Gradient-based Optimization of Postbuckled Steered-Fiber Aircraft Shell via ESLM

T. Ungwattanapanit, S.Kamath, A.Sasikumar, H. Baier
Institute of Lightweight Structures, Technical University Munich

**Goal:** Efficient optimization of steered-fiber Airbus Sagitta UAV shell subject to pre- & postbuckling constraints

**Motivation:**
- Steered fibers improve buckling stability via bending matrix-D tailoring
- Postbuckling allowance exploits panel’s load-carrying capability
- Both contribute to weight reduction of buckling critical aerostructures

**Challenges:**
- Steered-fiber laminate optimization
  - Complex FE modeling and increased number of optimization design variables
  - Higher level of non-convexity in design optimization space compared to that of straight-fiber laminates
  - Relevant manufacturing specifics e.g. max. fiber curvature allowance, gaps/overlaps (not tackled here)
- Nonlinear postbuckling response optimization
  - Expensive nonlinear analysis, expensive gradient calculations
  - Need of robust nonlinear analysis scheme to cover the whole range of designs during the optimization

**Solutions:**
- Steered-fiber laminate optimization
  - Linearly varied fiber path chosen
  - Design of experiments before conducting optimization
  - Increase number of plies (smearing) to remedy multimodality
- Nonlinear postbuckling response optimization
  - Equivalent Static Load Method (ESLM) in OptiStruct
  - RADIOSS implicit dynamic scheme (IMPDYN) chosen as it is more stable than quasi-static scheme (NLGEOM)

**Benefits:**
- 31-59% mass reduction from quasi-isotropic design
- 17% mass saving from postbuckling allowance (but stiffness decreases)
- Optimal design obtained within only 8 iterations (8 nonlinear analyses, 56 design variables)