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# VSPAERO SUGAR High/Volt TBW Aerodynamic Analysis

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# Acknowledgments

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# Purpose and Outline

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## **Purpose:**

Develop process to incorporate aerodynamics into TBW conceptual design studies to allow for quick analysis capability of AATT advanced aircraft concepts

## **Outline:**

- Background
- VSPAero Modeling
- VSPAero Setup
- Results
- Lessons Learned
- Next Steps

# Portfolio Development: N+3 Advanced Vehicle Concept Studies Summary



**Boeing, GE,  
GA Tech**



Advanced concept studies for commercial subsonic transport aircraft for 2030-35 Entry into Service (EIS)



**NG, RR, Tufts,  
Sensis, Spirit**



## Trends:

- Tailored/multifunctional structures
- High aspect ratio/laminar/active structural control
- Highly integrated propulsion systems
- Ultra-high bypass ratio (20+ with small cores)
- Alternative fuels and emerging hybrid electric concepts
- Noise reduction by component, configuration, and operations improvements

**GE, Cessna,  
GA Tech**



**MIT, Aurora,  
P&W, Aerodyne**



**NASA,  
VA Tech, GT**



**NASA**



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Advances required on multiple fronts...

# NASA TBW Research



- NASA In-house, NIA, VT, GT
- N+3 NRA – Boeing SUGAR
  - SUGAR High (gas fueled turbofan)
  - SUGAR Volt (gas/electric parallel hybrid turbofan)
  - SUGAR Freeze (LNG fuel cell hybrid turbofan and electric rear fuselage BLI propulsor)

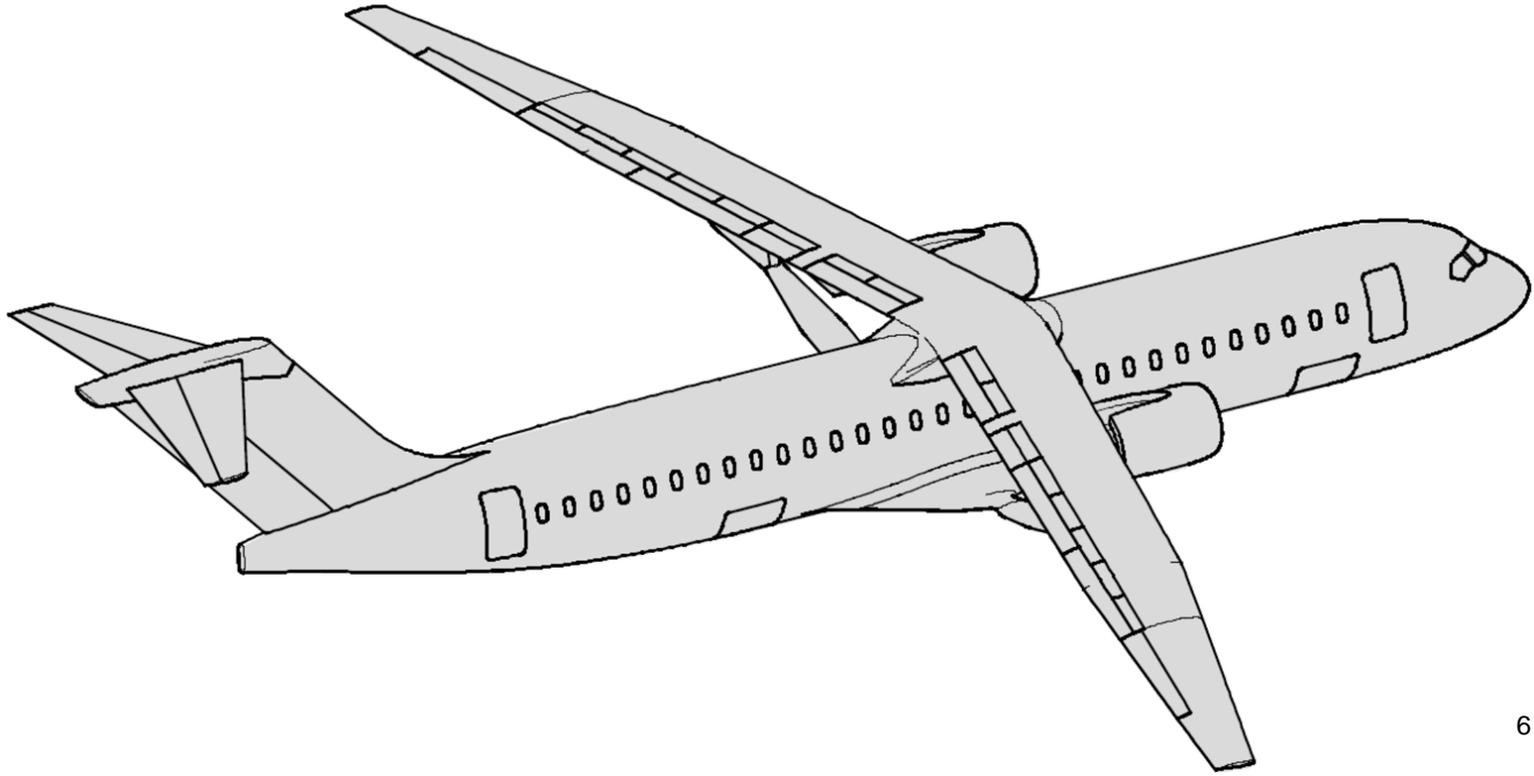


# SUGAR High 765-095-RD

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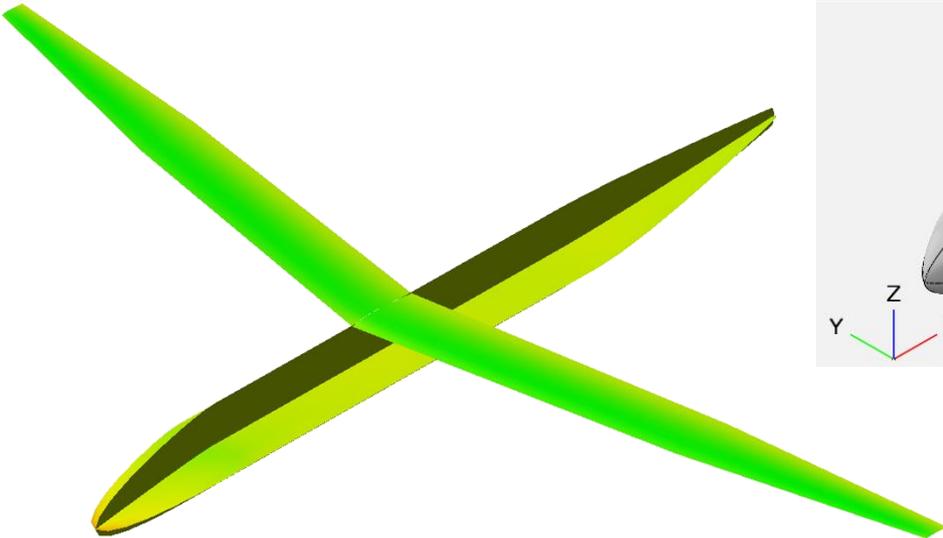
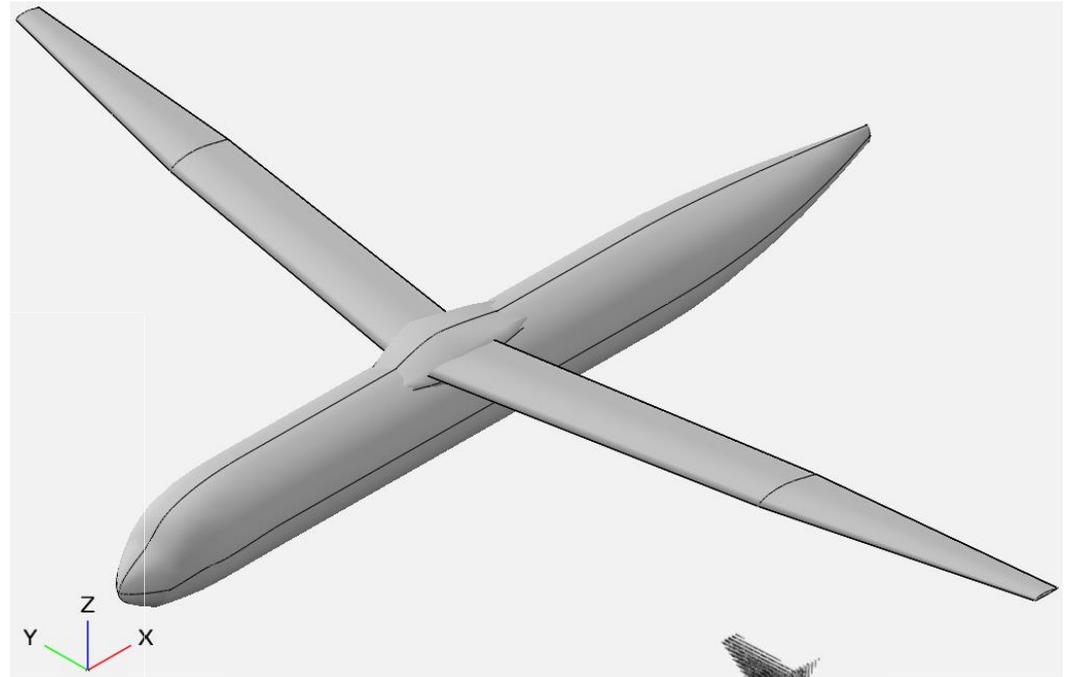
- B737 / A320 class
- 154 passenger
- 4,260 nm range
- 40,800 ft cruise altitude
- 0.70 Mach cruise
- NASA/CR-2015-218704/Volume I



# SUGAR High 765-095-RD OpenVSP Model



- Wing Body
- Mass
- Degen Geom



Mach: 0.700, Beta: 0.00000000, Alpha: 2.000

# SUGAR High 765-095-RD VSPAero Setup



- Analysis at cruise altitude
  - 42,000 ft
  - 11.2M Reynold's Number
  - 0.7 Mach

**VSPAERO**

Overview Solver Console Viewer Console

**Case Setup**

File: C:\WORKING\VSPAero\SHDir20160805\_DegenC ...

Geometry Set: WingBody2 Generate Geometry

Num CPU: 2

Stability Calculation

**Wake**

Num It.: 5

Avg Start It.: 0

Skip Until It.: 0

**Reference Area, Lengths**

Manual From Model

Ref. Wing: 2\_Wing

Sref: 1477.112

bref: 169.942

cref: 9.191

**Moment Reference Position**

Mass Set: Mass Calc CG

Num Slices: 150

Xref: 58.520

Yref: -0.000

Zref: 0.829

**Flow Condition**

Parameter	Start	End	Npts
Alpha	-5.000	5.000	11
Beta	0.000	0.000	1
Mach	0.700	0.000	1

**Execute**

Create New Setup Kill Solver Setup

Launch Solver Kill Solver

Show Results Mgr Launch Viewer

Export to \*.csv

**VSPAERO Setup File: SHDir20160805\_DegenGeom.vspaero**

Sref = 1477.111510

Cref = 9.190500

Bref = 169.941761

X\_cg = 58.520394

Y\_cg = 0.000000

Z\_cg = 0.828645

Mach = 0.700000

AoA = 2.000000

Beta = 0.000000

Vinf = 677.6525

Rho = 0.00053148776

ReCref = 11200000.0

ClMax = -1.000000

MaxTurningAngle = -1.000000

Symmetry = No

FarDist = -1.000000

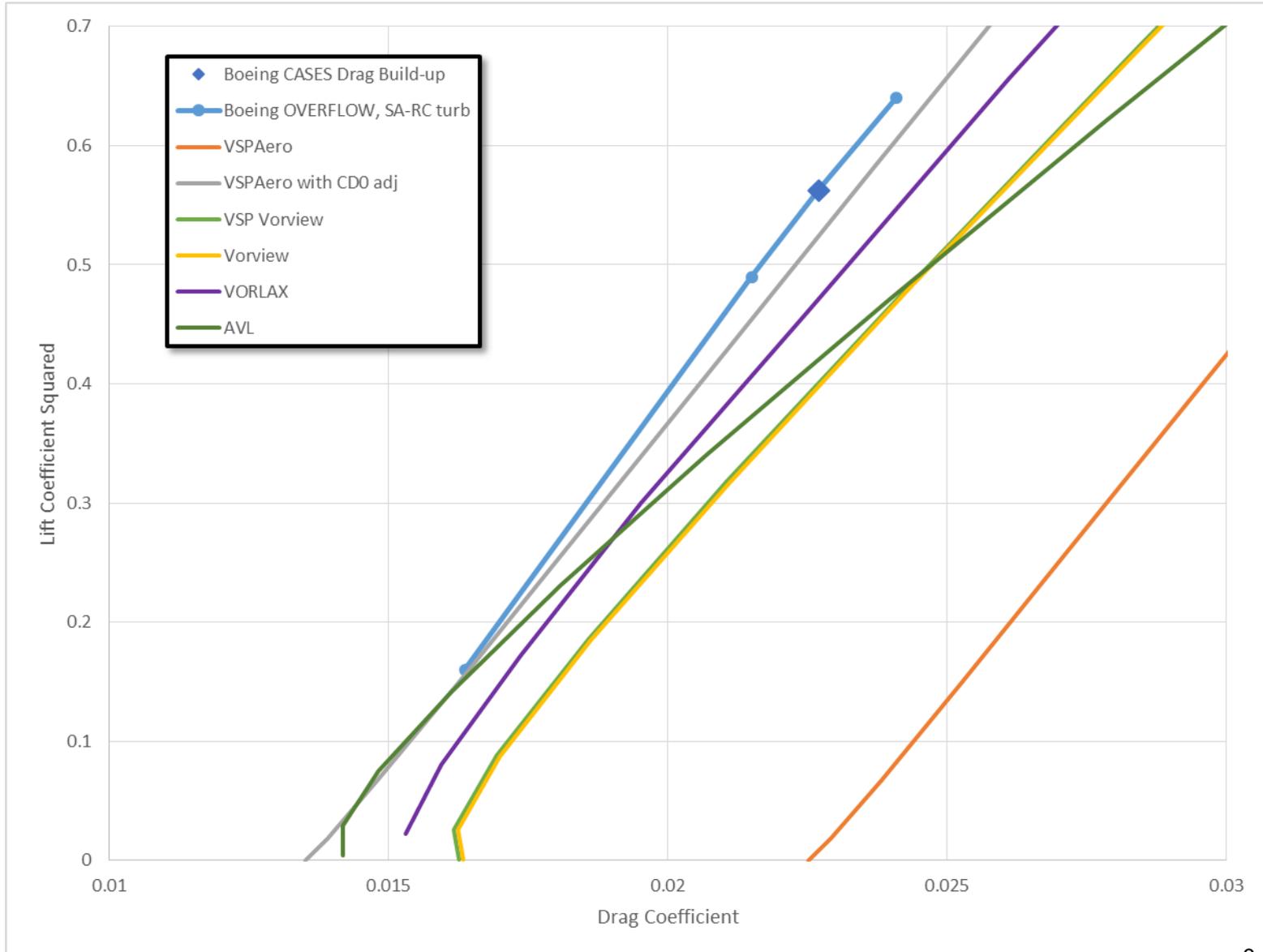
NumWakeNodes = -1

WakeIters = 5

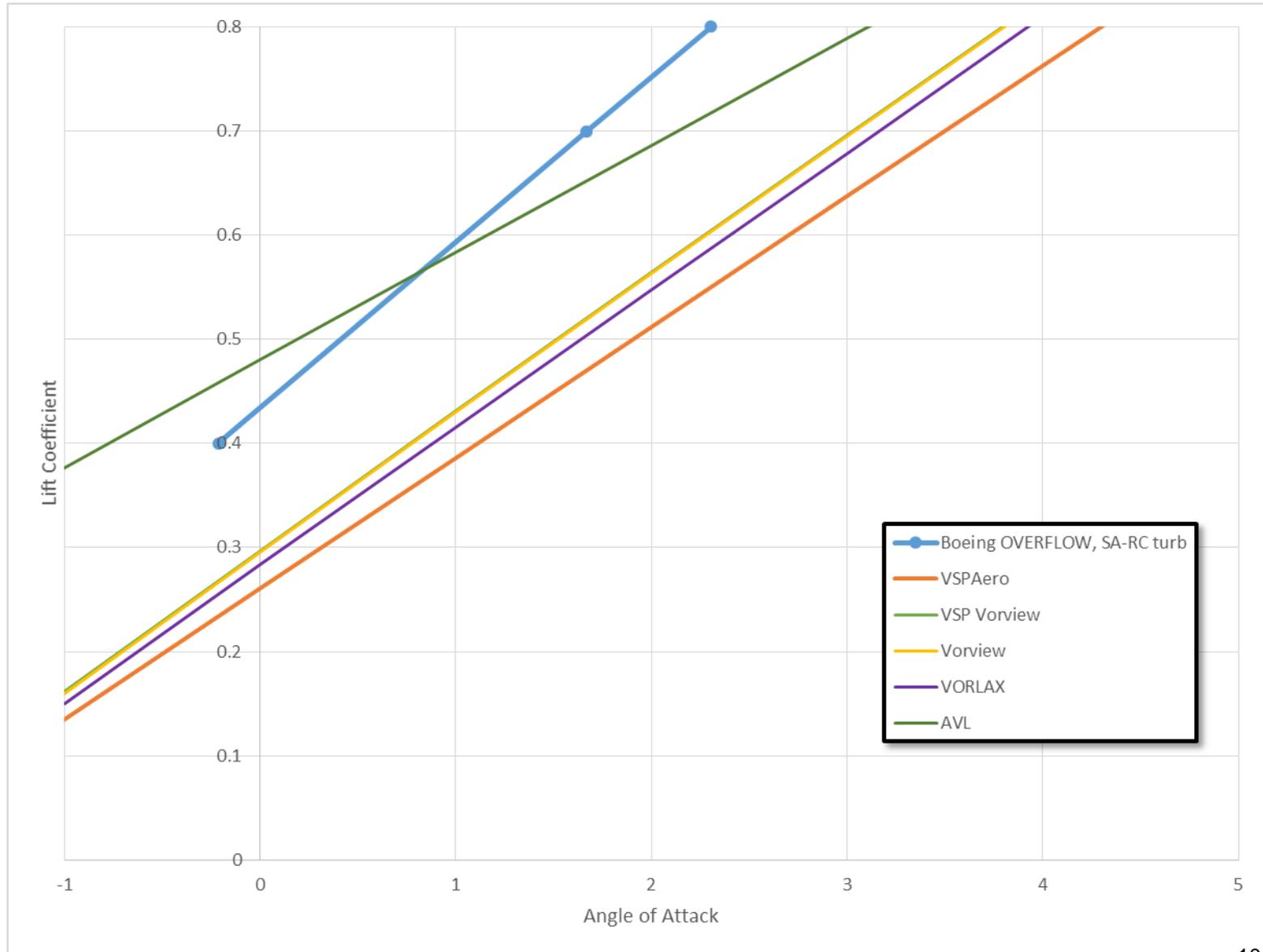
NumberOfRotors = 0

Read Setup Save Setup

# SUGAR High 765-095-RD VSPAero Results



# SUGAR High 765-095-RD VSPAero Results





# Lessons Learned

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## **Modifications:**

- Simplified fuselage
- Removed wing fairing
- Input skin friction drag

## **Resolution:**

- Grid resolution
- Lower = faster

# Next Steps

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- Compare with NASA, Virginia Tech, Georgia Tech TBW design
- Incorporate recent Boeing SUGAR results

# Questions?

