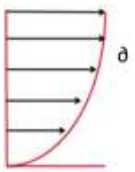
Current Laminar Flow Control Experiments at NASA Dryden

Experimental Soaring Association

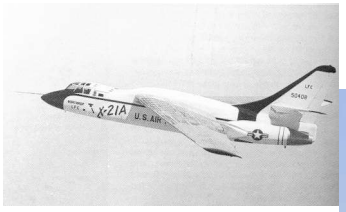
04 Sep 10

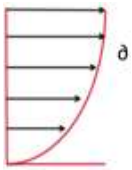
Al Bowers



Laminar Flow

- Decades of research
- Increase the amount of low-drag boundary-layer laminar flow over the wings
- Possible savings of 10-15% in total aircraft drag (more with optimization?)

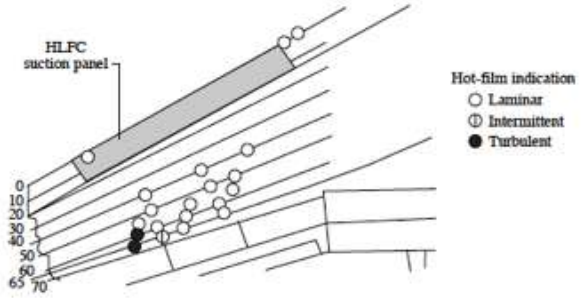




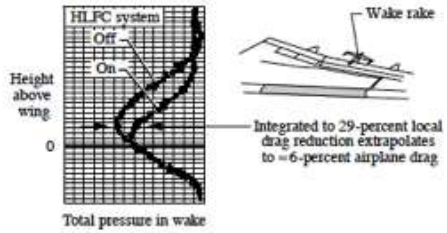
Experiment Background

- ~13 billion gallons of aviation fuel per year
- Laminar flow = substantial fuel savings

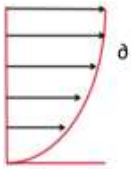
- Swept wings above Mach 0.6
- Crossflow transition
- Traditional answer = suction



(a) Laminar flow extent; $M = 0.82$; $h = 38\,600$ ft; $C_L = 0.48$.

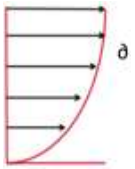


(b) Drag reduction; $M = 0.82$; $C_L = 0.475$.

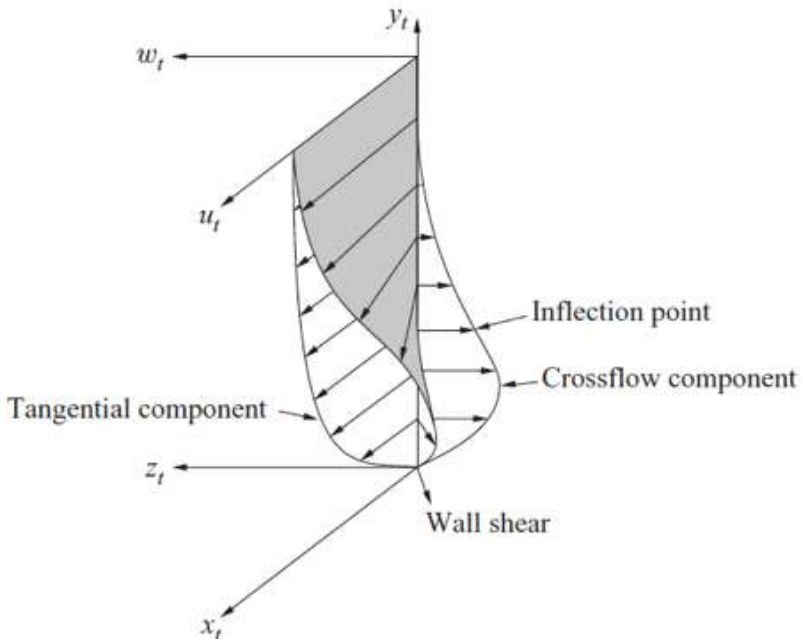


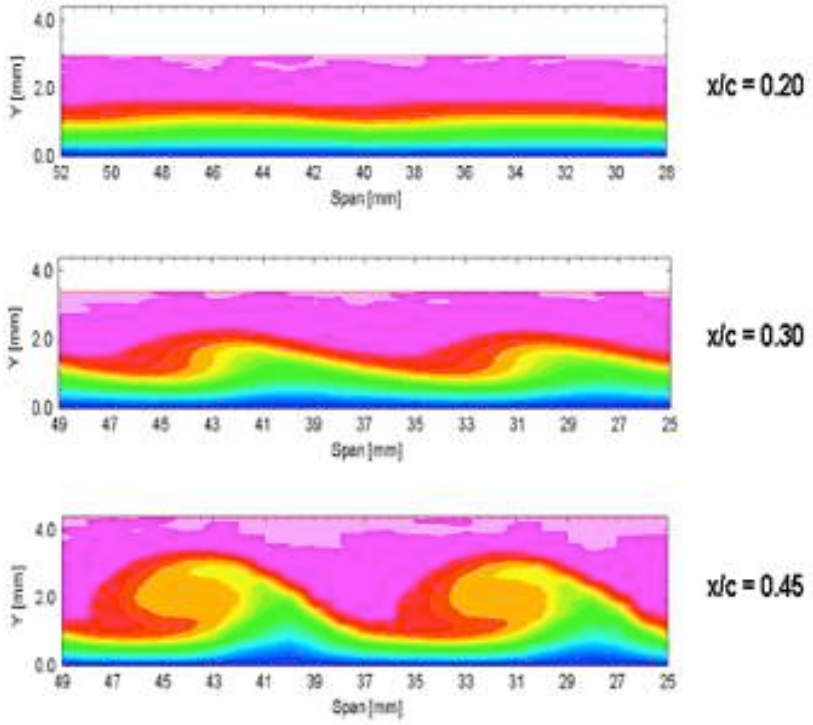
Discrete Roughness Elements

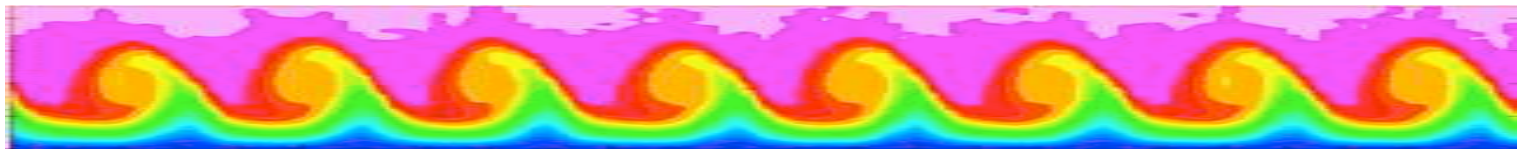
- Swept wings are strongly crossflow dominated
- Discrete Roughness Elements show the ability to stabilize the laminar boundary layer
- Subcritical frequency wave in the boundary layer is stabilizing
- Research sponsored by NASA Environmentally Responsible Aviation Project (Dr Fay Collier)

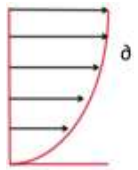


Discrete Roughness Elements



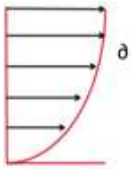




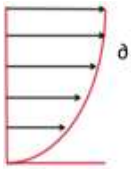


Current State of the Art

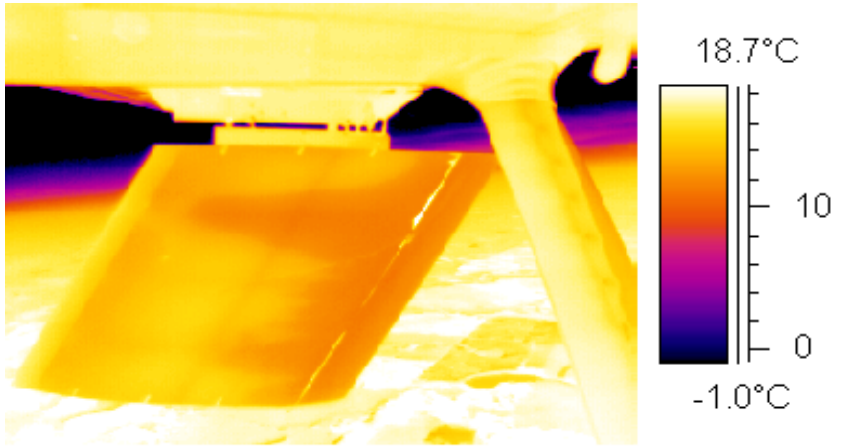
- Texas A&M (Saric & Reed)
- Air Force Research Labs (Flick & Dale)



Swept Wing In-Flight Test

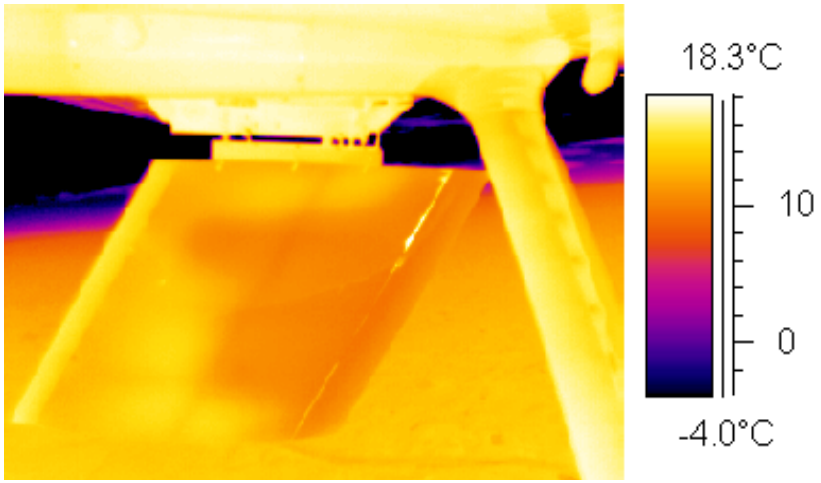


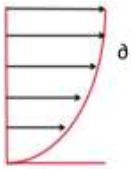
SWIFT Experiment



without DRE

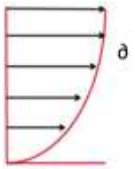
with DRE





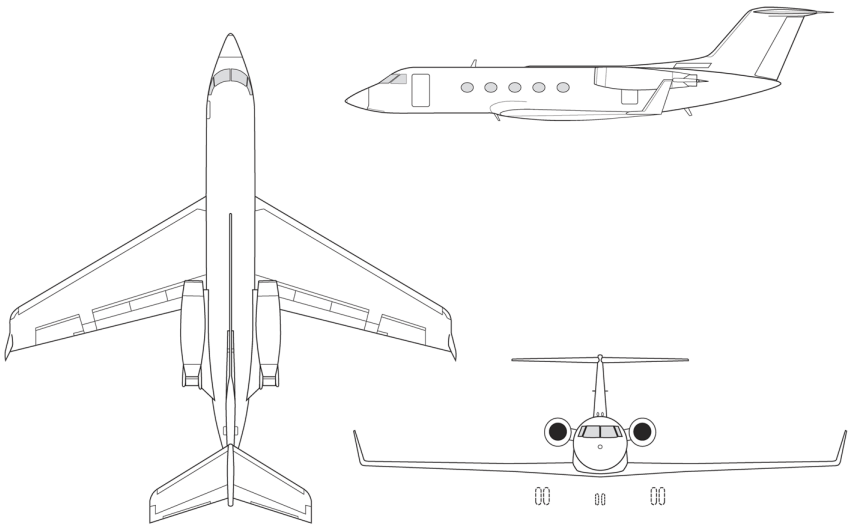
TAMU SWIFT Success

- 30 deg leading edge wing sweep
- Up to 8 million chord Reynolds number
- Up to 60% laminar flow with DRE
  - Laminar flow region was doubled



NASA Gulfstream III

- G III good representative “small” airliner
- Big wing (chord between 737 & 757)

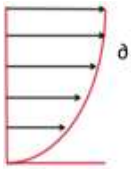


Gulfstream III

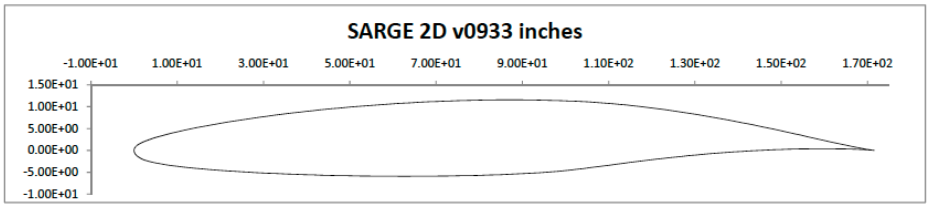
flexsys

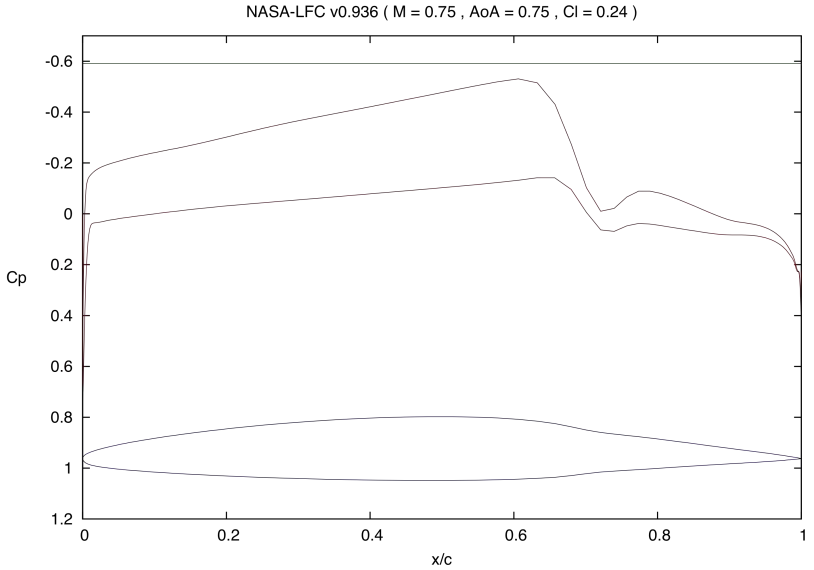
Experiment Design

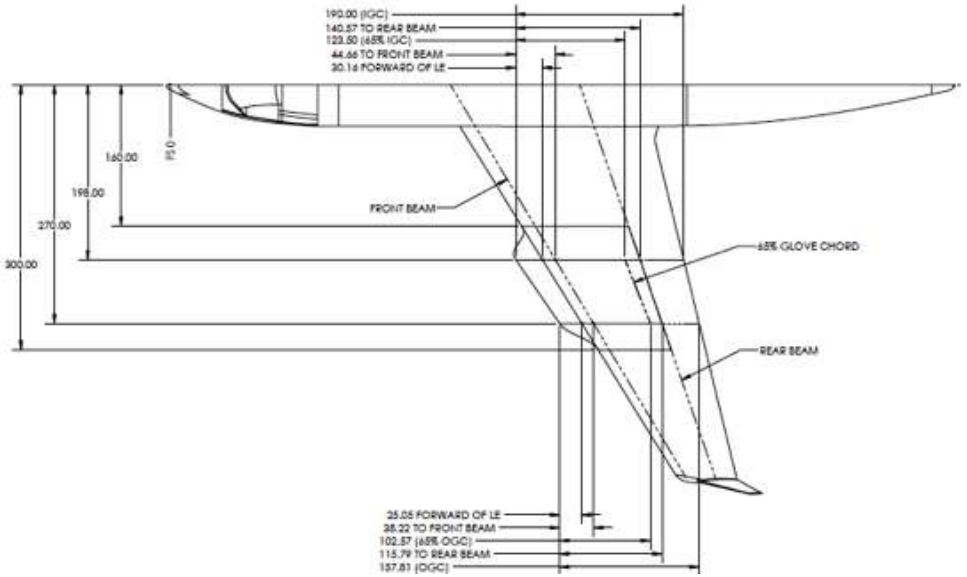
- Passive Laminar Flow w/ DRE
- 1/ get the best experiment possible (Bill Saric & Helen Reed @ Texas A&M)
- 2/ base the next step on previous work (SWIFT experiment by TAMU/AFRL)
- 3/ be ambitious and go for full cruise envelope of medium airliner (M 0.75, CL 0.3, & Re 20M)

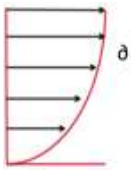


TAMU Airfoil & Glove



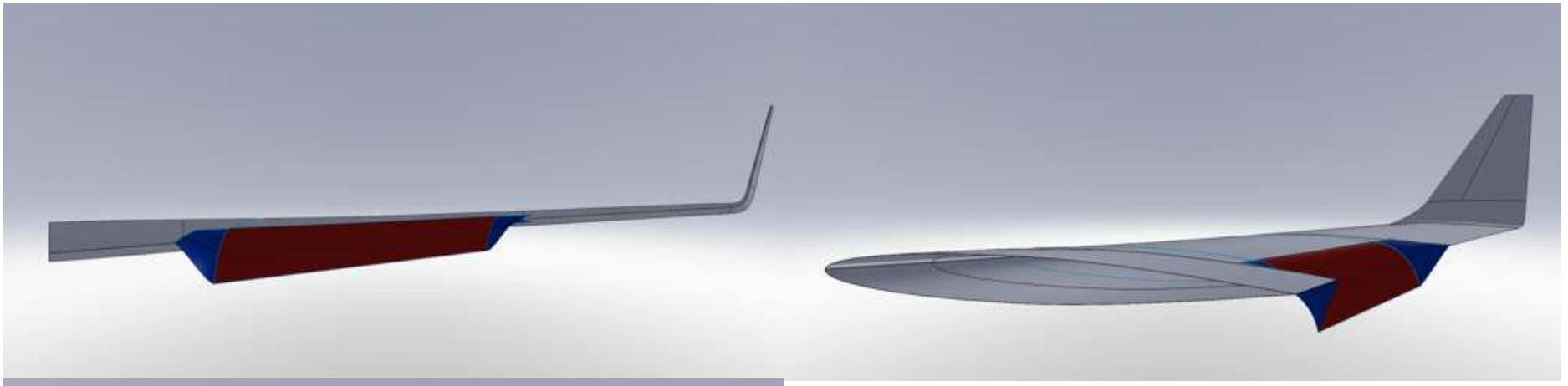


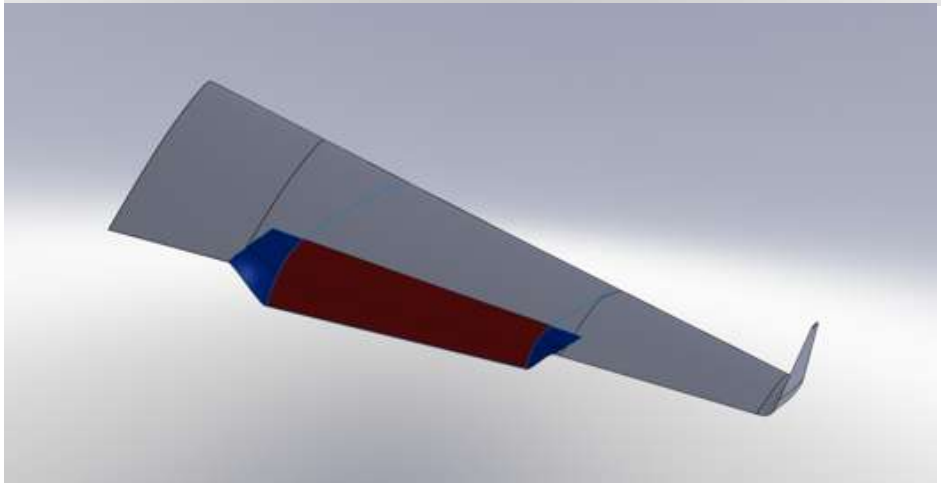


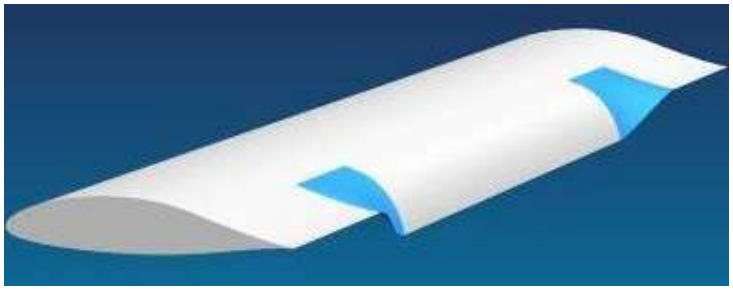


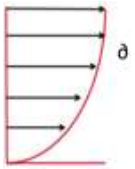
Add-on Experiment

- Active Compliant Trailing Edge Flap (AFRL & FlexSys)



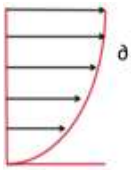






Concluding Remarks

- Passive laminar flow control using Discrete Roughness Elements
- Texas A&M and Air Force Research Labs teamed with NASA
- Push for full cruise envelope of a medium size airliner
- Continuous moldline flap experiment



Questions?