



CSE583

Aerodynamic Force and Moment

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Outline

- Background
- Motivation
- Project Overview
- Progress at UW and Experimental Setup
- Samples
- Project Outline





Supersonic Configuration Evolution

Late 1990s to Present

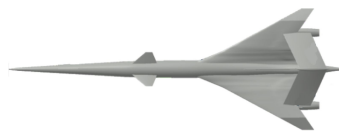
Lockheed L-1201



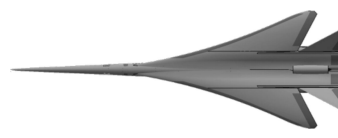
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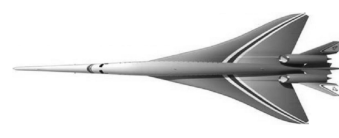
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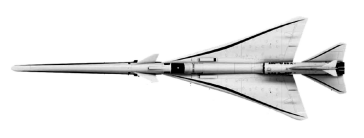
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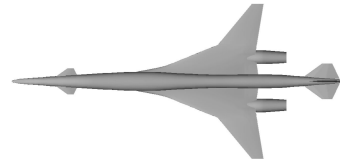
Lockheed QSTA



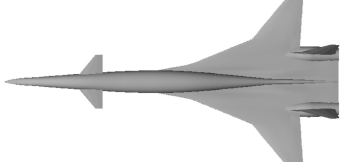
Lockheed X-59s



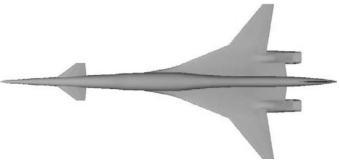
Boeing 765-070A



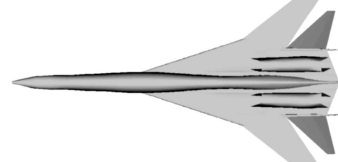
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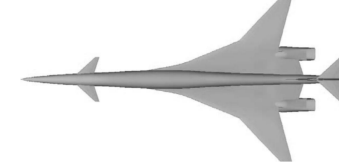
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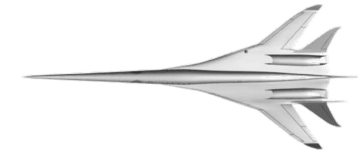
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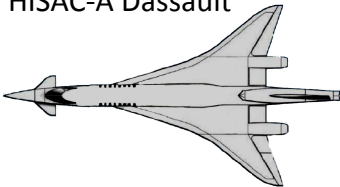
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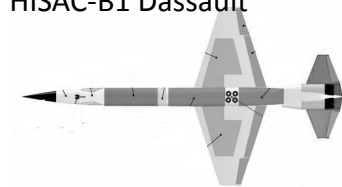
Boeing QEVC



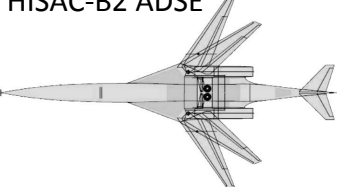
HISAC-A Dassault



HISAC-B1 Dassault



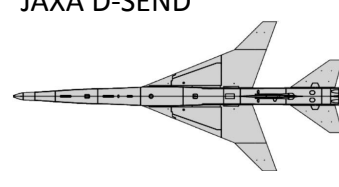
HISAC-B2 ADSE



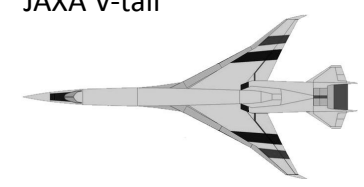
HISAC-C Sukhoi, TsAGI



JAXA D-SEND



JAXA V-tail



Aerion AS-1



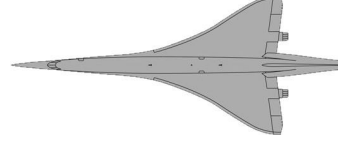
Aerion AS-2



Aerion AS-3



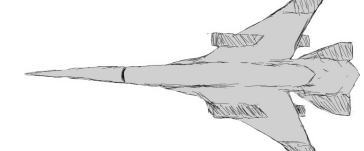
Boom Overture



Boom XB-1

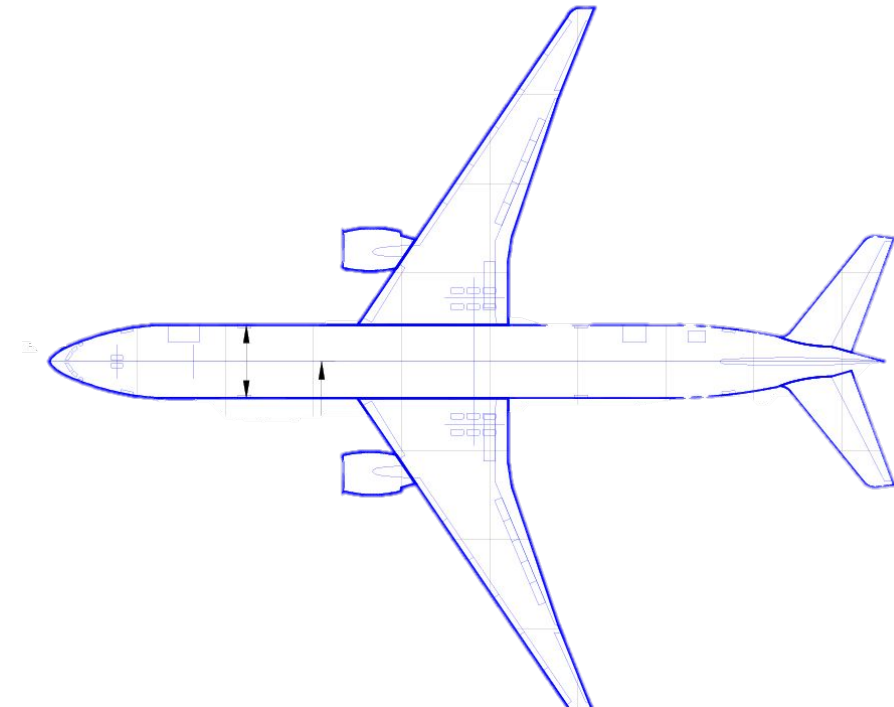
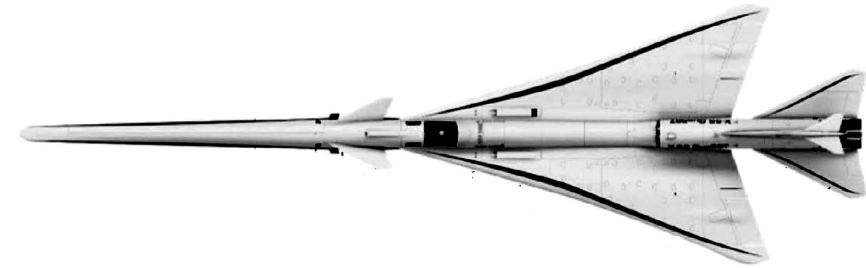


Exosonic

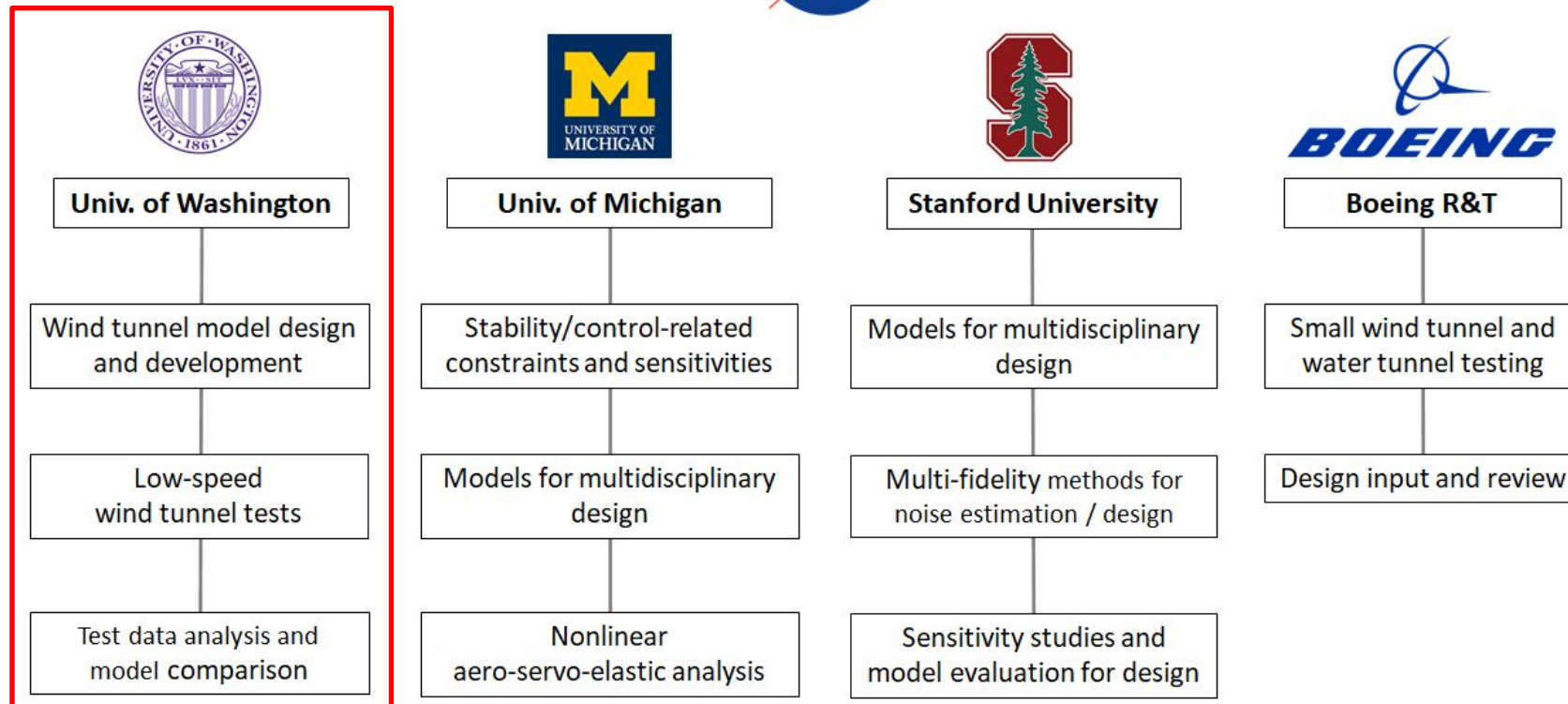


Motivation

Supersonic airliners/SSBJs are optimized at cruise speed and often neglect low-speed impact at takeoff, approach, and landing. Studies on how the shapes and configurations affect handling qualities, dynamic, stability and control of the aircraft.

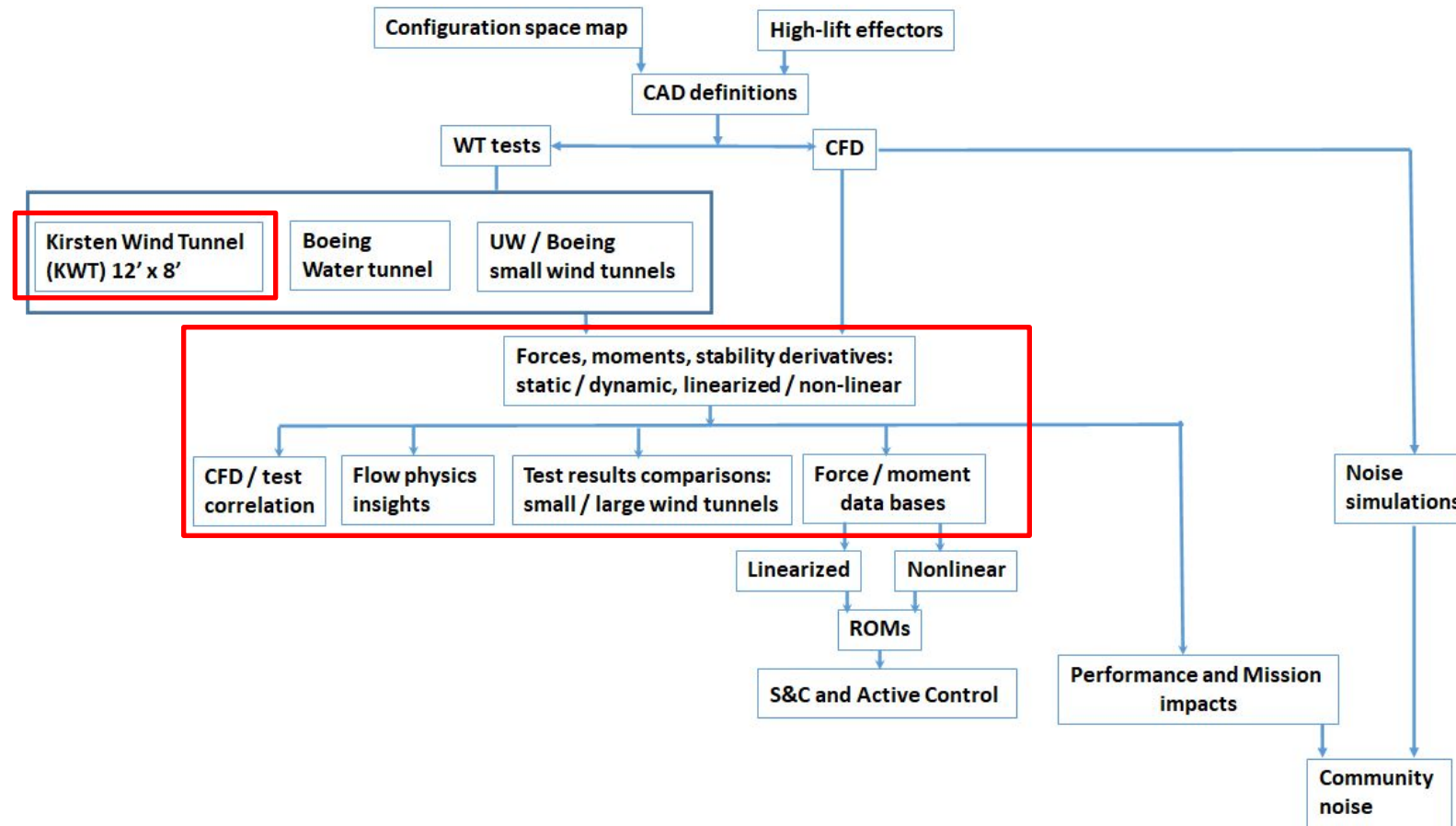


Project Overview





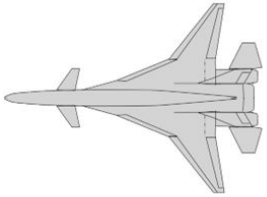
Workflow



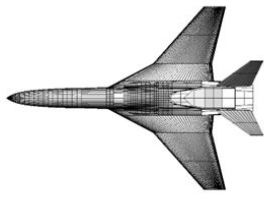


Progress at UW

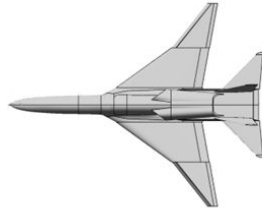
2005



2009



2010



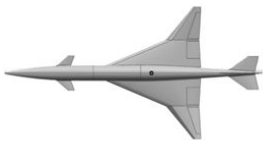
2013



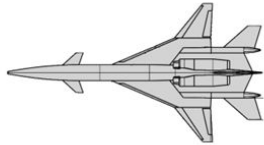
2014



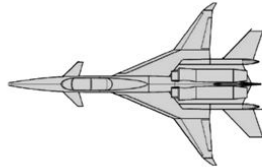
2015



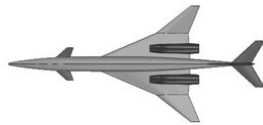
2016



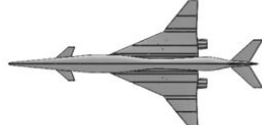
2017-2018



2020



2021



2005



2006



2007



2009



2010



2014



2015



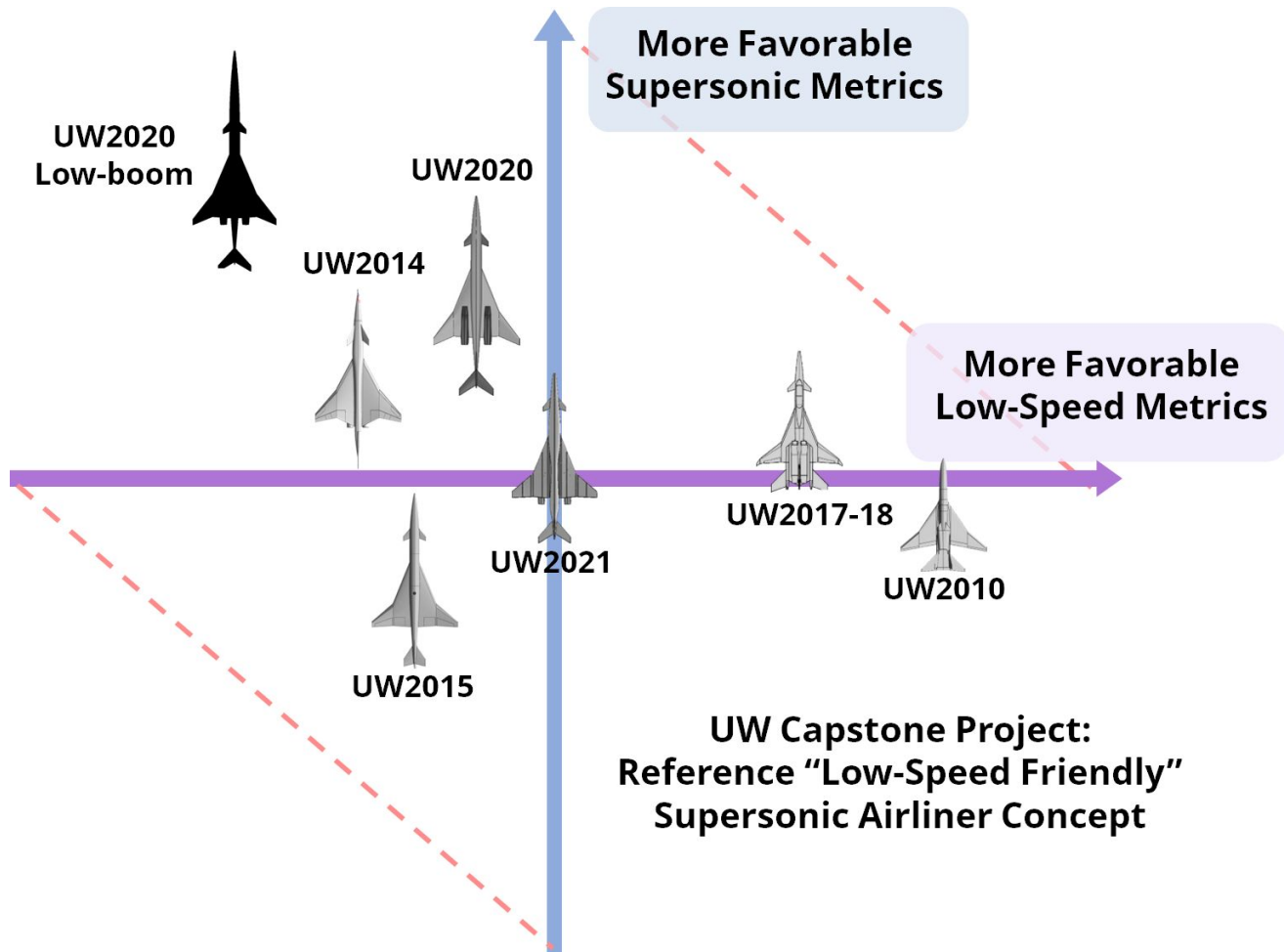
2017-2018



2019

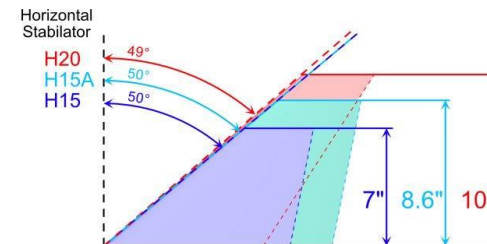
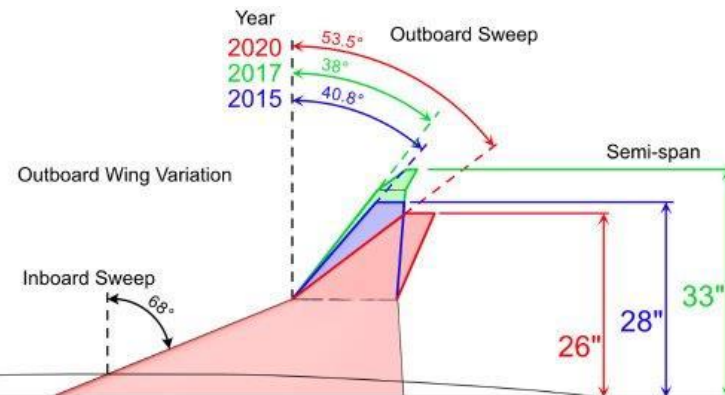
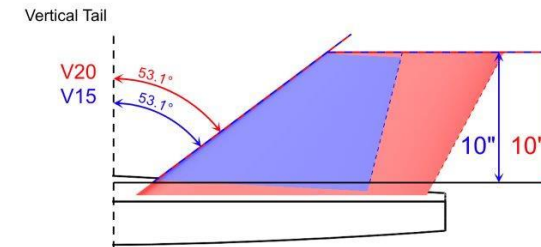
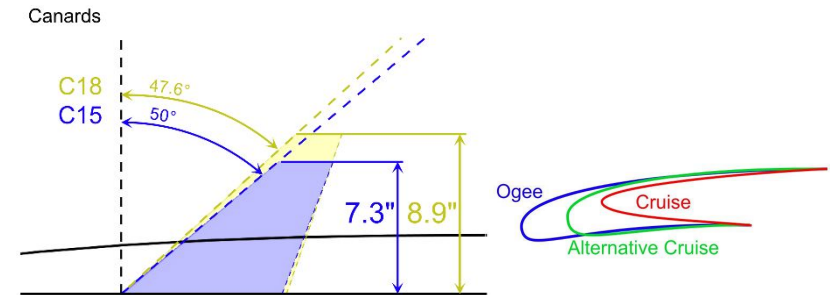
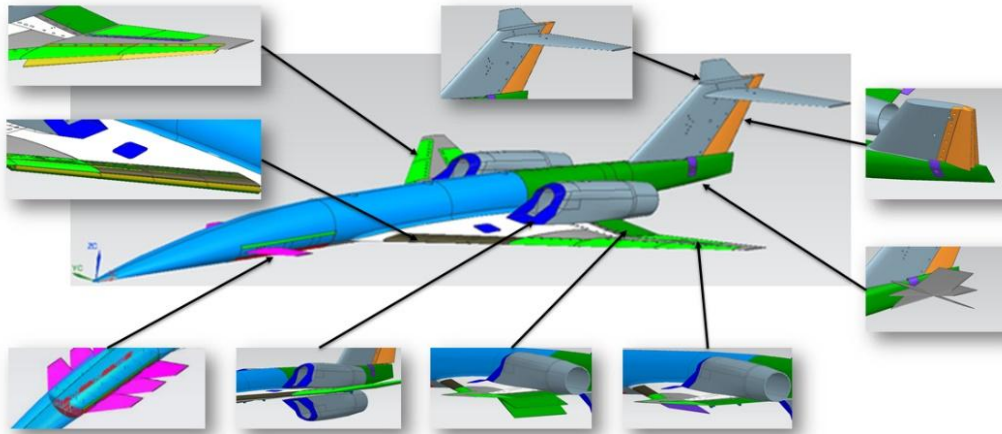


Supersonic Metrics



- Cruise L/D
- Transonic Acceleration
- Reduced Sonic Boom
- LTO noise
- S&C Requirement
- Holding and Climb

Test Model & Geometry





Test Entries and Configurations

Year	Month	Test period (days)	Total Runs (#)	Data collection
2020	July	5	152	Force & moment and flow visualization
2020	August	3	23	Force & moment
2020	September	6	133	Force & moment
2021	June	7.5	148	Force & moment
2021	August	4	54	Flow visualization
2021	September	6	225	Force & moment
2021	November	5	150	Force & moment and flow visualization
Total		36.5	885	













	Fuselage	Canard	Wing	Horizontal tail	Vertical tail	Nacelle
Model	2015	2015, 2018	2015, 2017, 2020	2015, 2015 RUAV, 2020	2015, 2020	2020
Variants	Nominal/long	Forward/nominal/afterward	Outboard	Low/Mid-tail/T-tail	Nominal	Top/bottom

(a) Component dimensions

Components	Model	Λ (°)	b (ft)	\bar{c} (ft)	S_{ref} (ft ²)	t/c
Canard	2015	50	1.22	0.536	0.61	0.04
	2018	47.6	1.48	0.540	0.68	0.04
Wing	2015	40.9	4.67	2.17	8.29	0.05
	2017	38	5.5	1.90	8.67	0.05
	2020	53.5	4.41	2.24	8.09	0.05
Horizontal tail	2015	50	1.17	0.67	0.73	0.04
	2015 RUAV	50	1.43	0.82	1.09	0.04
	2020	49.2	1.74	0.61	1.01	0.07
Vertical tail	2015	53.1	0.72	0.87	0.58	0.05
	2020	53.1	0.72	1.29	0.94	0.07
	Model	d_f (ft)	l_f (ft)			
Fuselage	2015	0.54	9.55			

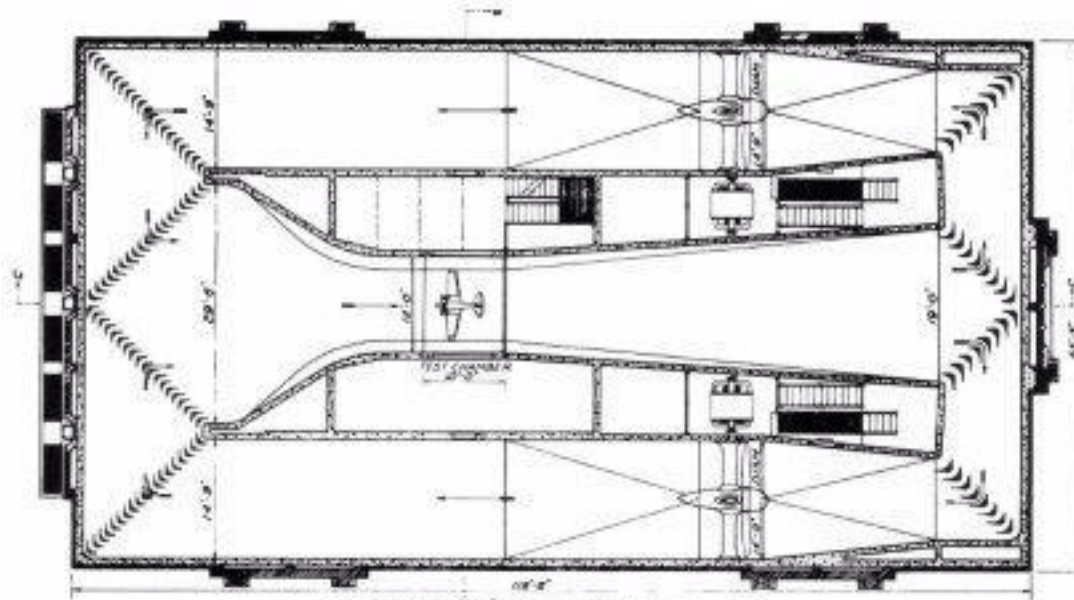
(b) Control surfaces and deflections

	Model	Deflections (°)
All-moving canard	2015, 2018	0, ± 5 , ± 10 , ± 15 , ± 30 , ± 20 , ± 25 ,
LE IB	2015, 2017, 2020	0, 15, 30
LE OB	2015, 2017, 2020	0, 15, 30
TE IB (flaps)	2015, 2017, 2020	15, 30
TE OB (ailerons)	2015, 2017, 2020	0, ± 10 , ± 25 , $\pm 10R$, $\pm 25R$
All-moving stabilator	2015, 2015 RUAV, 2020	0, ± 5 , ± 10 , ± 15
Rudder	2015	0, 10, 25
	2020	0, 10, 20

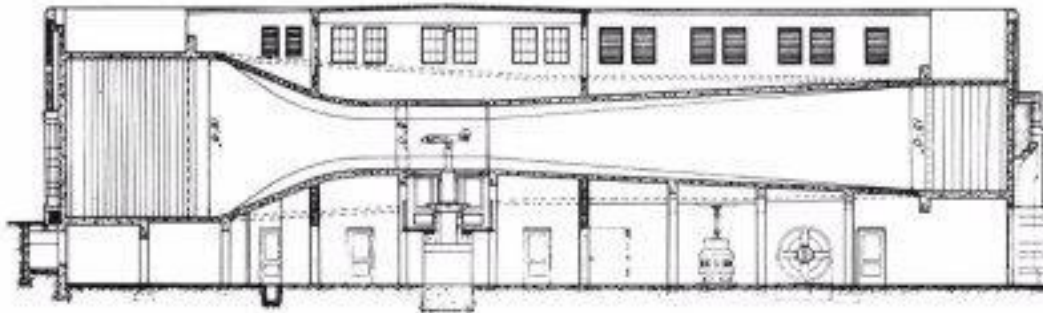
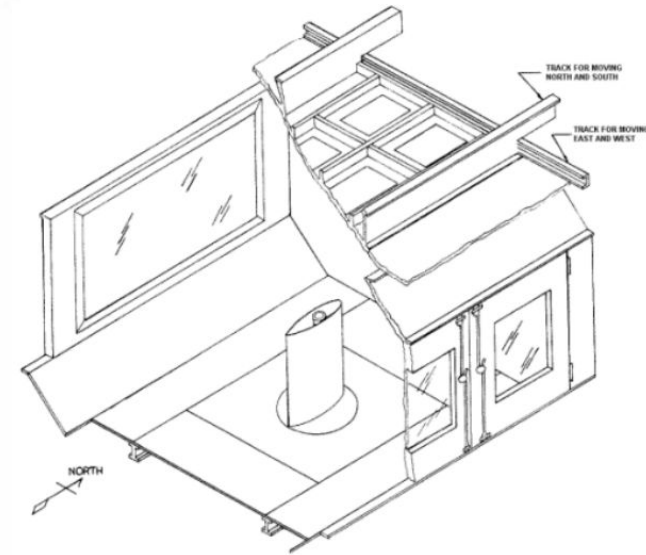
Figures/ Configuration	For-body		Aft-body		Wing			Canard		Horizontal tail						Vertical tail		Fins		Nacelles			
SCALOS configurations	F15	F15.L	A15	A20	W15	W17	W20	C15	C18	H15.L	H15.A	H20.T	H20.M	H20.L	V15	V20	VF1	DF1	N20.T	N20.B	NSRD		
 F15+A15+W17+N20.B+V15+H20.L+C15.F+VF1+DF1 UW-S-17A	X		X			X		X						X	X		X	X			X		
 F15+A20+W20+N20.T+V20+H20.T+C15.F UW-S-20A	X			X			X	X				X				X				X			
 F15.L+A20+W20+N20.T+V20+H20.T+C15.F UW-S-20AL		X		X			X	X				X				X				X			
 F15+A20+W20+N20.B+V20+H20.T+C15.F UW-S-20B	X			X			X	X				X				X					X		
 F15+A20+W20+N20.T.NSRD+V20+H20.T+C15.F UW-S-20C	X			X			X	X				X				X				X		X	
 F15.L+A20+W20+N20.T.NSRD+V20+H20.T+C15.F UW-S-20CL		X		X			X	X				X				X				X		X	
 F15+A20+W20+N20.T+V20+H20.T+C18.F UW-S-20D	X			X			X		X			X				X				X			
 F15+A15+W20+N20.B+V15+H20.L+C15.F+VF1+DF1 UW-S-20E	X		X				X	X						X	X		X	X			X		
 F15+A15+W20+N20.B+V15+H20.L+C15.F UW-S-20F	X		X				X	X						X	X						X		
 F15+A15+W20+N20.T+V15+H20.L+C15.F+VF1+DF1 UW-S-20G	X		X				X	X						X	X		X	X	X				
 F15+A20+W20+N20.T+V20+H20.M+C15.F UW-S-20H	X			X			X	X					X			X				X			
 F15+A15+W15+N20.B+V15+H20.L+C15.F+VF1+DF1 UW-S-21A	X		X		X			X						X	X		X	X			X		
F15+A15+W15+N20.B+V15+H20.L+C15.F UW-S-21B	X		X		X			X						X	X						X		
F15+A15+W15+N20.B+V15+H20.L+C18.F+VF1+DF1 UW-S-21C	X		X		X				X					X	X		X	X			X		



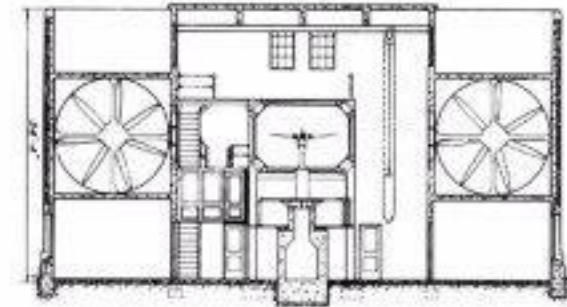
Kirsten Wind Tunnel



SECTIONAL PLAN THRU TUNNEL AXIS



SECTIONAL ELEVATION "C"



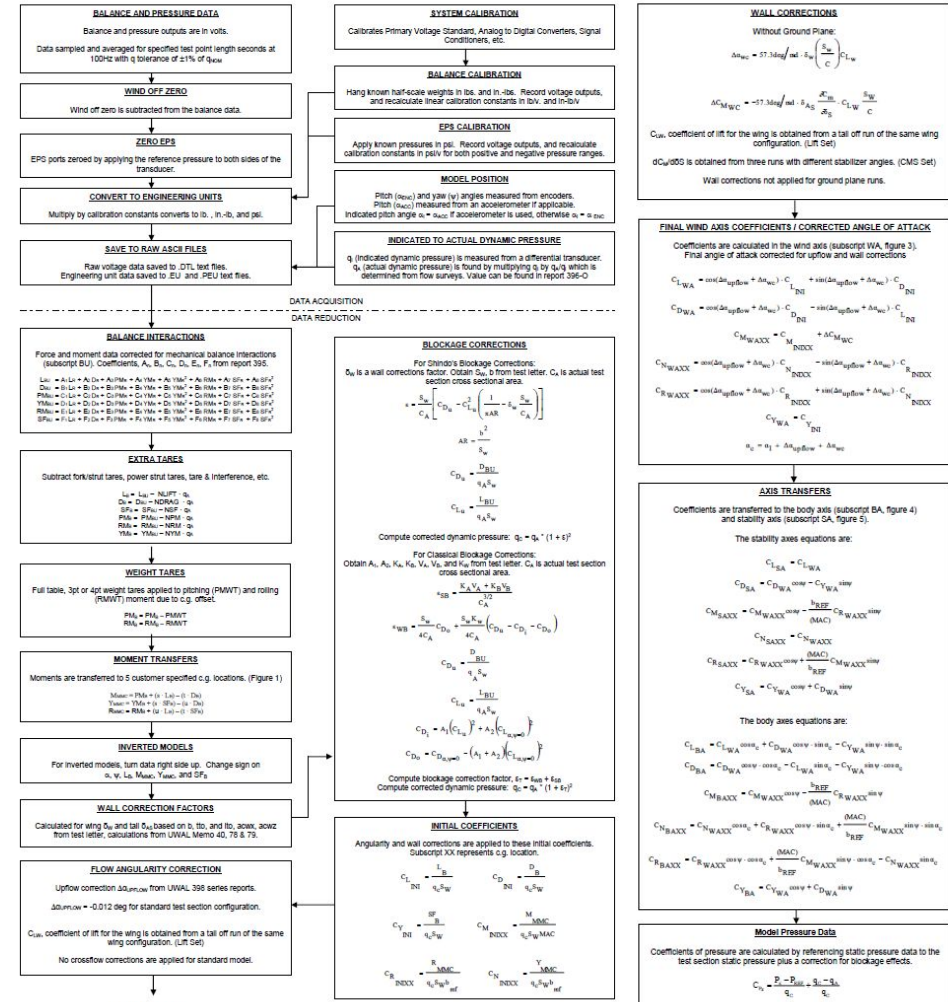
SECTIONAL ELEVATION "B"



Wind Tunnel Data Reduction

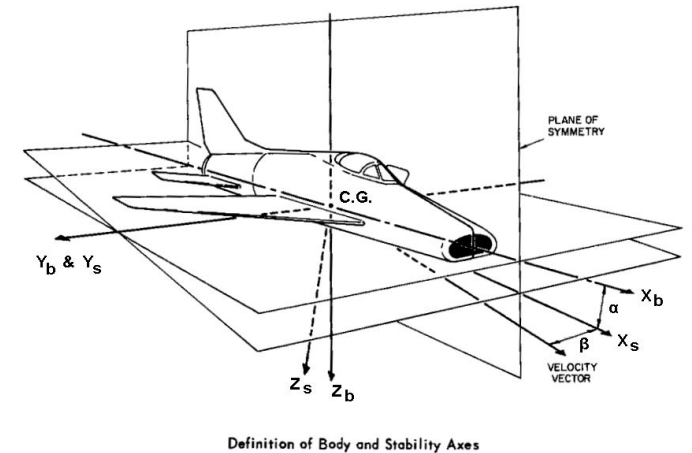
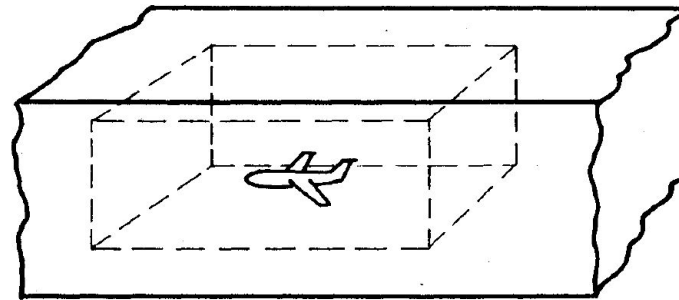
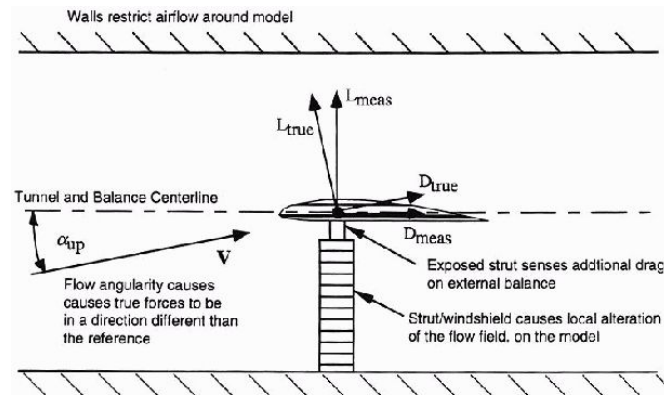
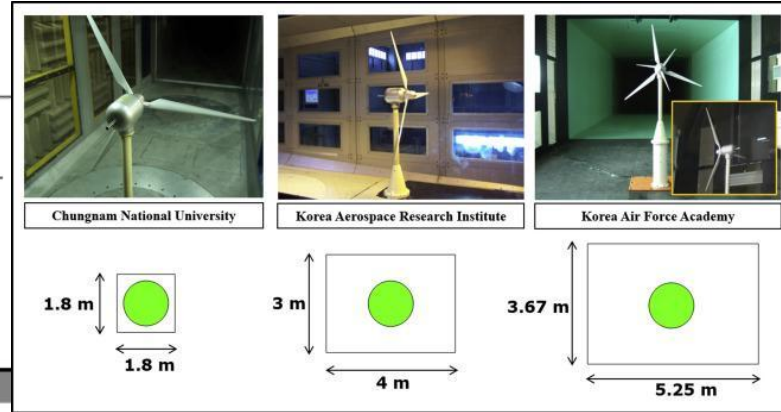
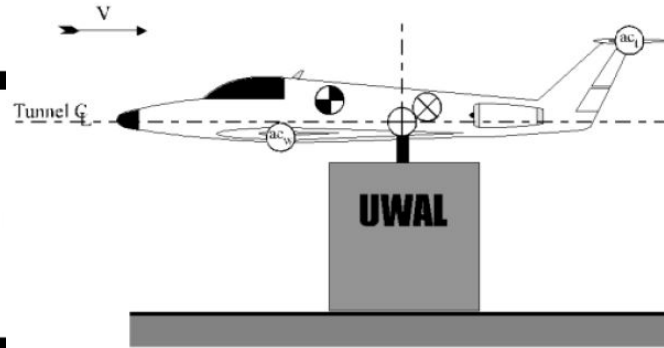
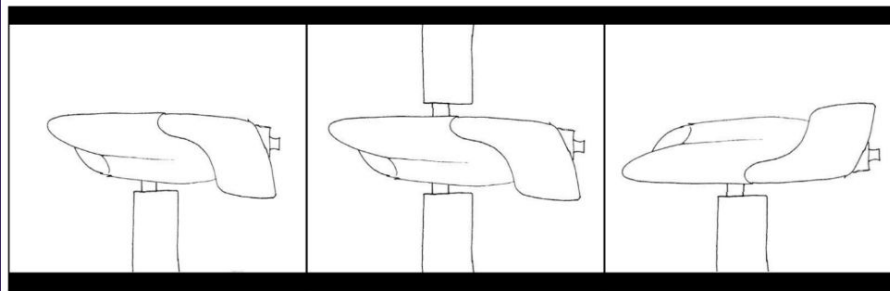
1. Balance Interaction
2. Weight Tares
3. Moment Transfer
4. Blockage Correction
5. Flow Angularity
6. Wall Correction
7. Correction for AOA
8. Axis Transfer

CHART OF THE STANDARD FORCE DATA ACQUISITION / REDUCTION METHOD AT UWAL

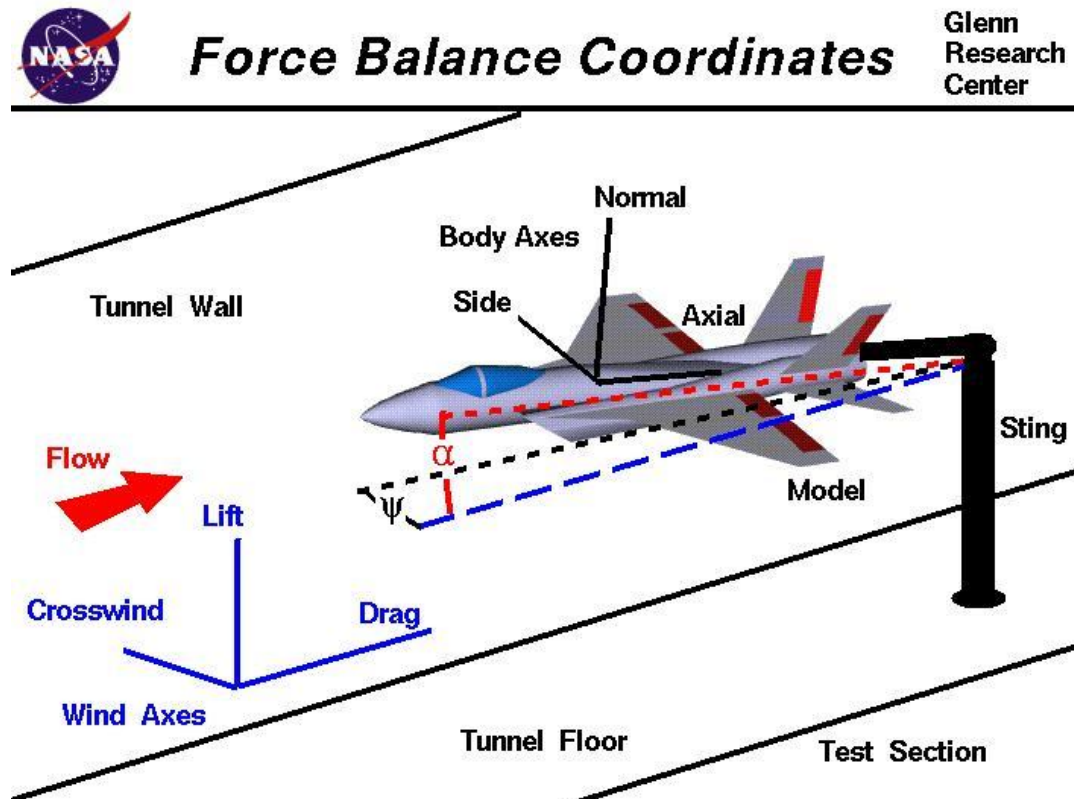




Wind Tunnel Data Reduction



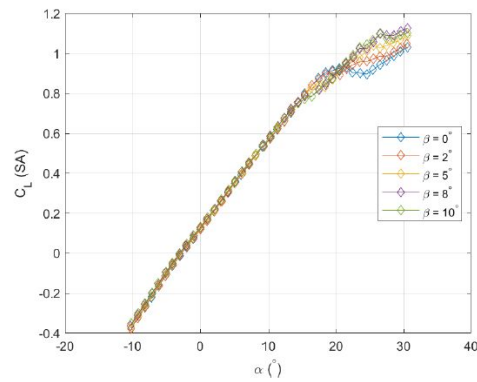
Axis, Force, and Moments



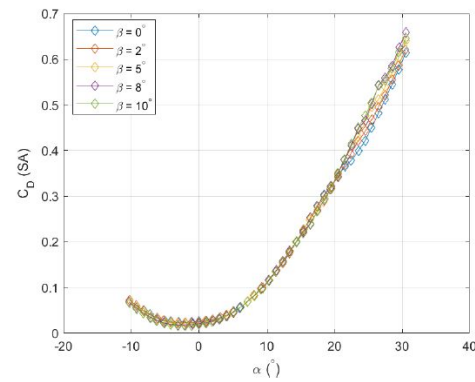
- 3 axes (body, wind, and stability)
- 3 forces (lift, drag, sideforce)
- 3 moments (pitch, roll, yaw)
- 7 CG locations (15%, 20%, 25%, 30%, 33%, 35%, 40%)
- Total of



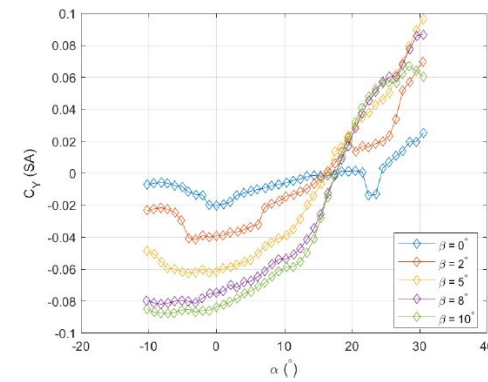
Sample - 1



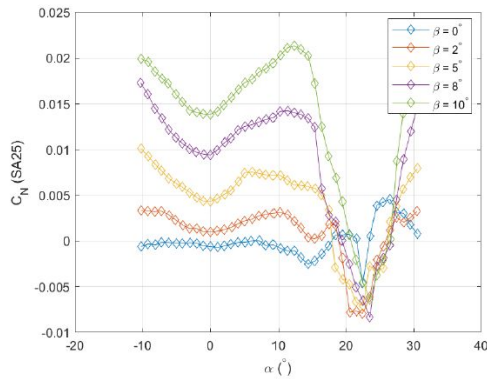
(a) C_L vs α



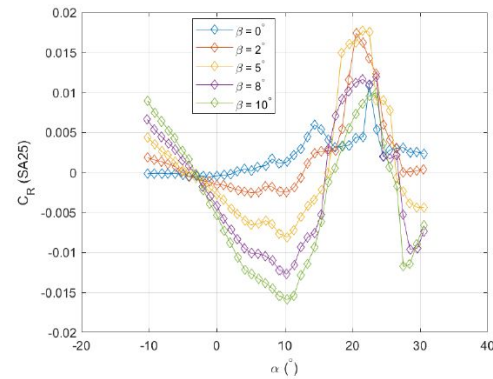
(b) C_D vs α



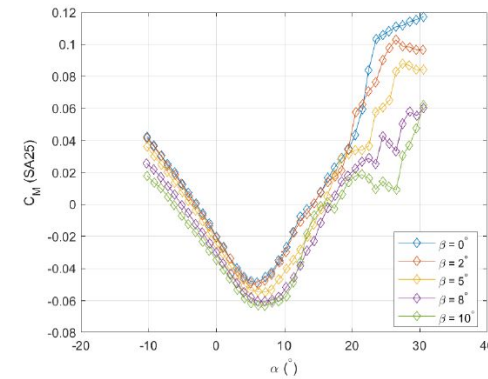
(c) C_Y vs α



(d) C_N vs α



(e) C_R vs α

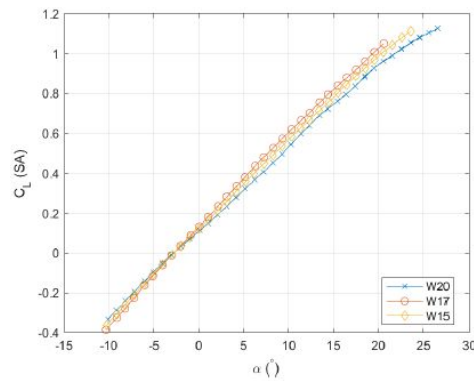


(f) C_M vs α

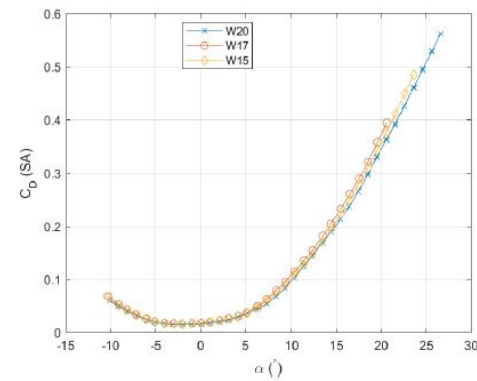




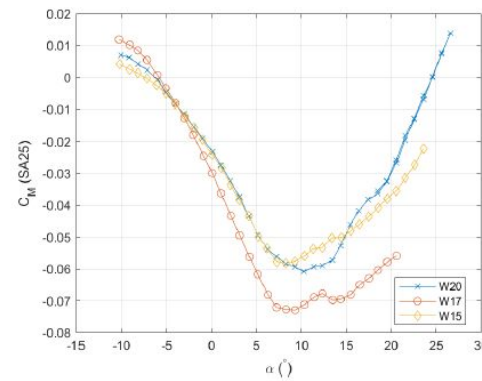
Sample - 2



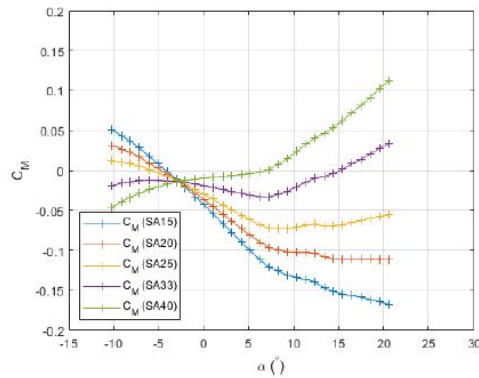
(a) C_L vs. α



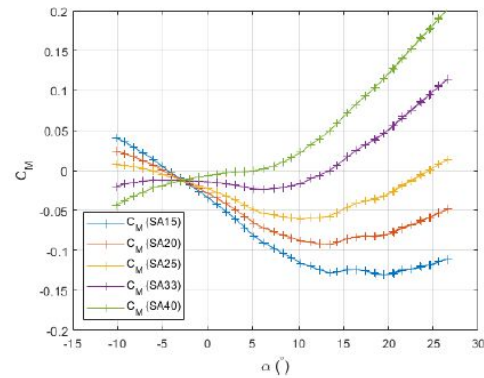
(b) C_D vs. α



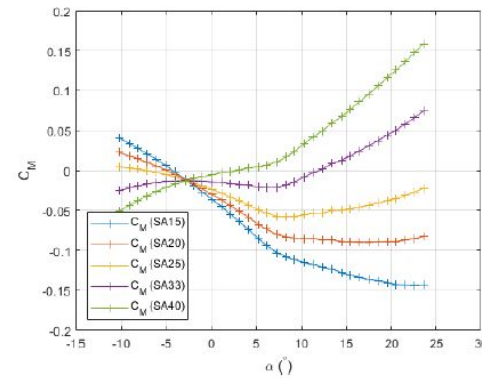
(c) C_M vs. α



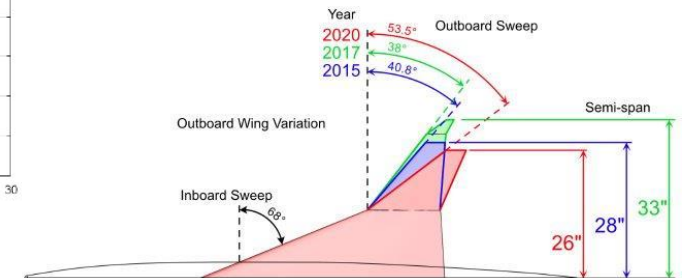
(d) C_M vs. α , W17 OB



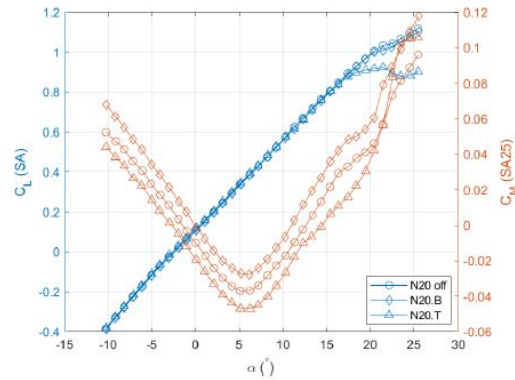
(e) C_M vs. α , W20 OB



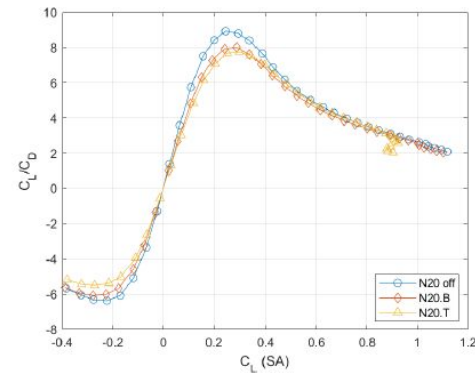
(f) C_M vs. α , W15 OB



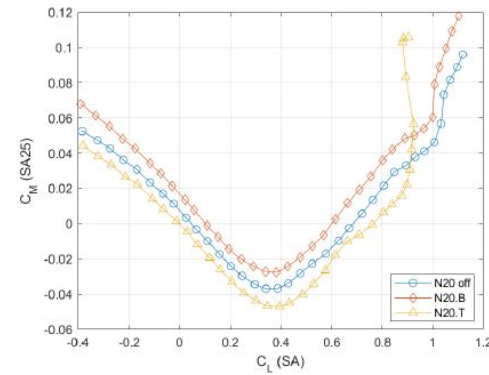
Sample - 2



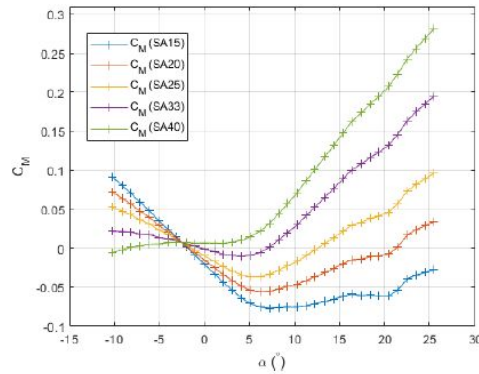
(a) C_L and C_M vs. α



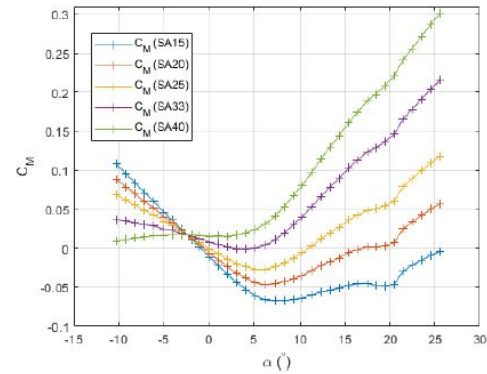
(b) C_L/C_D vs. C_L



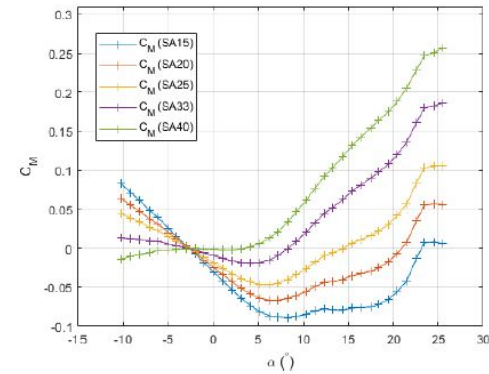
(c) C_M vs. C_L



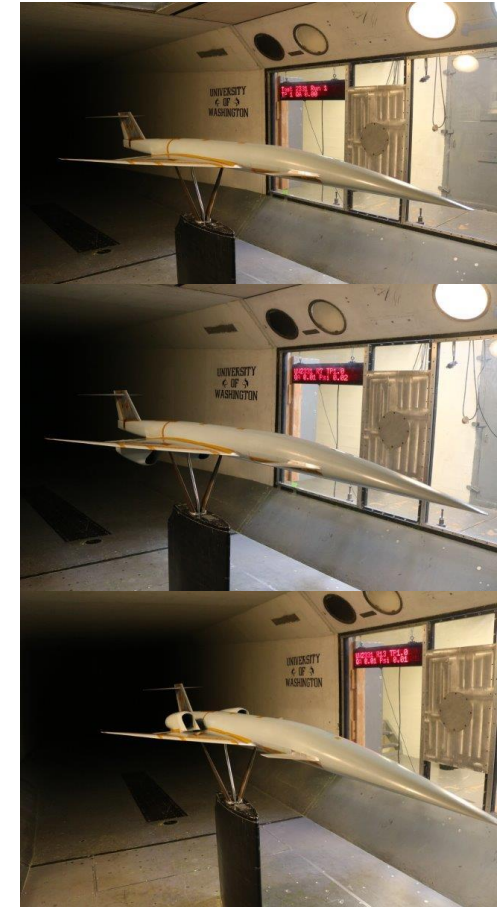
(d) C_M vs. α , no nacelles



(e) C_M vs. α , N20.B



(f) C_M vs. α , N20.T





Proposal

Core

1. Search run log
2. Extract data
3. Data truncation
4. Data interpolation
5. Data manipulation
6. Data variables
7. Data Visualization
8. Debug features

Goal

1. Regression
2. Learning



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Thank you!



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NASA CST Grants

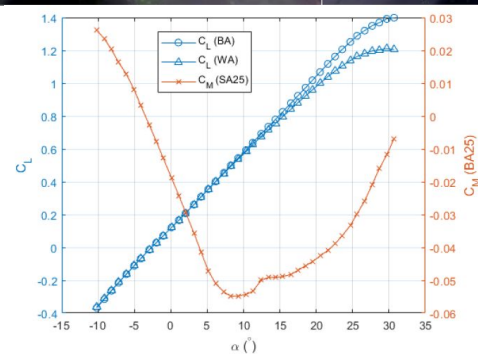
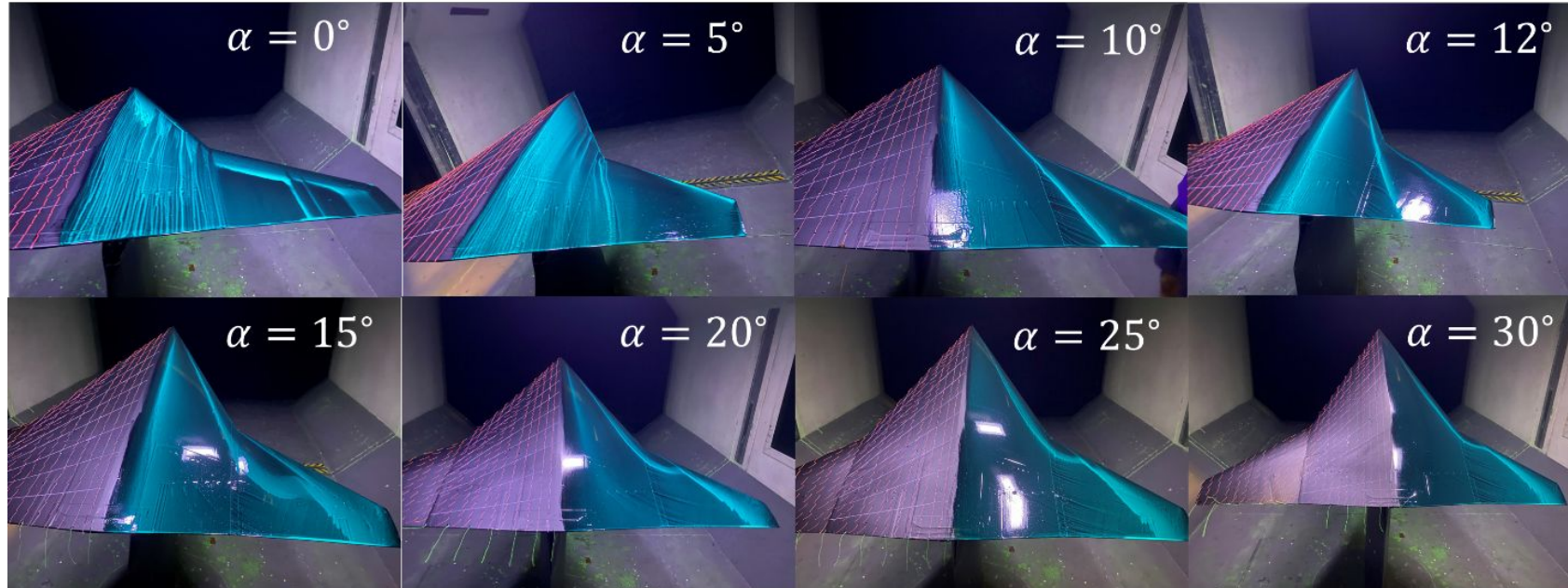
KWT Staff and Crew

2021 UW Capstone students, Anwar Moustafa and Colton Hill

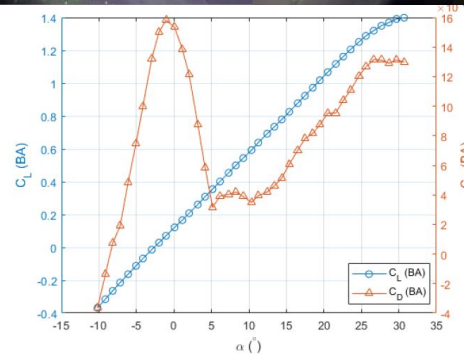
2022 UW Capstone students, Josh Ignacio



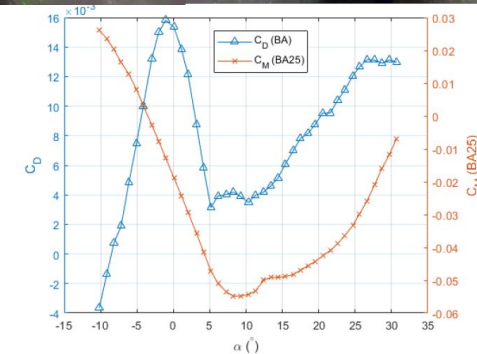
Flow Physics – Wing only



(a) C_L and C_M vs α



(b) C_L and C_D vs α , body axis



(c) C_D and C_M vs α , body axis