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Flow Features of 3D Shock Wave Boundary-Layer Interactions

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Background

- Shockwave and boundary layer interactions (SBLIs) occur on high speed vehicles
- Complexity added with sweep
- Influence of sweep and 3D effects are still not well understood in literature

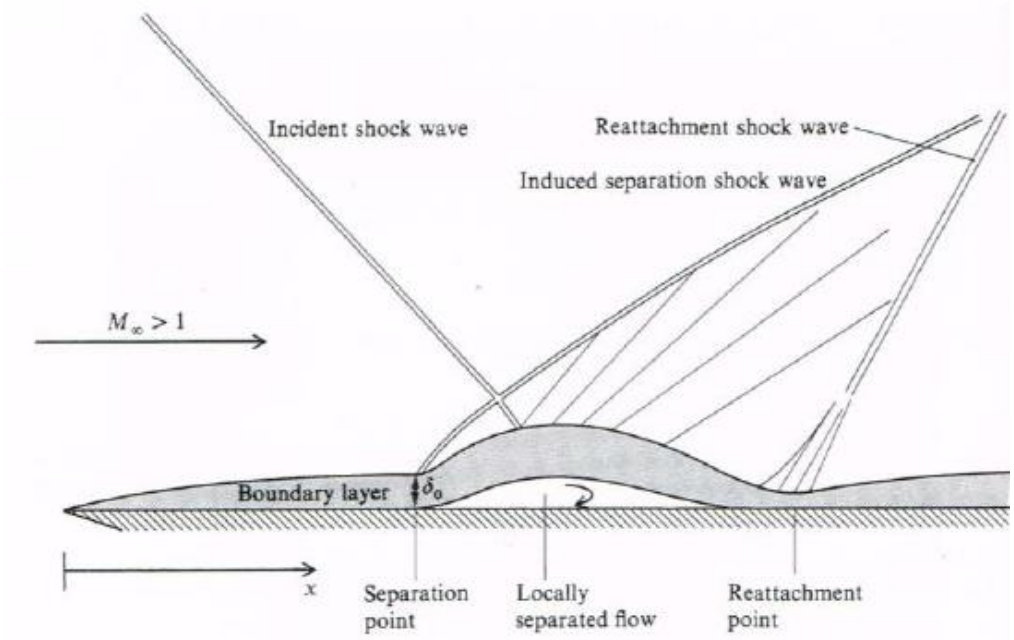


Image: Engineering Project Conference

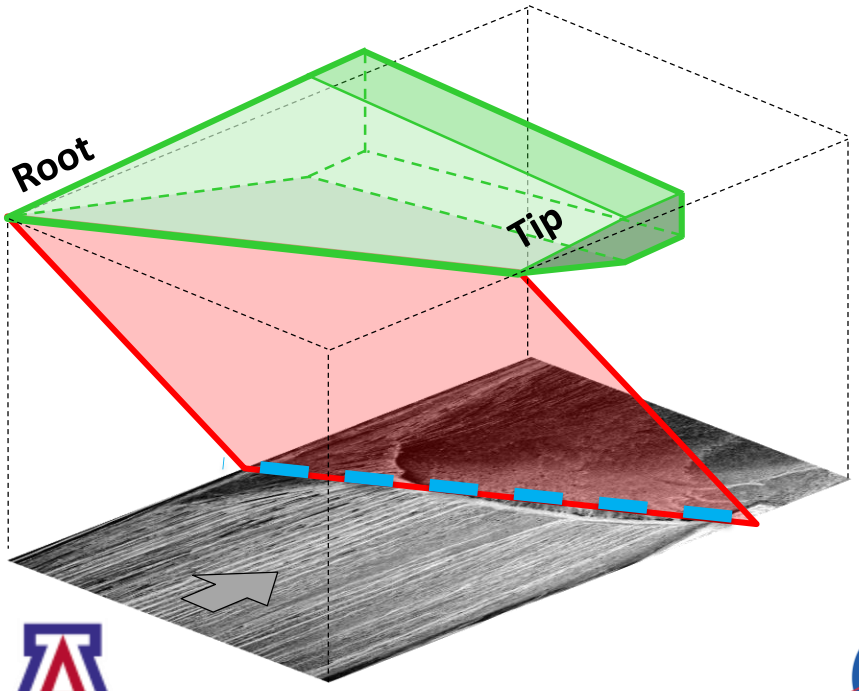
Image: Boeing

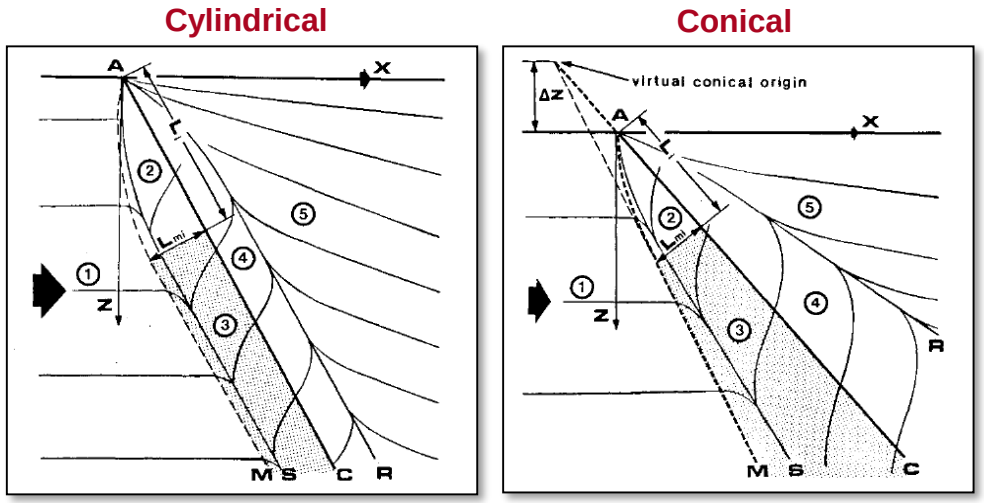
Image: Lockheed Martin

Image: NASA

Objective

- Characterization of flow interaction between separation and reattachment at moderate Mach Numbers using two swept shock generators
- Comparison between theoretical and experimental sweep flow
- Oil flow visualization of interactions to characterize flow





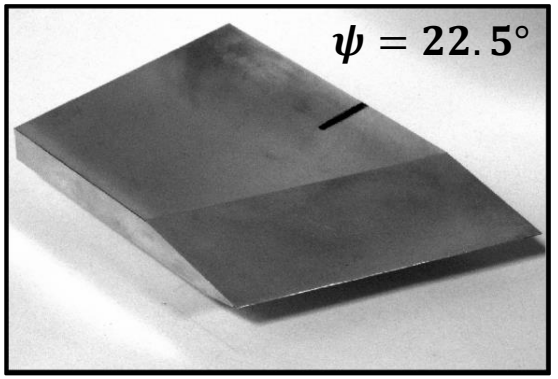
Settles and Teng (1984)

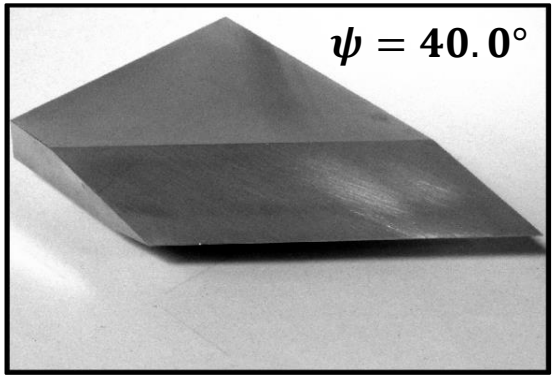
Experimentation

- Indraft Supersonic wind tunnel
- Adjustable throat for Mach 1.5 to 5
- Run times of approximately 20 seconds
- Two shock generators tested at Mach 3:

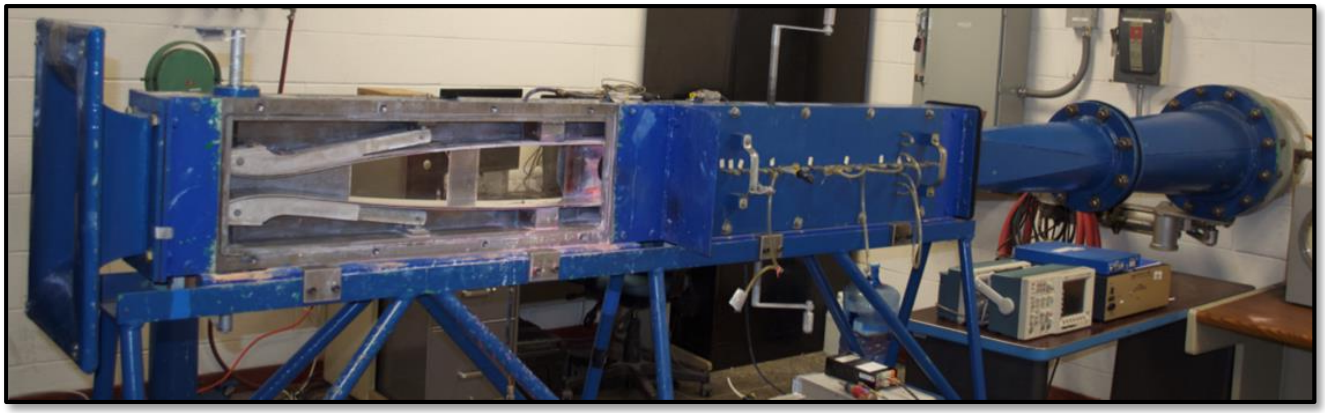
  22.5° sweep sharp fin wedge

  40° sweep sharp fin wedge



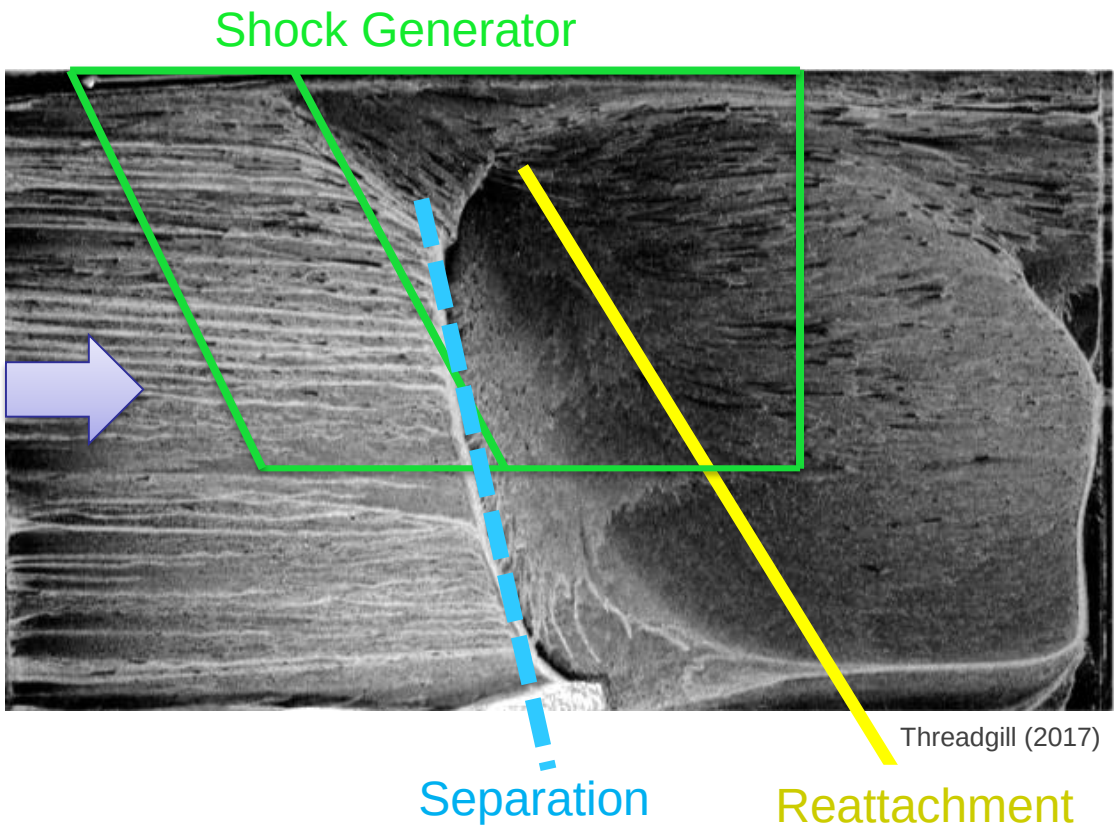


Threadgill (2017)



Oil Flow Visualization

- UV oil is painted along the wind tunnel mirror
- Oil flow presents skin-friction stream lines, shock waves, and separation features
- Difficulty in creating an effective mixture
- SBLI region is between separation and reattachment lines

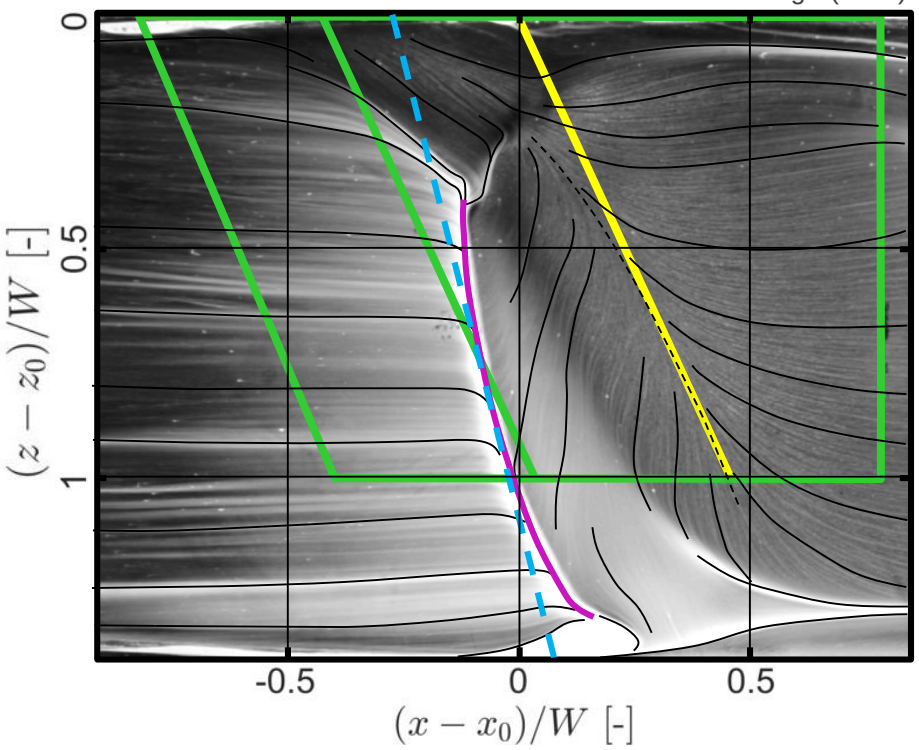


Threadgill (2017)

Results

M = 3.0, ψ = 22.5°

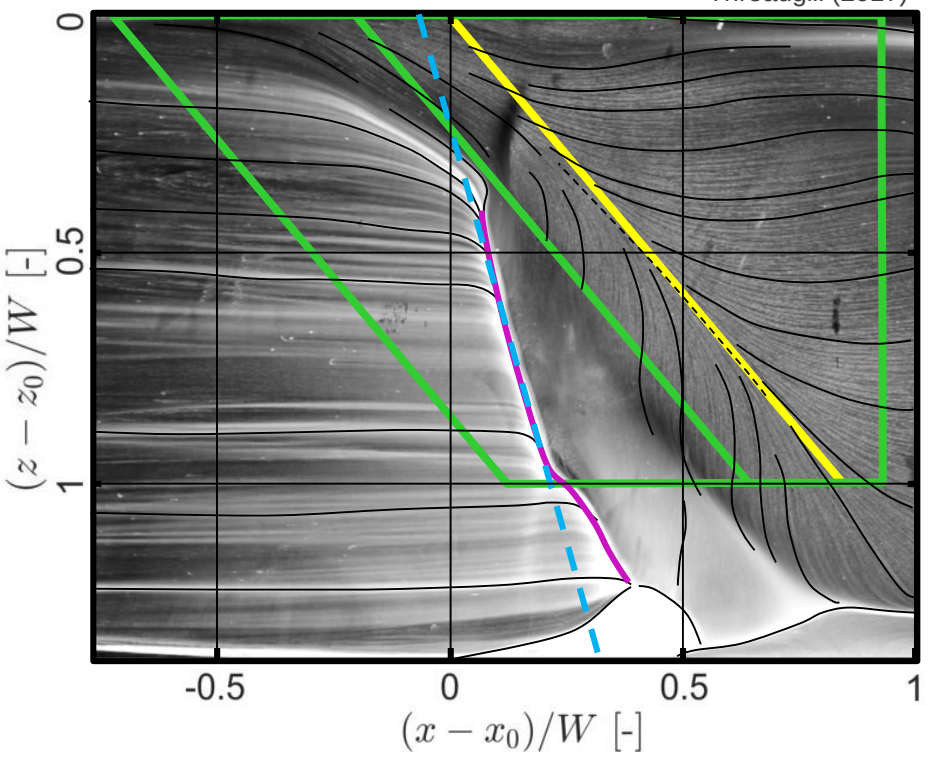
Threadgill (2017)



Conical Similarity

M = 3.0, ψ = 40.0°

Threadgill (2017)



Conical Similarity

The theory states that at 22.5° sweep angle, the interaction should be cylindrical. The 40° sweep interaction is predicted as conical.

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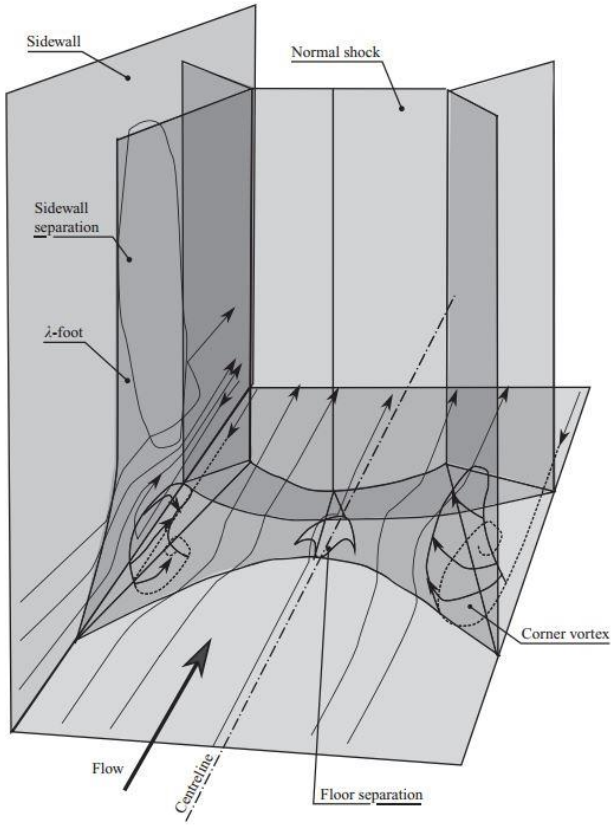
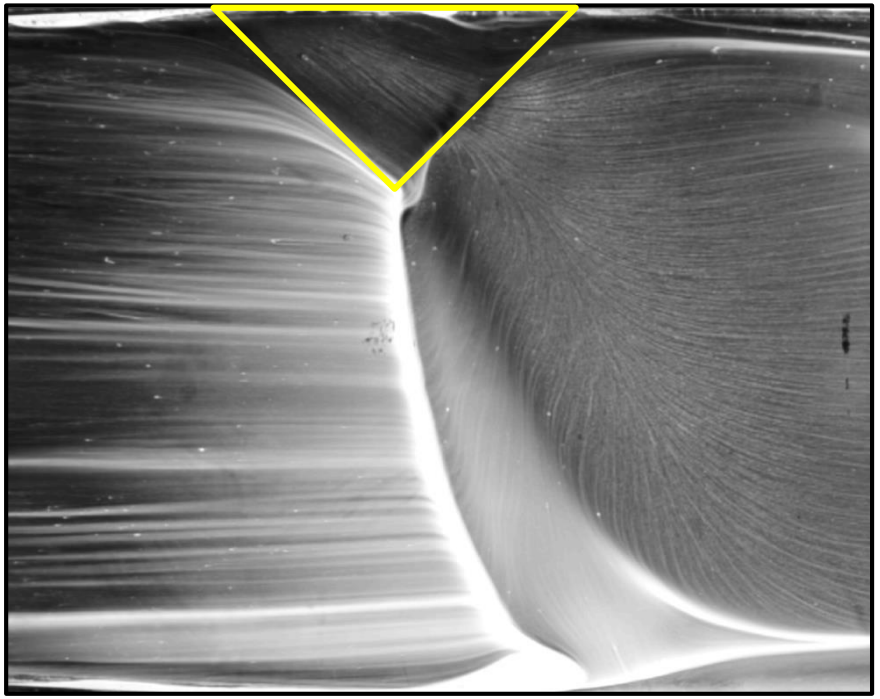
Corner Effects

- Are conical results just a consequence of corner disturbances?
- The corners of the test section create corner vortices
- These vortices may be the cause of conical interactions in the 22.5° case



Bruce et. all (2011)

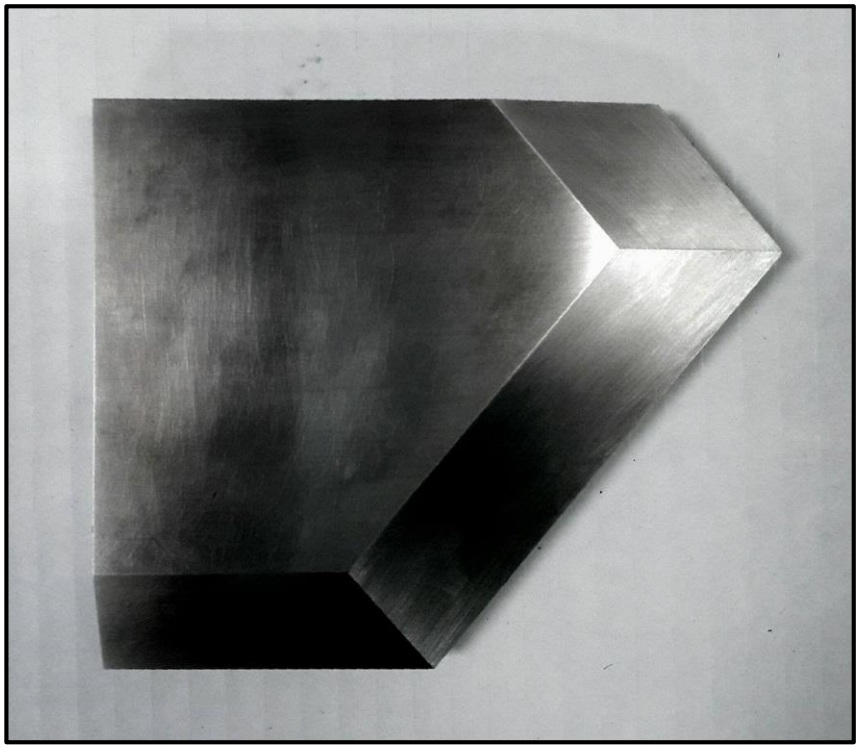


Threadgill (2017)

Corner Separation

Conclusions & Future Work

- Highly swept SBLIs confirm predicted conical similarities
- Conical separation at more moderate angles showed unpredicted level of conical flow
- Future work involves Chevron Cut wedge which is designed to avoid and reduce the strength of corner effects
- Wedge would create a virtual slip wall



Chevron Cut Shock Generator

References

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Threadgill, James. "Three-Dimensional Flow Features of Swept Impinging SBLI." AIAA SciTech. Texas, Grapevine. Lecture.

Thank You

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