Comprehensive Forced Response Analysis of J2X Turbine Bladed-Discs with 36- Degree Variation in CFD Loading

At NASA/MSFC, Structural Dynamics personnel continue to perform advanced analysis for the turbomachinery in the J2X Rocket Engine, which is under consideration for the new Space Launch System. One of the most challenging analyses in the program is predicting turbine blade structural capability. Resonance was predicted by modal analysis, so comprehensive forced response analyses using high fidelity cyclic symmetric finite element models were initiated as required. Analysis methodologies up to this point have assumed the flow field could be fully described by a sector, so the loading on every blade would be identical as it travelled through it. However, in the J2X the CFD flow field varied over the 360° of a revolution because of the flow speeds and tortuous axial path. MSFC therefore developed a complex procedure using Nastran Dmap's and Matlab scripts to apply this circumferentially varying loading onto the cyclically symmetric structural models to produce accurate dynamic stresses for every blade on the disk. This procedure is coupled with static, spin, and thermal loading to produce high cycle fatigue safety factors resulting in much more accurate analytical assessments of the blades.

Figure Caption: J2X Turbine Blade Finite Element Higher Order Mode Shape