Viscosity and Compressiblity

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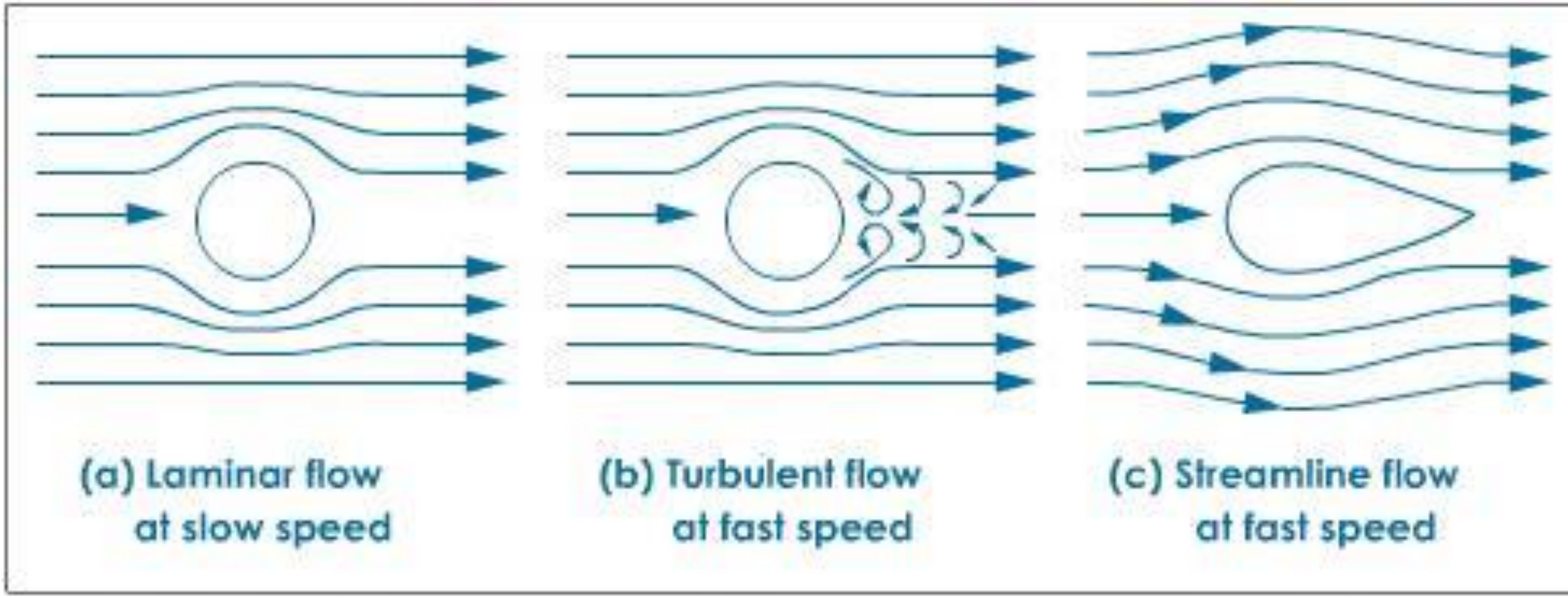
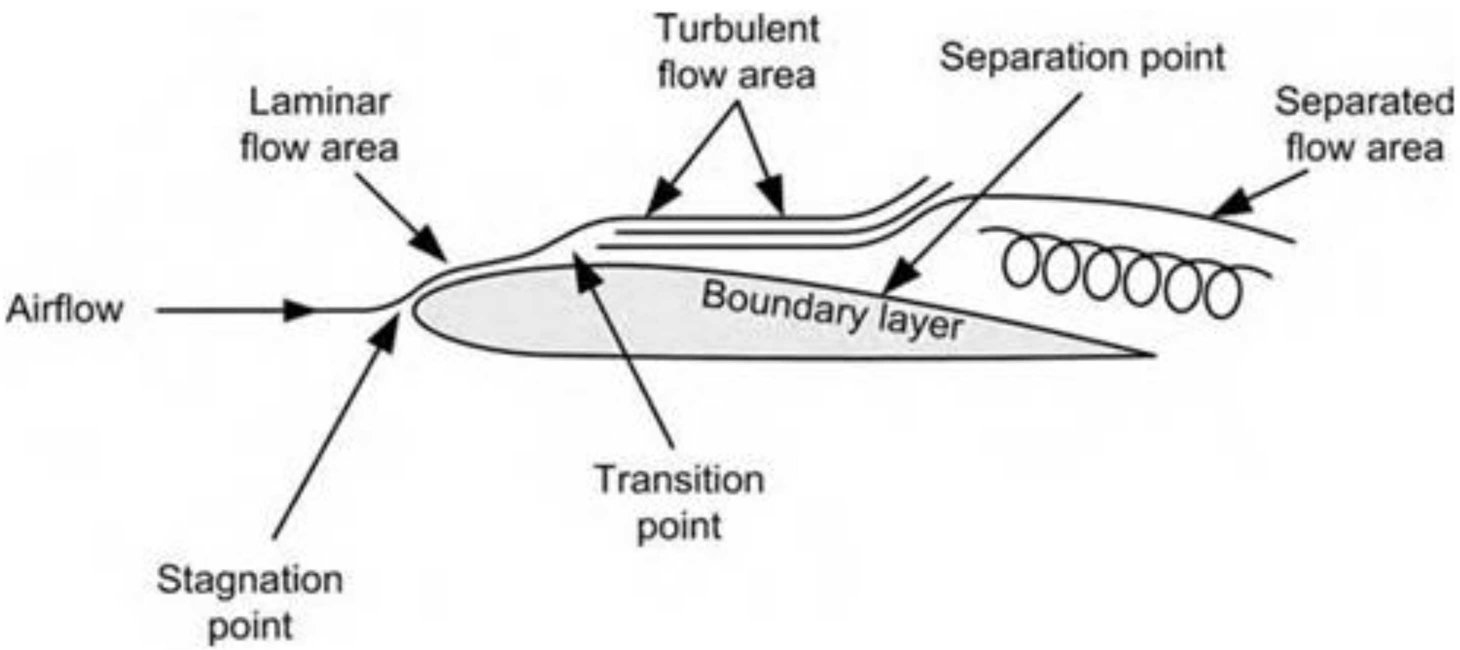
Ideal Flow & Viscous Flow



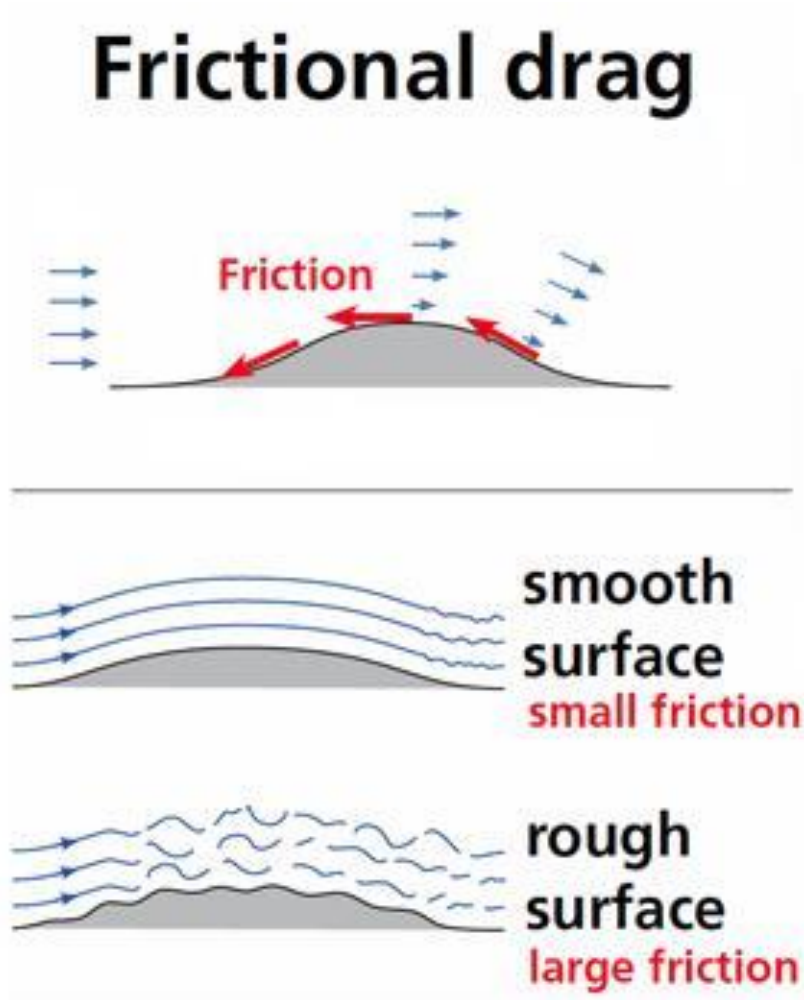
http://dvapphysics.wikispaces.com/Fluids+in+motion?showComments=1

Boundary Layer

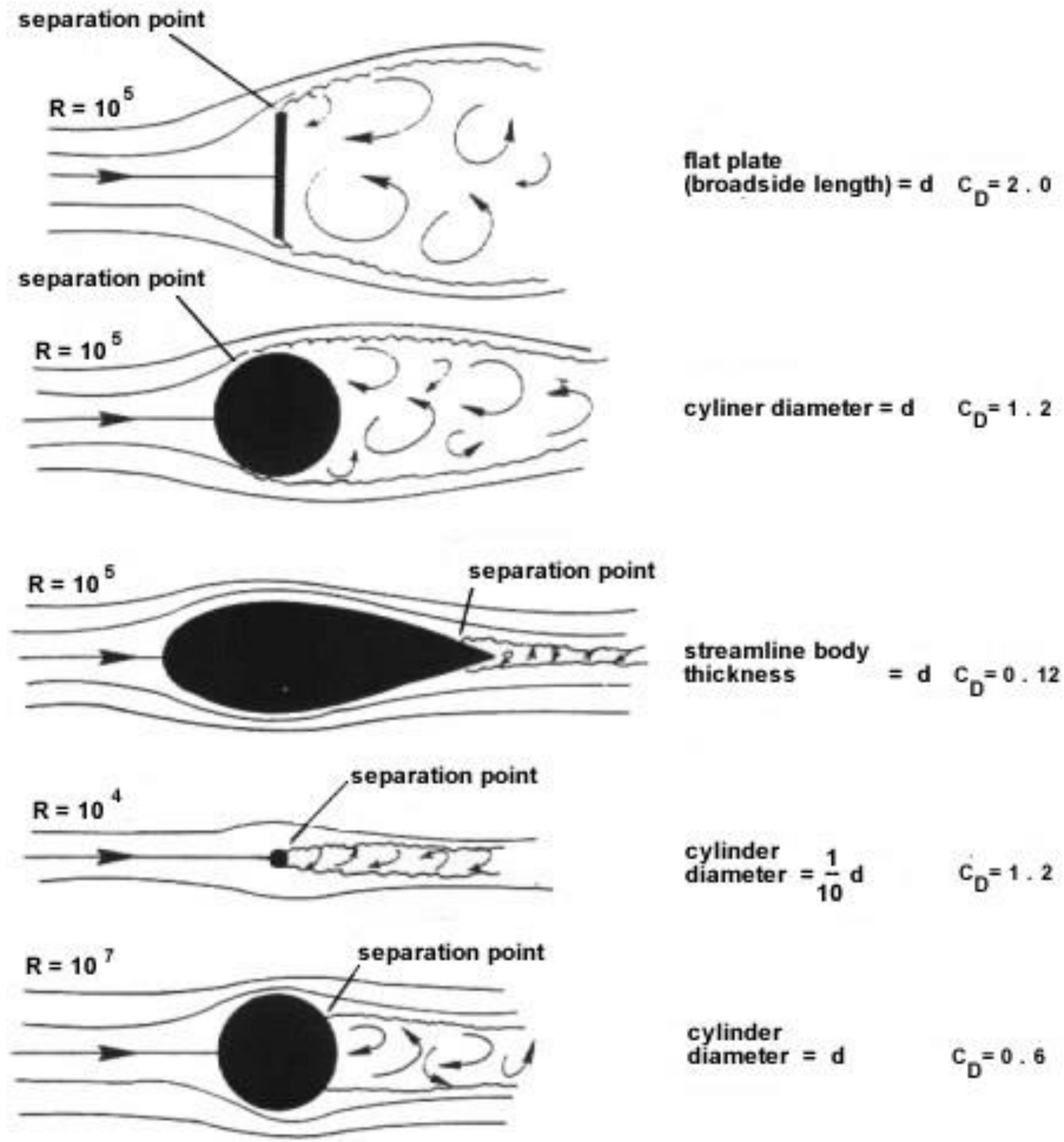


http://www.zoombd24.com/boundary-layer-control-airfoil-boundary-layer-separation-control-devices-details/

Reason of Boundary Layer Seperation



http://www.newtonsapple.org.uk/forces-of-drag-what-are-they/



http://www.newtonsapple.org.uk/forces-of-drag-what-are-they/

Newtonian Fluid Reynolds Number (Re) Formula

$$Re = \frac{\rho V D}{\mu}$$

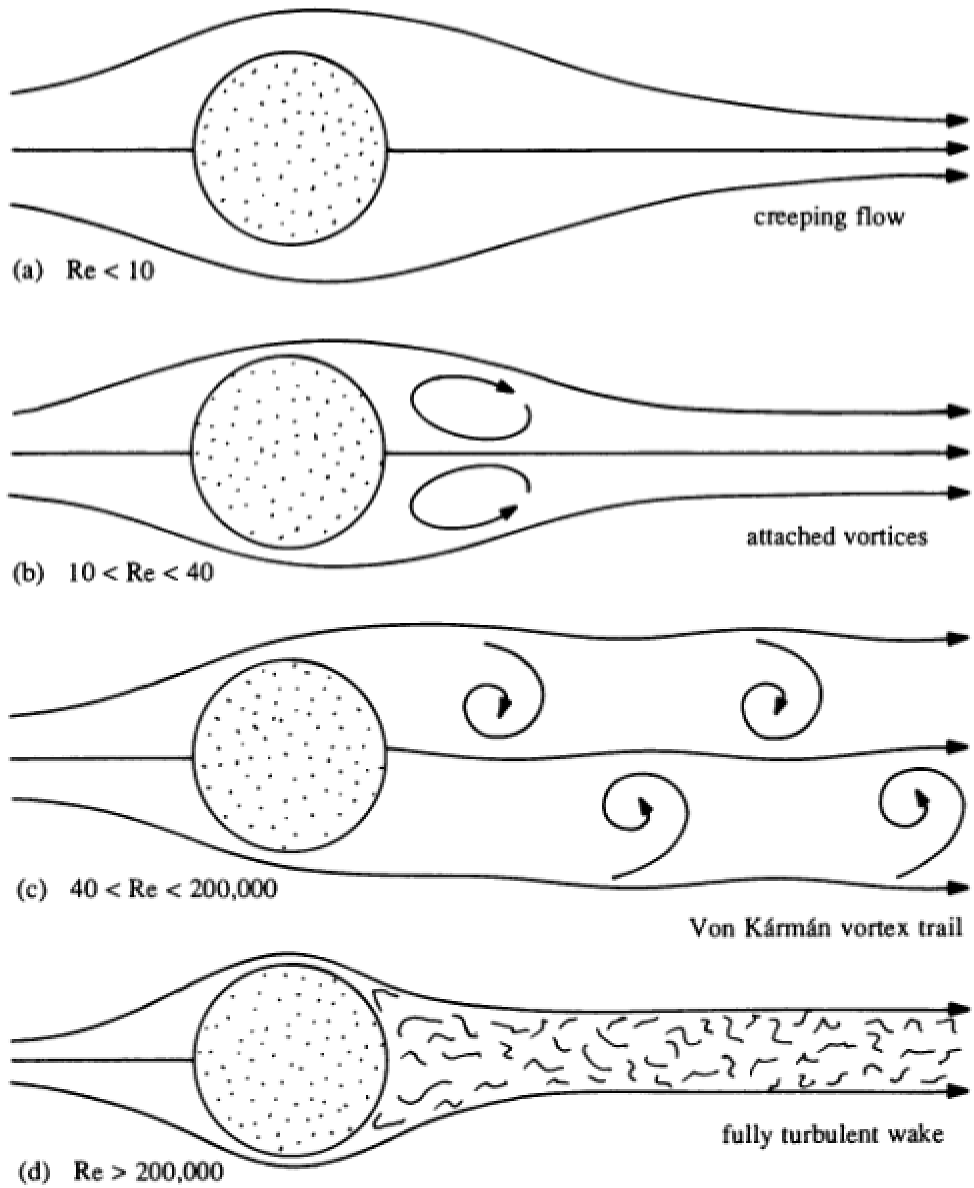
$\mu - fluid\ dynamic\ viscosity\ in\ kg/(m.s)$

$\rho - fluid\ density\ in\ kg/m^3$

$V - fluid\ velocity\ in\ m/s$

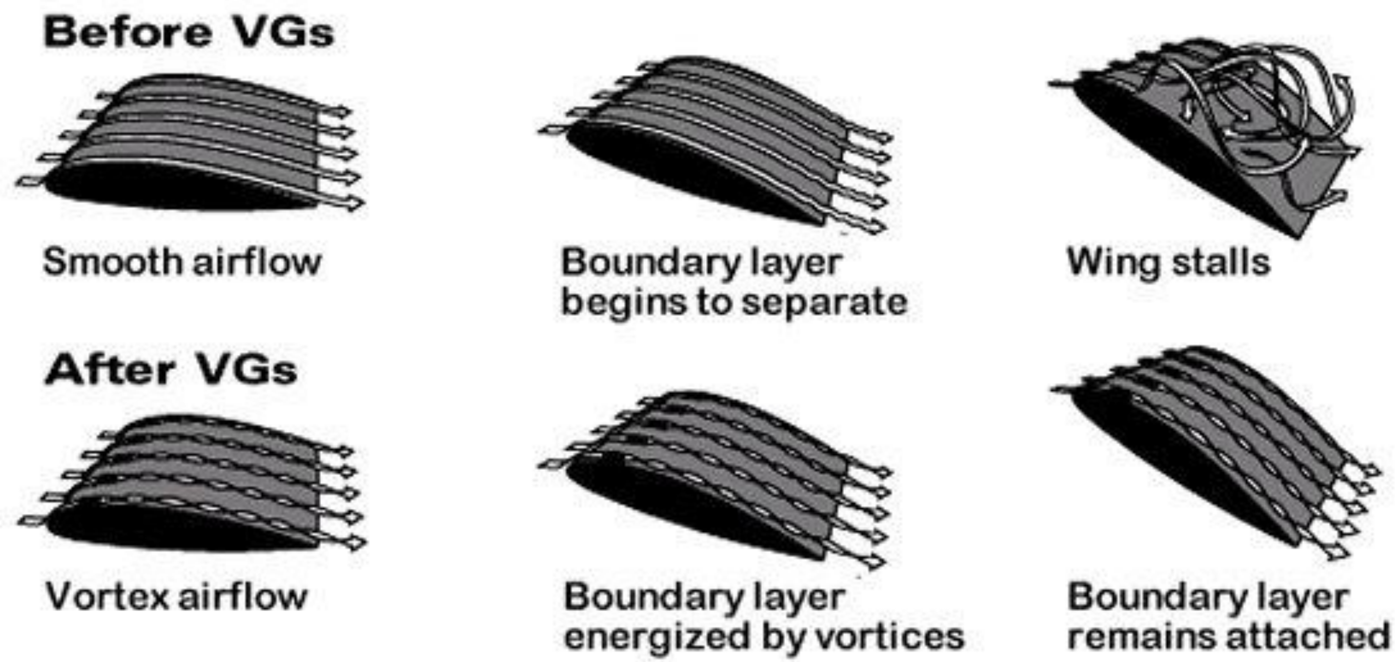
$D - pipe\ diameter\ in\ m$

http://ncalculators.com/mechanical/reynolds-number-calculator.htm



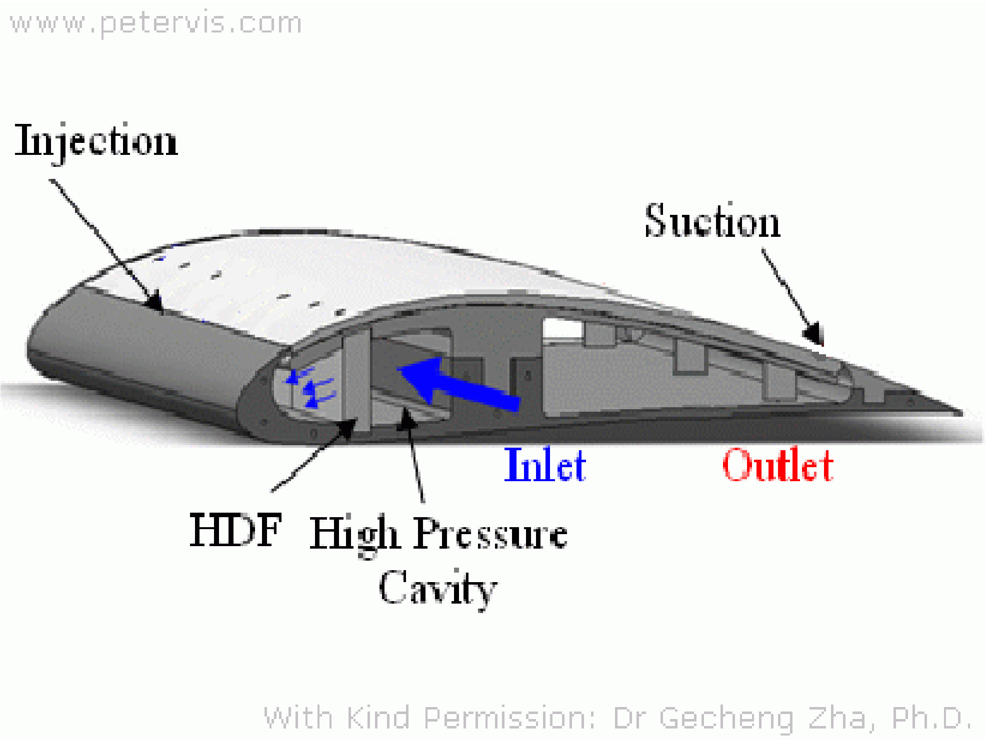
http://www.empiricalzeal.com/2011/07/14/what-it-feels-like-for-a-sperm/

Vortex Generator



https://aviation.stackexchange.com/questions/13876/what-is-a-vortex-generator

Airfoil Suction

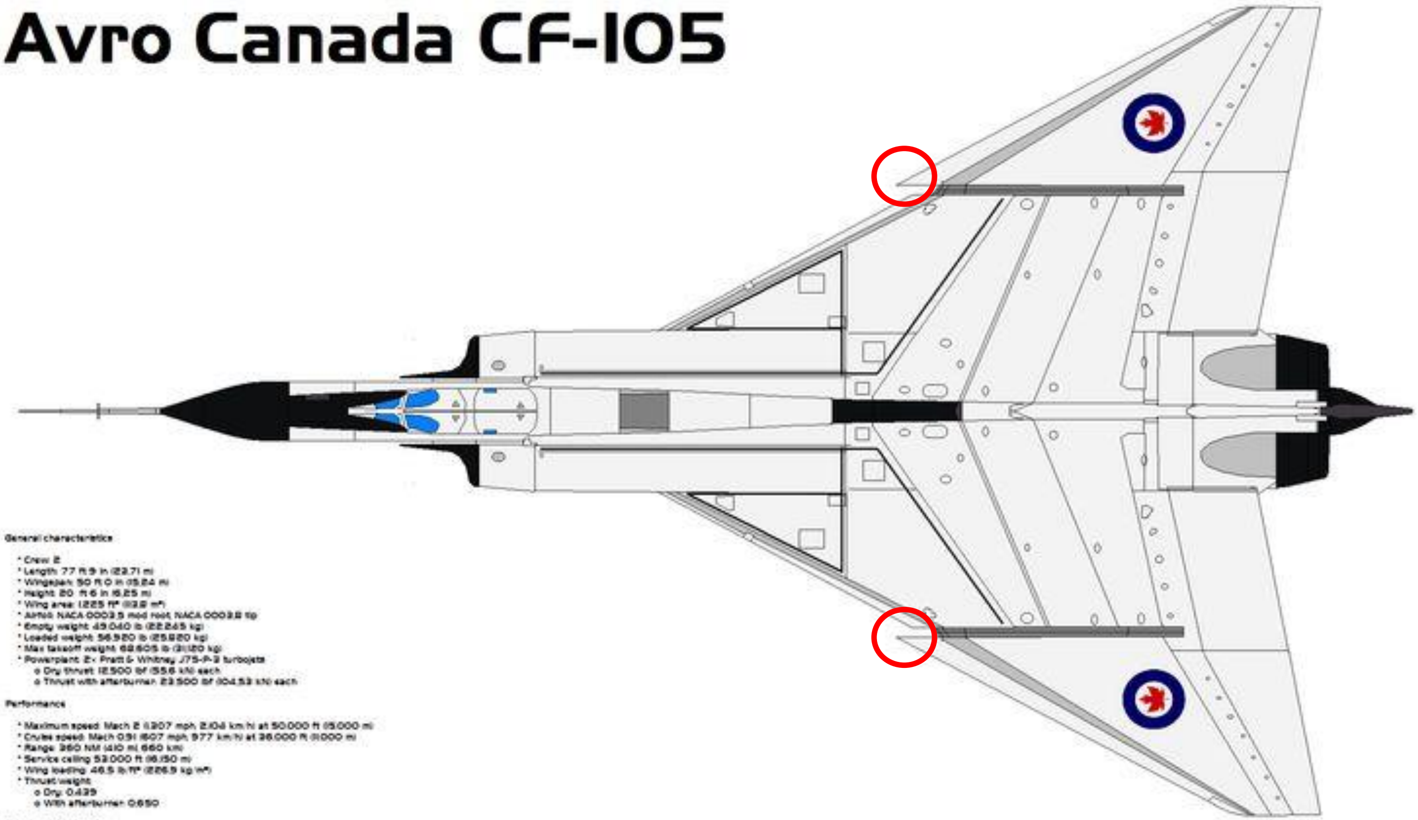


https://www.petervis.com/interests/published/Supersonic_Bi-directional_flying_wing_SBiDir_Sideways_Flying_Plane/ZNMF_CFJ_Airfoil.html

Applying Saw-Tooth

https://www.reddit.com/r/aviation/comments/6dn56x/mcdonnell_douglas_f4_phantom_ii/

Avro Canada CF-105



General characteristics

* Crew: 2
* Length: 77 ft 9 in (23.71 m)
* Wingspan: 50 ft 0 in (15.24 m)
* Height: 20 ft 6 in (6.25 m)
* Wing area: 1225 ft² (113.8 m²)
* Airfoil: NACA 0003.5 mod root, NACA 0003.8 tip
* Empty weight: 49,040 lb (22,245 kg)
* Loaded weight: 56,920 lb (25,820 kg)
* Max takeoff weight: 68,605 lb (31,120 kg)
* Powerplant: 2× Pratt & Whitney J75-P-3 turbojets
    * Dry thrust: 12,500 lbf (55.6 kN) each
    * Thrust with afterburner: 23,500 lbf (104.53 kN) each

Performance

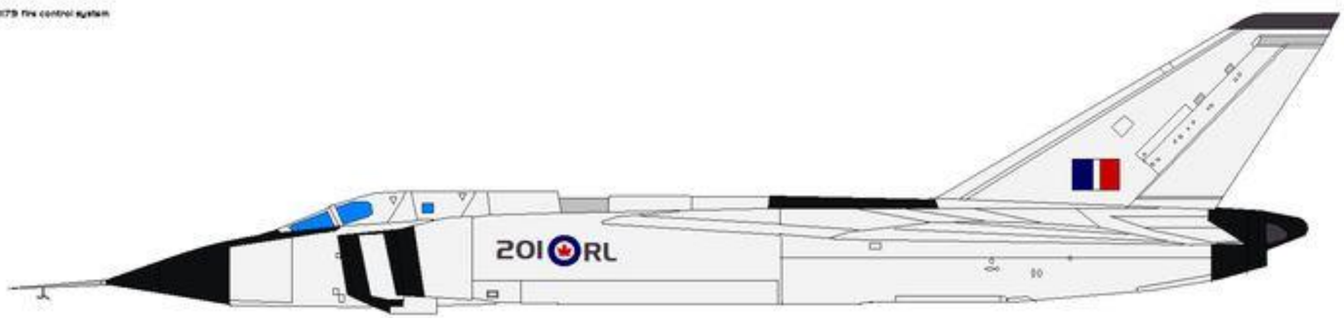
* Maximum speed: Mach 2 (1,307 mph, 2,104 km/h) at 50,000 ft (15,000 m)
* Cruise speed: Mach 0.91 (607 mph, 977 km/h) at 36,000 ft (11,000 m)
* Range: 360 NM (410 mi, 660 km)
* Service ceiling: 53,000 ft (16,150 m)
* Wing loading: 46.5 lb/ft² (226.9 kg/m²)
* Thrust/weight:
    * Dry: 0.439
    * With afterburner: 0.850

Armament (projected)

* Rockets: 1-4× AIR-2 Genie unguided nuclear rockets
* Missiles: 8× AIM-4 Falcon, Canadair Velvet Glove (cancelled 1956), 2 AIM-7 Sparrow II 2D active guidance missiles (cancelled)

Avionics

* Hughes MX-1179 fire control system



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Mach Number

Role in Compressible Flows

Glenn Research Center

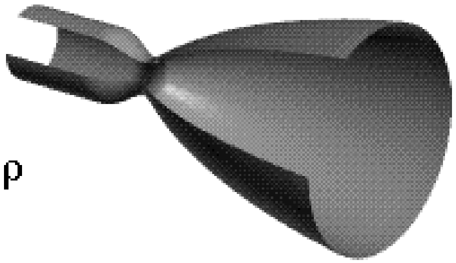
V = velocity
ρ = density

p = pressure
M = Mach

T = temperature
R = gas constant

a = speed of sound
γ = specific heat ratio

Conservation of Momentum: $\rho\ V\ dV = -\,dp$



Isentropic Flow: $\dfrac{dp}{p} = \gamma\,\dfrac{d\rho}{\rho}$

$$dp = \gamma\,\frac{p}{\rho}\,d\rho = \gamma\,R\,T\,d\rho$$

$$dp = a^2\,d\rho$$

Combine with Momentum: $\rho\ V\ dV = -\,a^2\,d\rho$

$$\boxed{-M^2\,\frac{dV}{V} = \frac{d\rho}{\rho}}$$

For subsonic flow (M < 1), density is relatively constant

For transonic flow (M ~ 1), density change is nearly equal to velocity change

For supersonic flow (M > 1), density changes faster than the velocity by a factor of M^2

Speed of Sound

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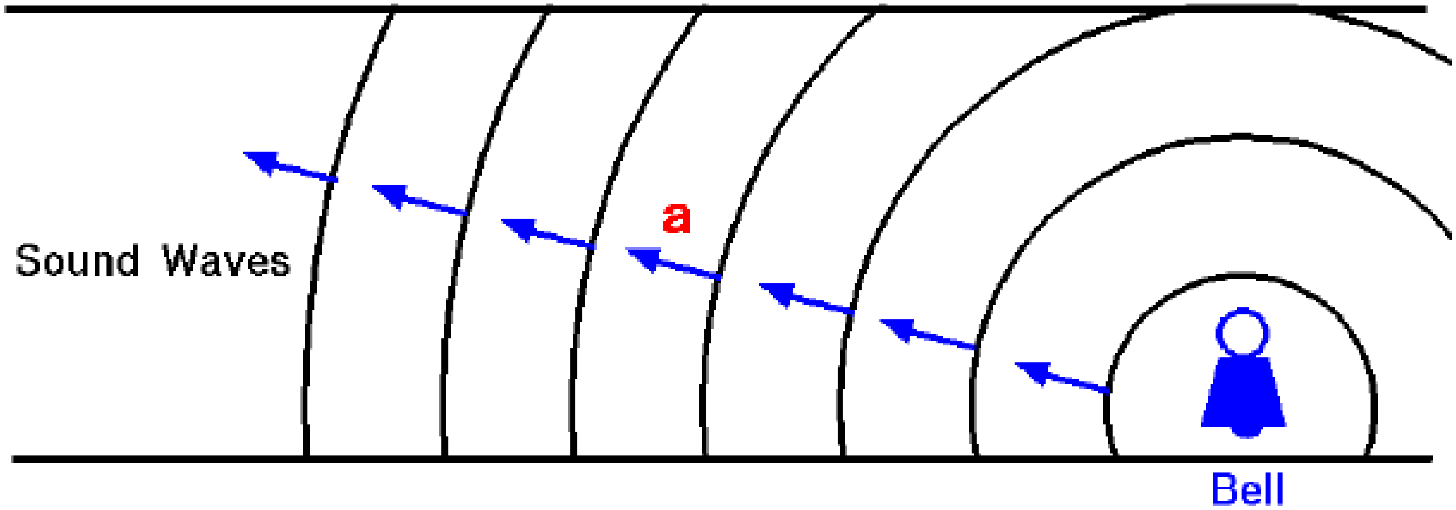


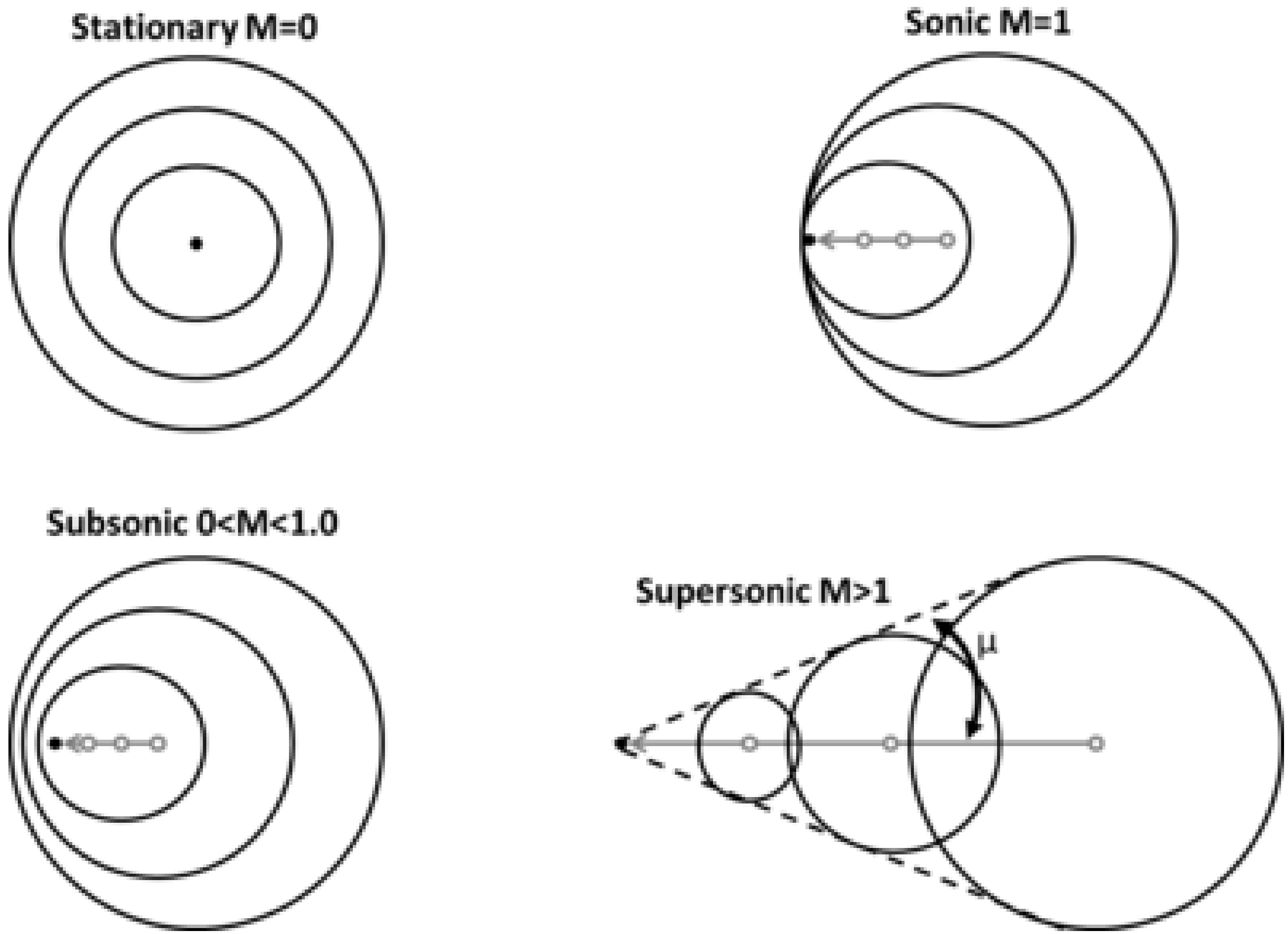
Speed of sound **(a)** depends on the type of medium and the temperature of the medium.

$$a = \mathrm{sqrt}\,(\gamma\ R\ \ T)$$

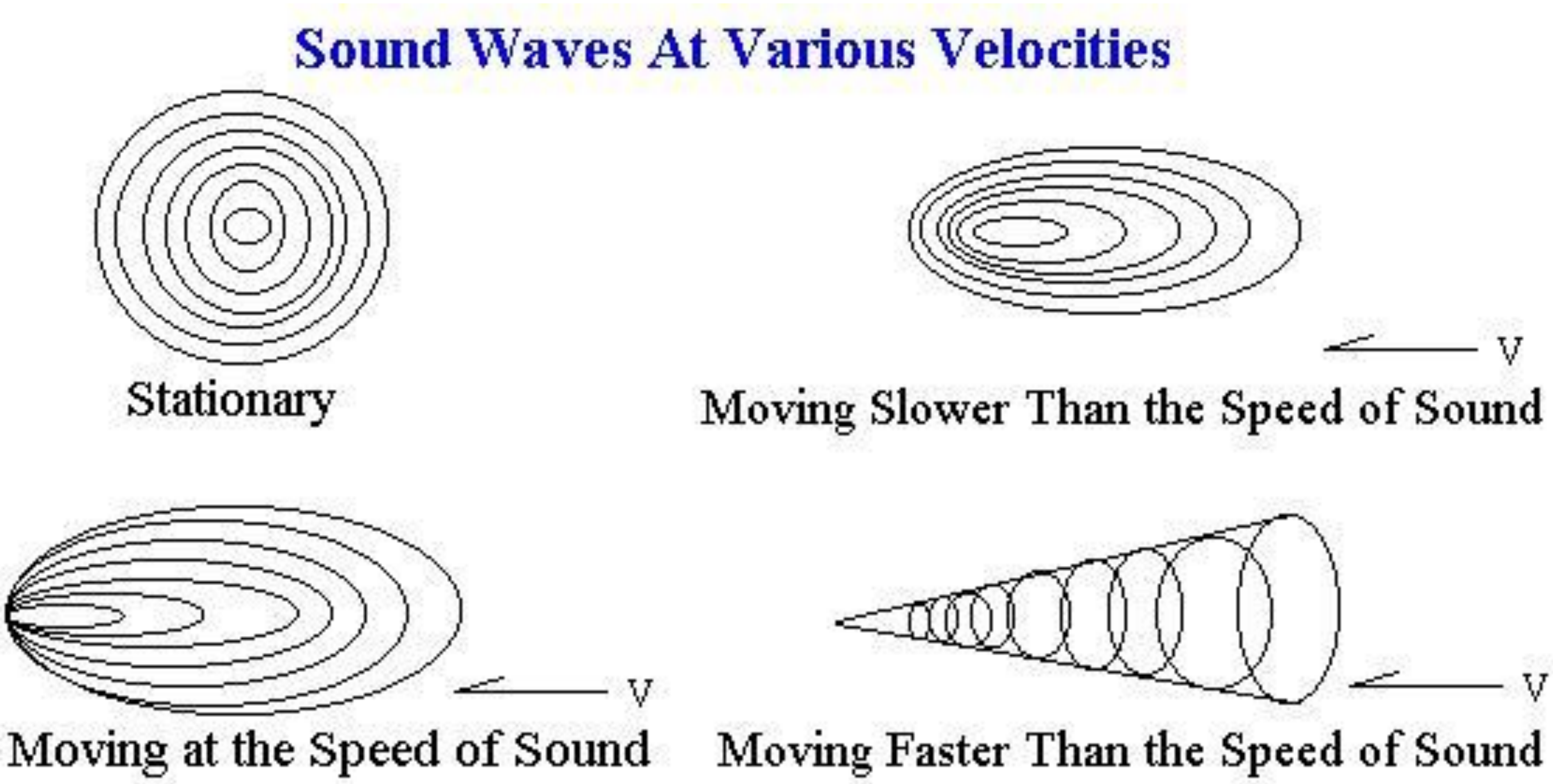
γ = ratio of specific heats (1.4 for air at STP)

R = gas constant (286 $m^2/s^2/K^o$ for air)

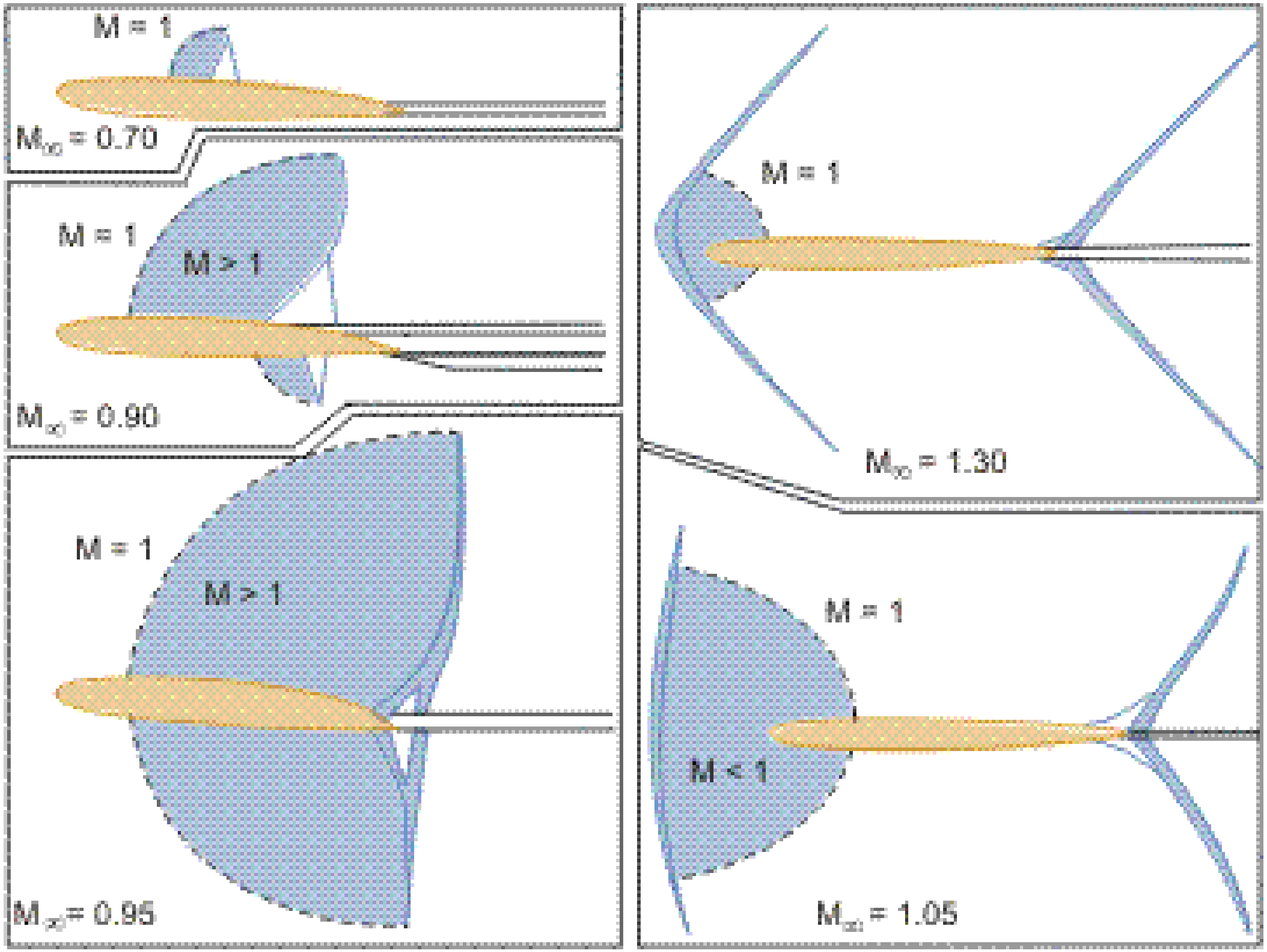
T = absolute temperature (273.15 + ^oC)



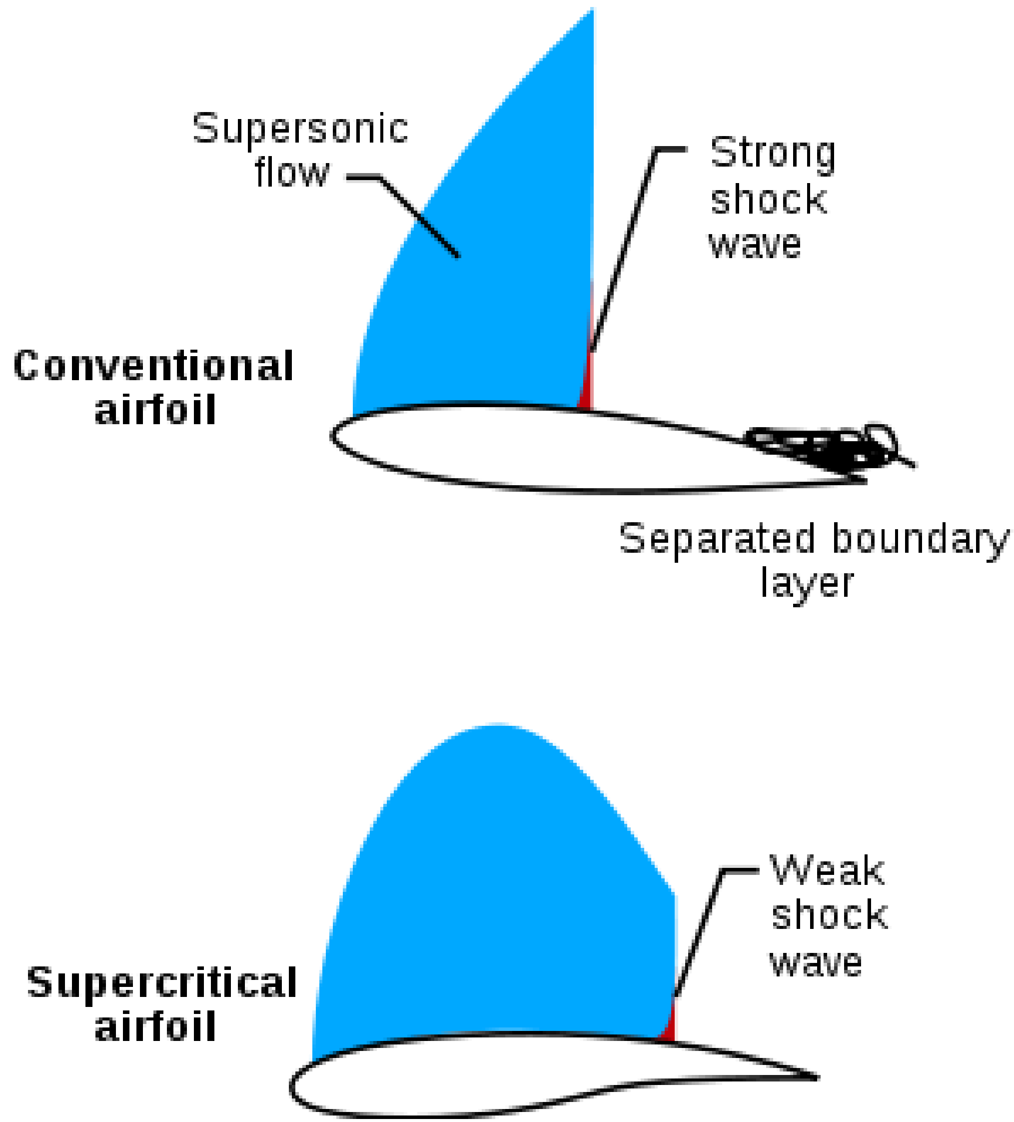
https://en.wikipedia.org/wiki/Compressible_flow



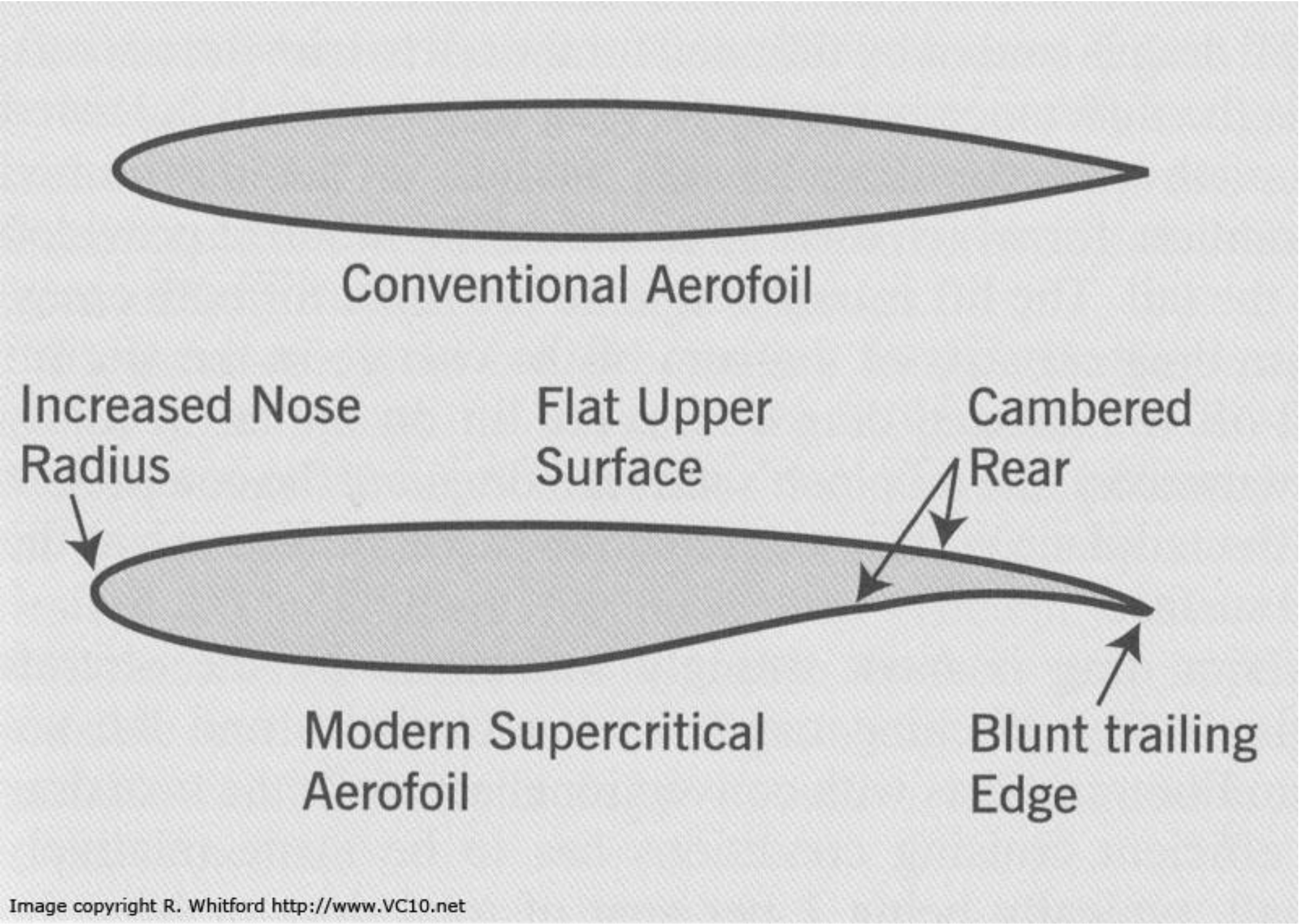
http://abyss.uoregon.edu/~js/space/lectures/lec04.html



http://www.thermopedia.com/content/646/

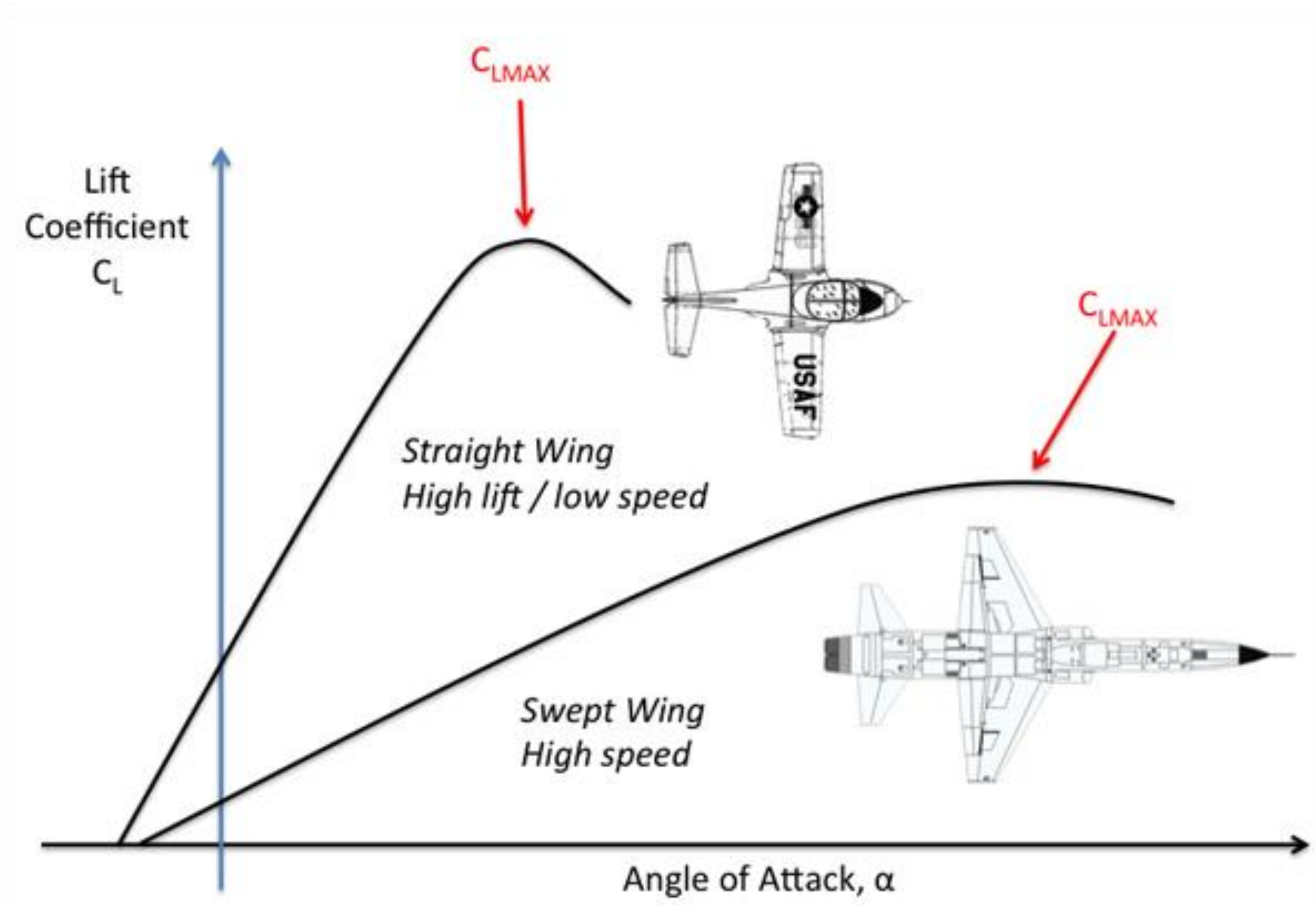


https://en.wikiversity.org/wiki/Aerodynamics_course:_Inviscid_and_compressible_flows



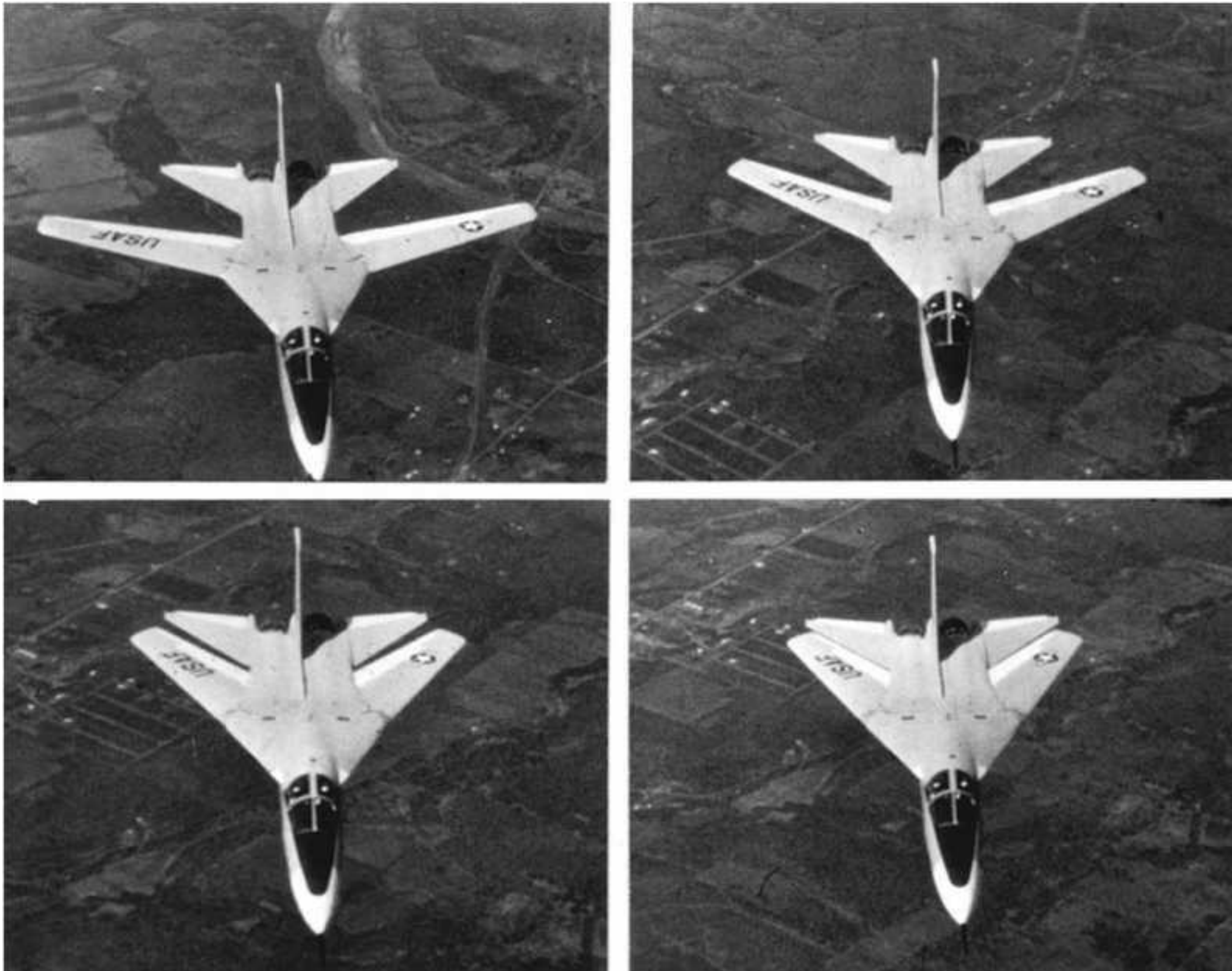
http://www.vc10.net/Technical/wing_shapes.html

https://www.flickr.com/photos/multiplyleadership/5299637305



https://aviation.stackexchange.com/questions/22757/what-is-the-reason-for-the-poor-low-speed-characteristics-of-sweptback-wings

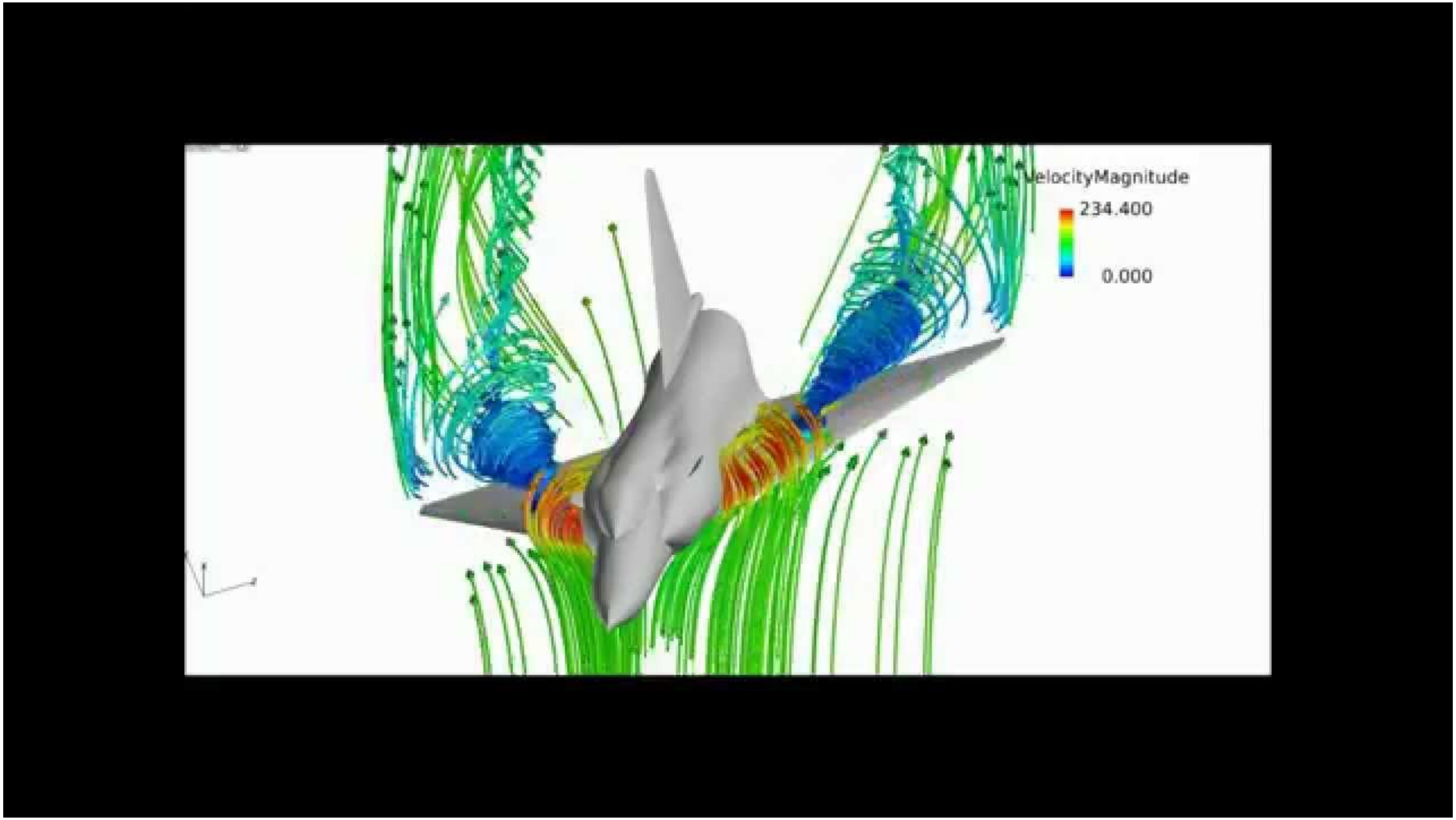
https://en.wikipedia.org/wiki/Swept_wing



http://aermech.com/variable-geometry-wing-design/

Delta Wing

http://www.ausairpower.net/Analysis-Typhoon.html



https://www.youtube.com/watch?v=S7V0awkweZc

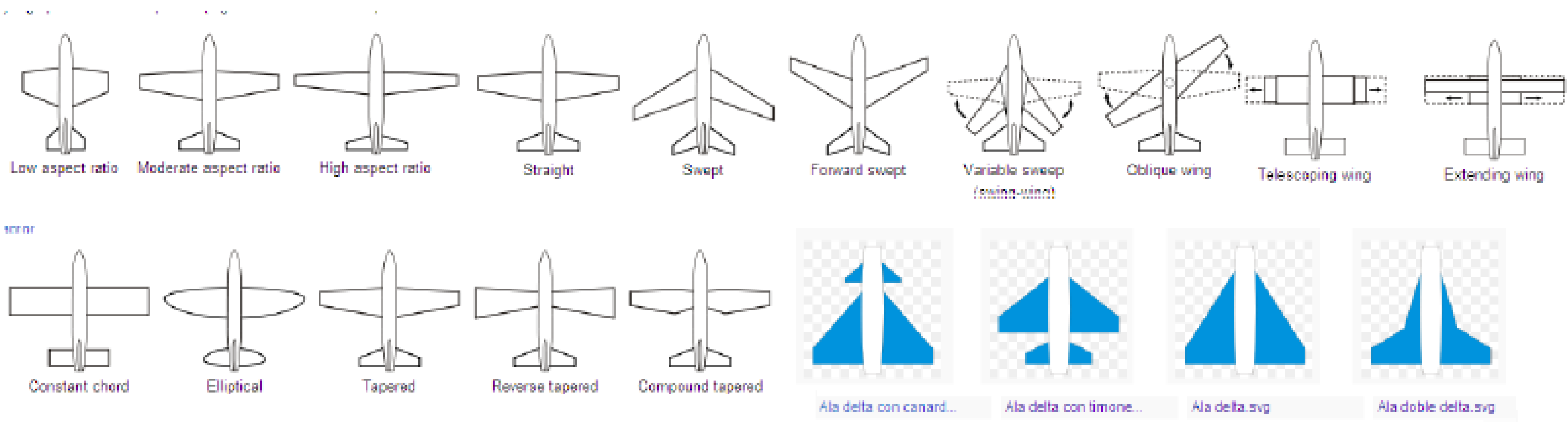
Ogee Wing

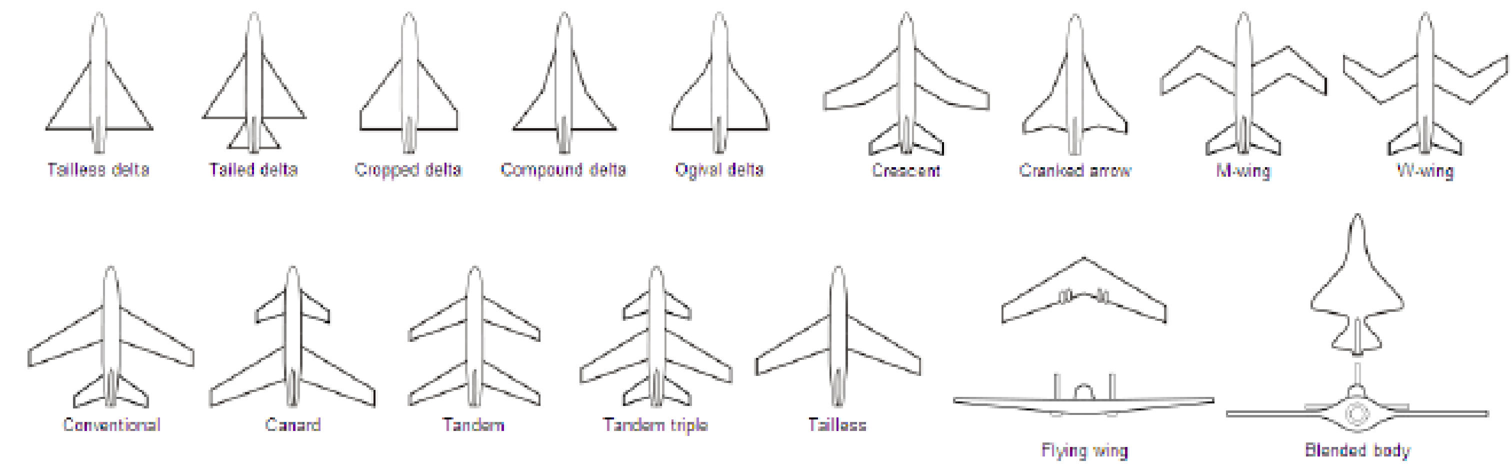
https://en.wikipedia.org/wiki/Supersonic_transport

Trapezoidal Wing

최신형 미군기에서 발견되는 특징이며 효율적인 초음속 비행을 수행할 수 있도록 구성되어 있다.
또한 날개 형상이 스텔스 기능에 매우 적합하다.
날개 하중이 높아 기동성이 떨어진다는 단점이 존재한다.
특히 선회력이 떨어지는데 과거와 같이 근접전을 벌일 필요가 없기에 가히 현존 최강의 전투기라 할 수 있다
(스텔스 기능에 고성능 레이더로 인해 미사일 트럭에서 좌표만 찍어주면 장거리에서 미사일이 날아가 내리 꽂는다)

https://en.wikipedia.org/wiki/Lockheed_Martin_F-35_Lightning_II
https://en.wikipedia.org/wiki/Lockheed_Martin_F-22_Raptor





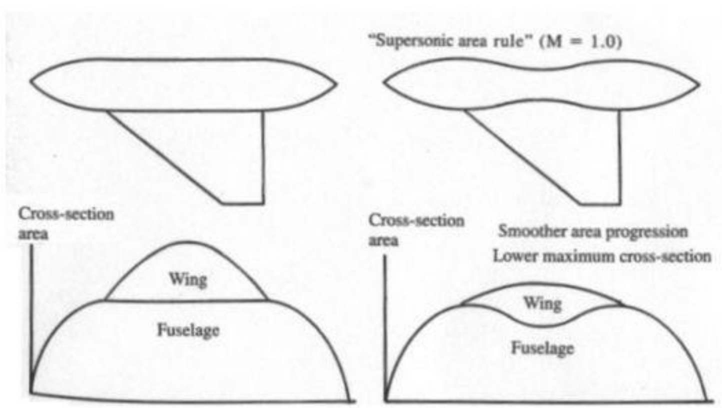
antibody

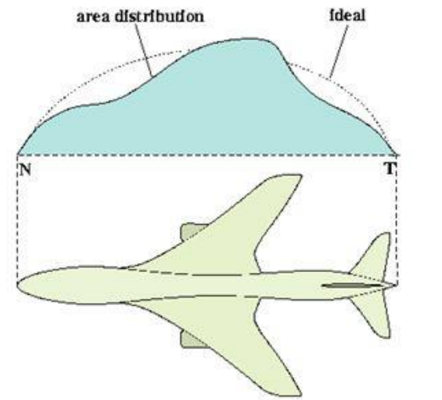
https://defence.pk/pdf/threads/design-characteristics-of-canard-non-canard-fighters.178592/page-2

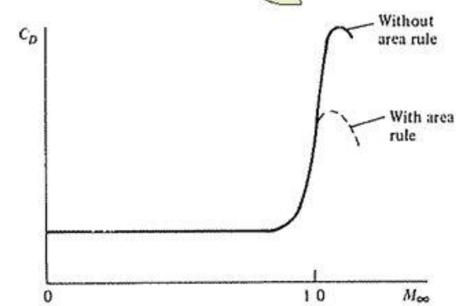
Area Rule

TRANSONIC AREA RULE

- Drag created related to change in cross-sectional area of vehicle from nose to tail
- Shape itself is not as critical in creation of drag, but rate of change in shape
  - Wave drag related to 2nd derivative of volume distribution of vehicle

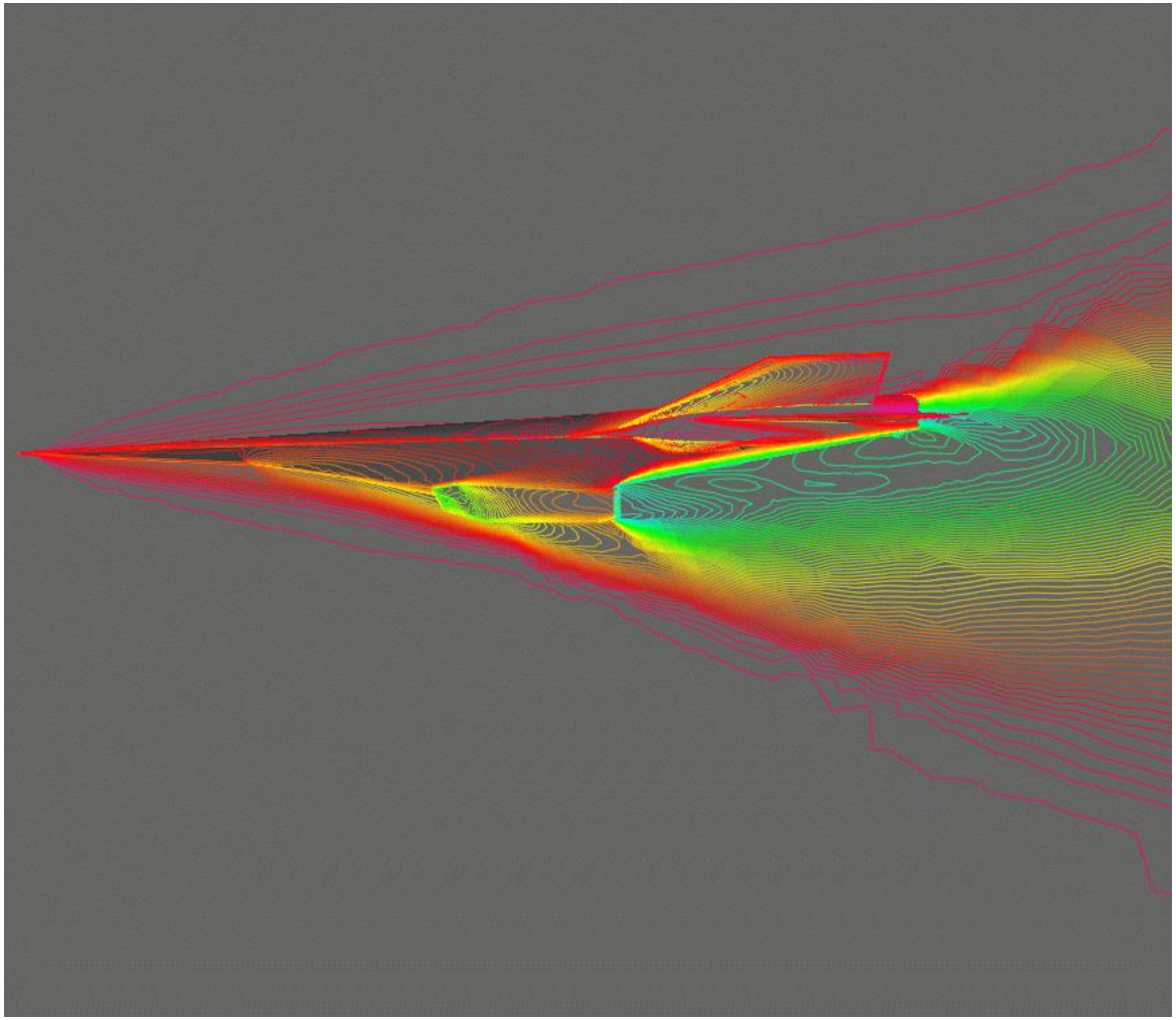






http://www.boldmethod.com/learn-to-fly/aerodynamics/area-rule/

Aerodynamic Heating on Hypersonic



https://cfd.gmu.edu/~rlohner/pages/pics/optimization.html