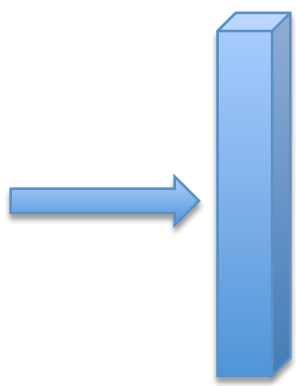
Misc Drag

- In addition to friction/form, there are numerous other parasite drag makers
- Often given in terms of "equivalent flat plate area"
  - removes S_{ref} issue for "stuff"



$$D = qf\underbrace{\cancel{C_{D_f}}}_{1} = qS_{REF}C_{D_{S_{REF}}}$$

So: $$\Delta C_D = \frac{f}{S_{REF}}$$

Hoerner, *Fluid Dynamic Drag* is a good place to look for values of misc. drag

Also:
- In WT test, base drag is usually removed
- Extrapolation to full scale *Re* means delta in C_F between WT *Re* and Flt *Re*

A-4M (Navy Museum near PAX)

A-4M Parasite Drag Buildup

$M = 0.65$, $C_L = 0.0$

COMPONENT	S_{wet} (ft^2)	S_π (ft^2)	C_{D_f}	C_{D_π}	Δf (ft^2)
1. Wing					
(a) Affected by slats	262		.00308		.80
(b) Not affected by slats	150		.0028		.42
2. Horizontal Tail	84.4		.0033		.28
3. Vertical Tail	117		.00385		.45
4. Fuselage (including inlets)	434		.00306		1.33
5. Enclosure		2.3		.122	.28
6. Appendages					
(a) Upper Avionics Pod					.18
(b) Drag-Chute Fairing					.03
(c) Landing-Gear Fairings					.11
(d) Aero 7A Rack-Pylon @ C_L					.15
(e) Arresting Hook					.15
(f) Inflight-Fueling Probe (TIAS)					.24
(g) Wing Vortex Generators					.30
(h) Boundary-Layer Diverter					.11
(i) Boundary-Layer Splitter Plate					.01
(j) Inlet Vortex Fences					.06
(k) Landing Spoilers					.03
(l) ECM Antenna and Chaff Dispensers					.10
(m) Pitot					.01
(n) Angle-of-Attack Indicator					.01
(o) Rudder Damper					.06
(p) Aileron Damper					.06
(q) Barrier Detents					.02
(r) Anti-Collision Lights					.02
(s) Radar Altimeter					.04
(t) Fuel Dump and Vent					.06
(u) Airblast Rain Removal					.02
(v) Catapult Holdback					.07
7. Inlets and Exits					
(a) Powerplant (vents, etc)					.07
(b) Air Conditioning					.02
8. Miscellaneous					.05
Total Equivalent-Parasite-Drag Area, f, ft^2					5.54
Drag Coefficient Based on Wing Area (260 ft^2)					.0213
Drag Coefficient Based on Total Wetted Area (1119 ft^2)					.00495

Paul L. Coe, Jr., NASA TN D-8206
"Review of Drag Cleanup Tests (1935-1945)"

Airplane Condition

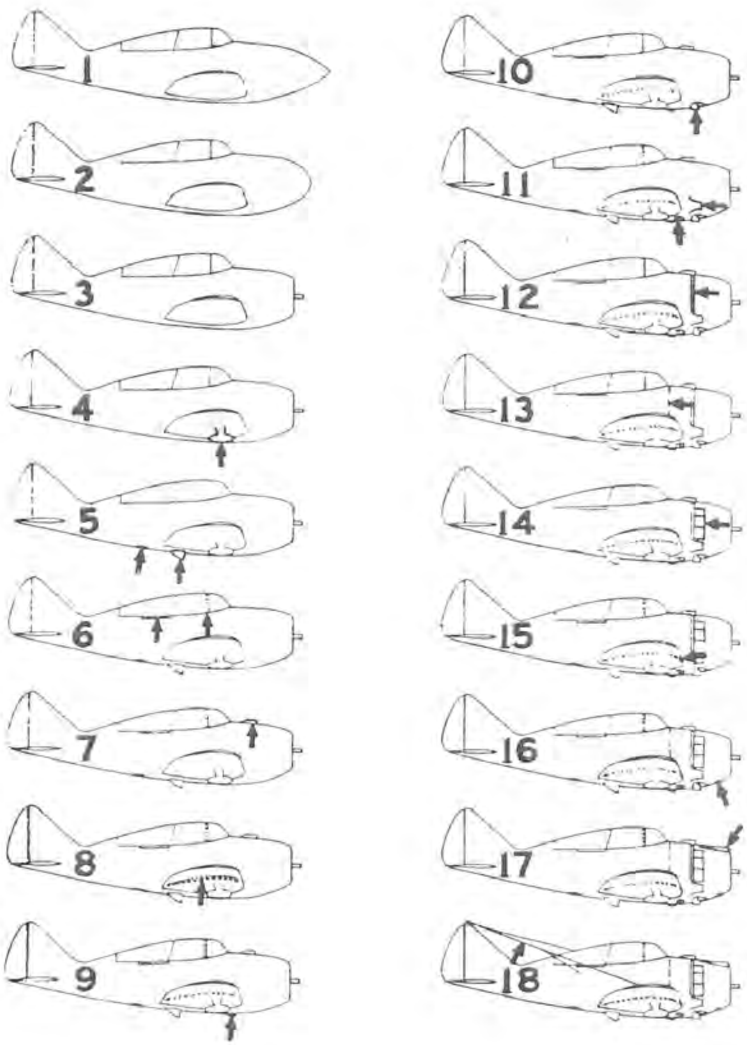


TABLE IV.- RESULTS OF TESTS TO IDENTIFY SOURCES OF DRAG FOR AIRPLANE 8 (SEVERSKY XP-41)

Condition number	Description	C_D ($C_L = 0.15$)	ΔC_D	ΔC_D, percent [a]
1	Completely faired condition, long nose fairing	0.0166		
2	Completely faired condition, blunt nose fairing	.0169		
3	Original cowling added, no airflow through cowling	.0186	0.0020	12.0
4	Landing-gear seals and fairing removed	.0188	.0002	1.2
5	Oil cooler installed	.0205	.0017	10.2
6	Canopy fairing removed	.0203	-.0002	-1.2
7	Carburetor air scoop added	.0209	.0006	3.6
8	Sanded walkway added	.0216	.0007	4.2
9	Ejector chute added	.0219	.0003	1.8
10	Exhaust stacks added	.0225	.0006	3.6
11	Intercooler added	.0236	.0011	6.6
12	Cowling exit opened	.0247	.0011	6.6
13	Accessory exit opened	.0252	.0005	3.0
14	Cowling fairing and seals removed	.0261	.0009	5.4
15	Cockpit ventilator opened	.0262	.0001	.6
16	Cowling venturi installed	.0264	.0002	1.2
17	Blast tubes added	.0267	.0003	1.8
18	Antenna installed	.0275	.0008	4.8
	Total		0.0109	

[a] Percentages based on completely faired condition with long nose fairing.

F-18E Example

Unknown photo source from web

F-18 Protuberance Drag (Fig 14.2 in B&C)

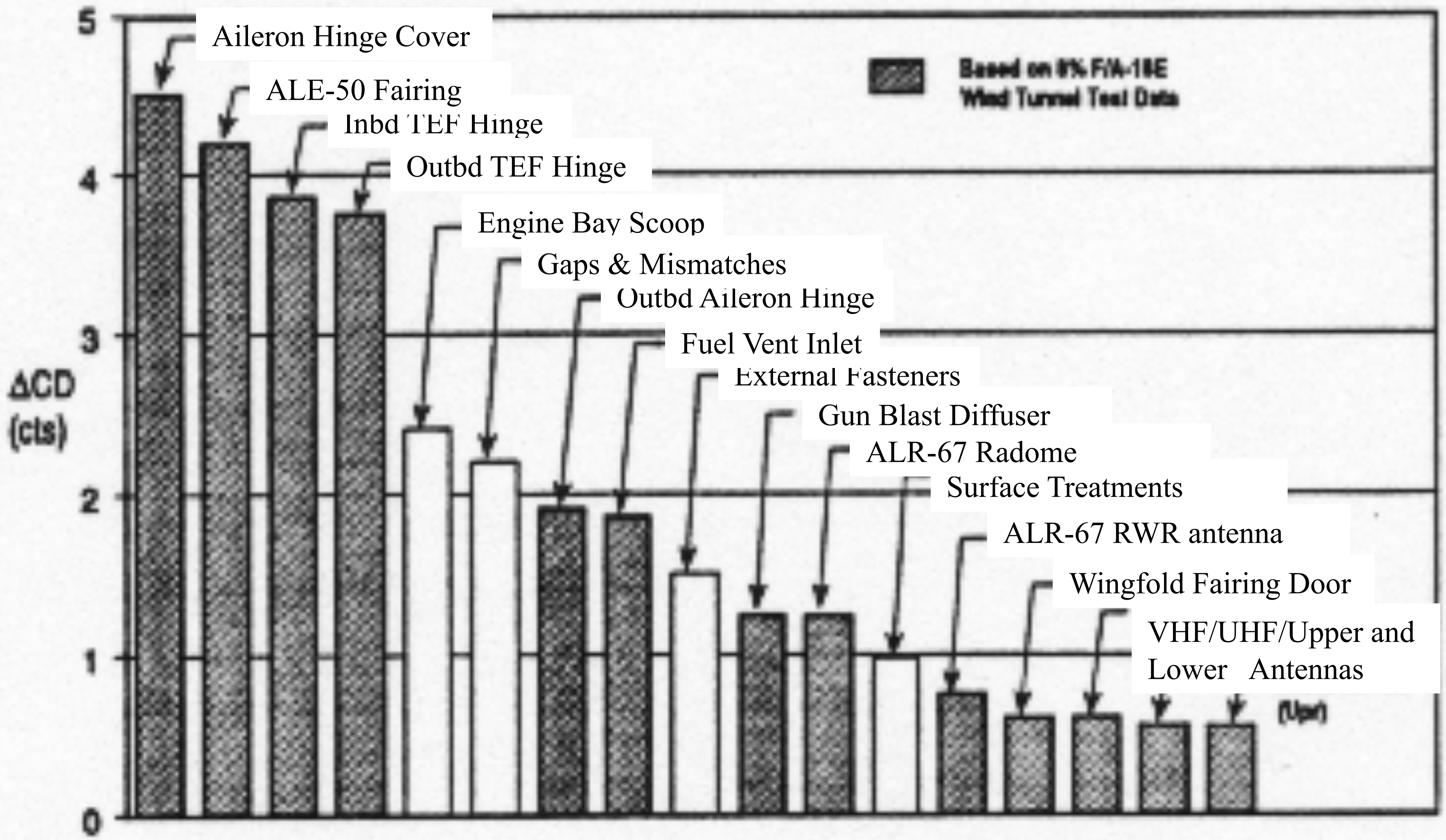


Fig. 11 Protuberance drag.

From "Wind-Tunnel Techniques to Successfully Predict F/A-18 In-Flight Lift and Drag," by Niewald and Parker, *Journal of Aircraft*, Vol. 37, No. 1, Jan-Feb. 2000, pp 9-14.

The Aeros Lose: The F-14 Dual Chin Pod!

Photo by Carrie Volkman, Dec. 30, 2017, at the Udvar-Hazy Air & Space Museum

Add base drag (pressure) if appropriate.

One ref: Frank G. Moore (a Hokie), *Approximate Methods for Weapon Aerodynamics*, AIAA, 2000

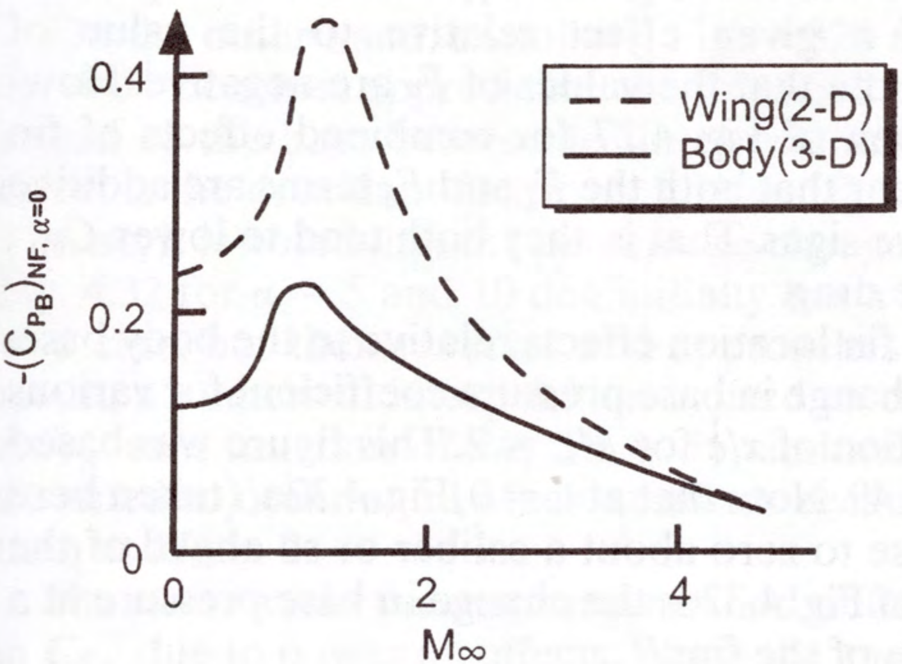


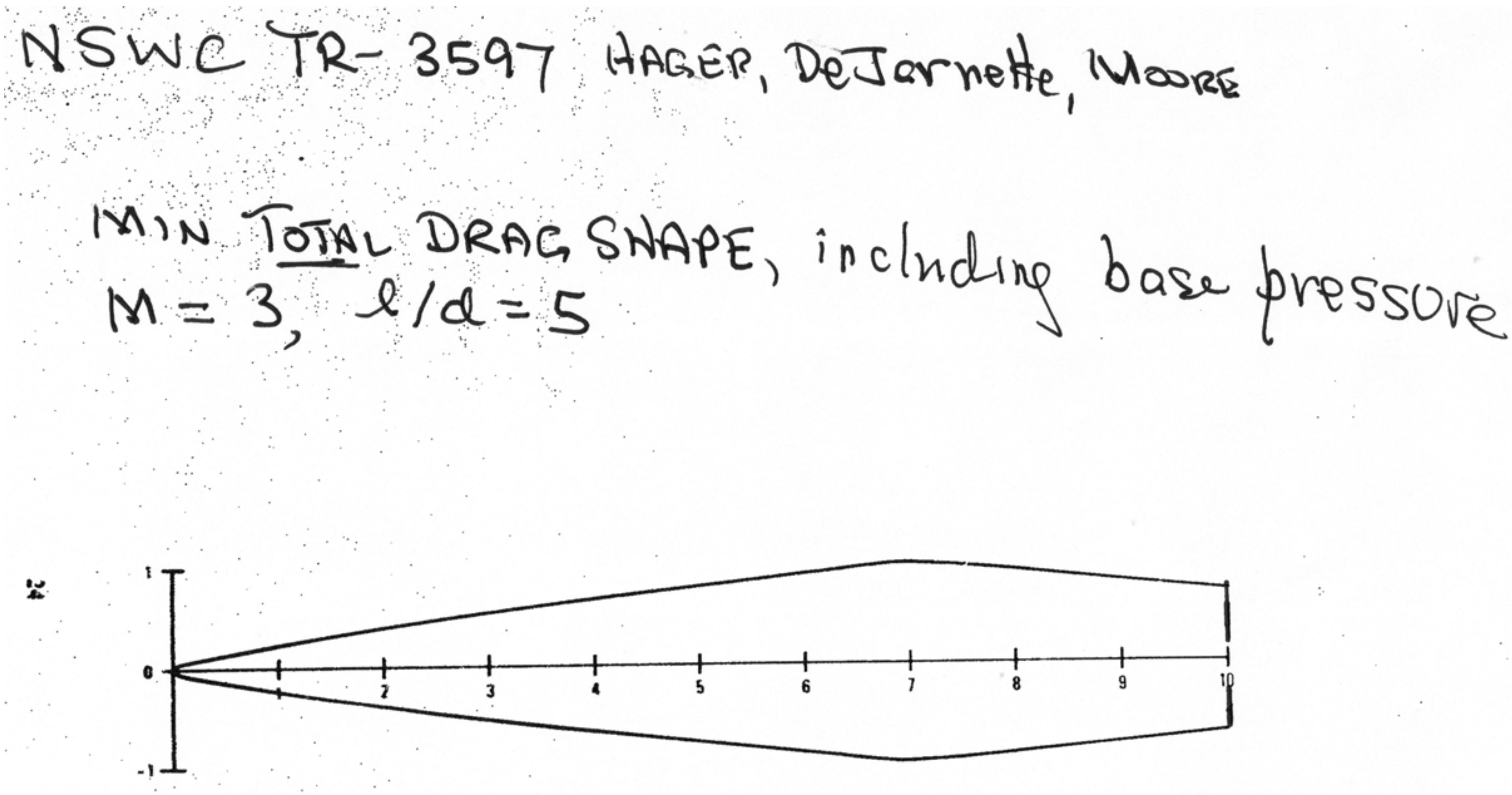
Fig. 4.28 Base pressure coefficient for blunt wing trailing edge and body base.

Note: highest drag is around Mach 1

Aeros have missed this in the past, notably the XB-70

For subsonic estimations, see Hoerner,
Journal of the Aeronautical Sciences (JAS), October 1950.

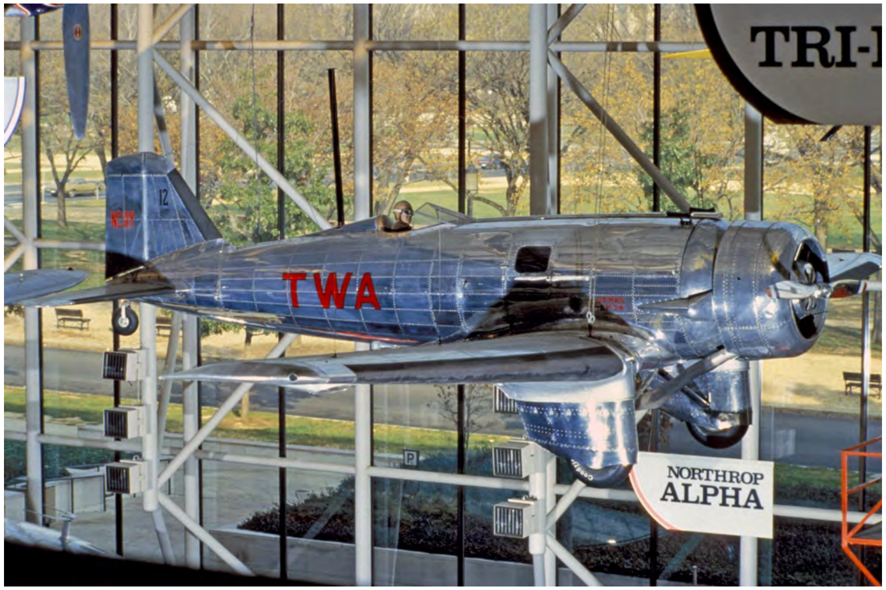
Min drag including base drag for a projectile



Frankie said adopted by the Navy but not the Army

To Ponder: Landing Gear – Wheel Pants

Northrop Alpha



Jack Northrop was the leading advocate of drag reduction, think the flying wing. Yet he found that well designed wheel pants were almost as good as retractable gear without the complications and weight.

Northrop Gamma

On display at the

Air & Space Museum

on the Mall

Photos by W. H. Mason