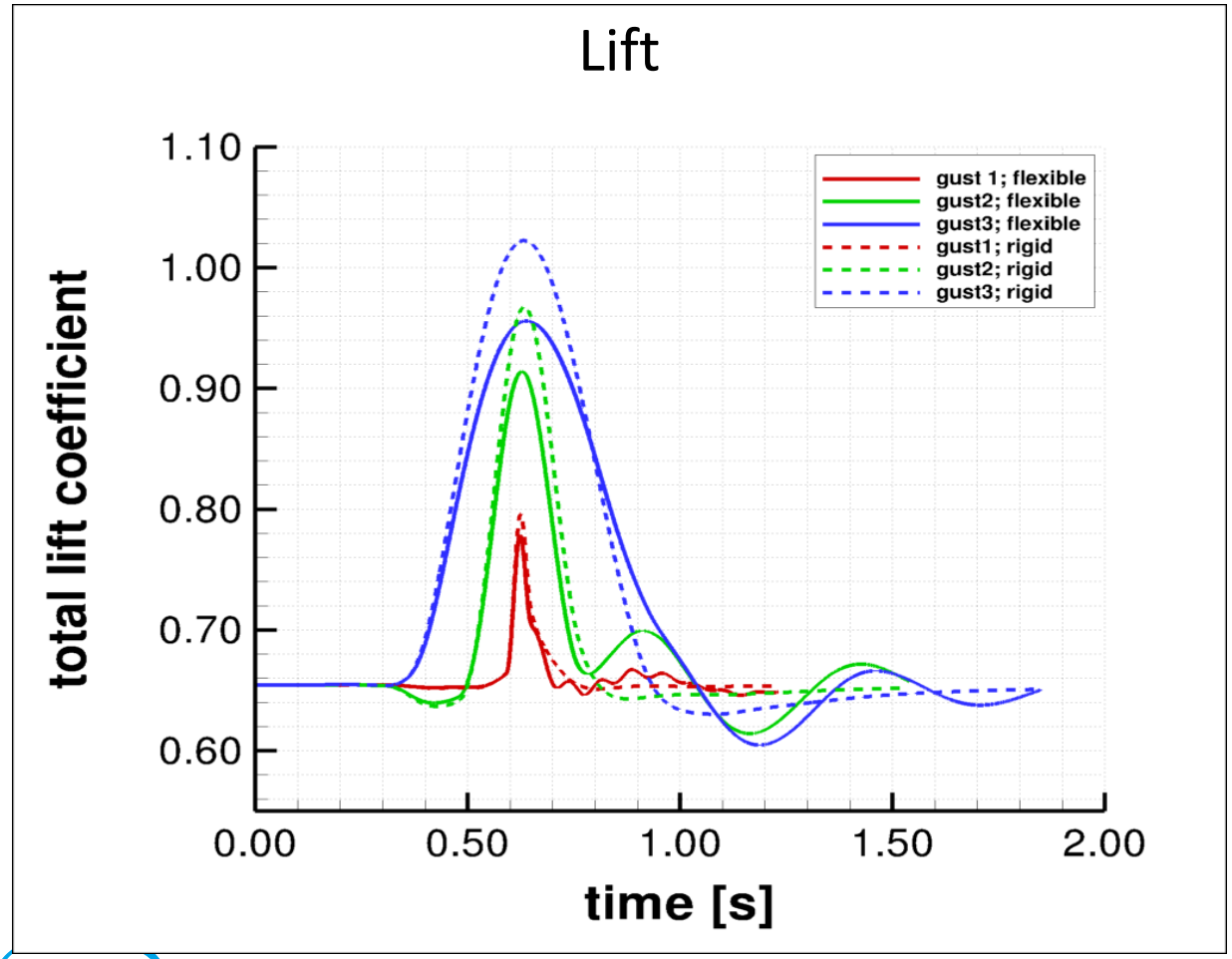
CRM – heavy – flow condition F

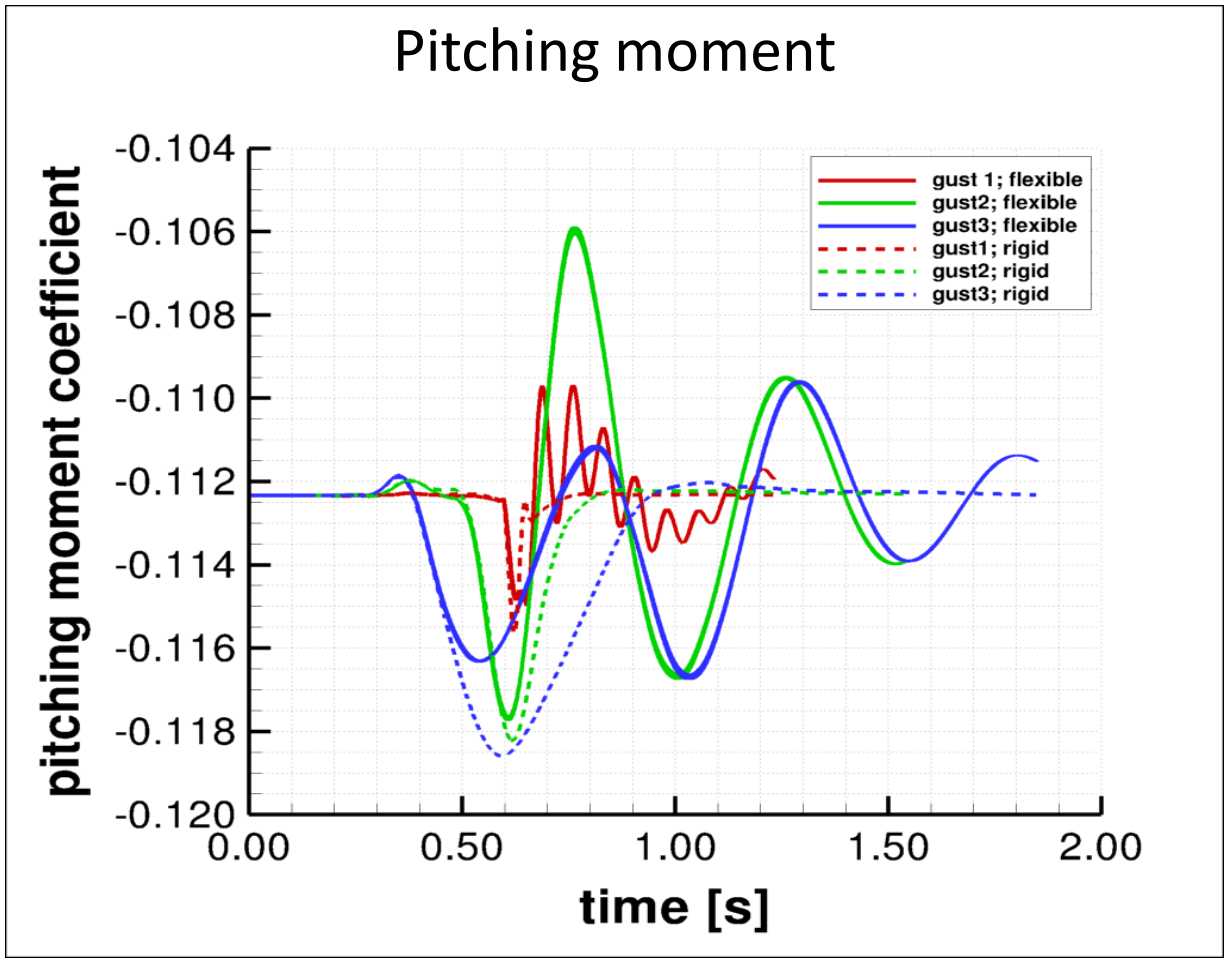




Gust 3, flexible calculation crashed due to grid folding

UAV– flow condition P





Upload of simulation results

Results have not been uploaded yet,

- which data?
- what format?
- on the wiki page?

Conclusions

Simulations completed (almost) on time (M30)

Multiple flight shapes is on track for M33

Quality of work on UQ would improve if more time granted

- Deliverable now planned for M33