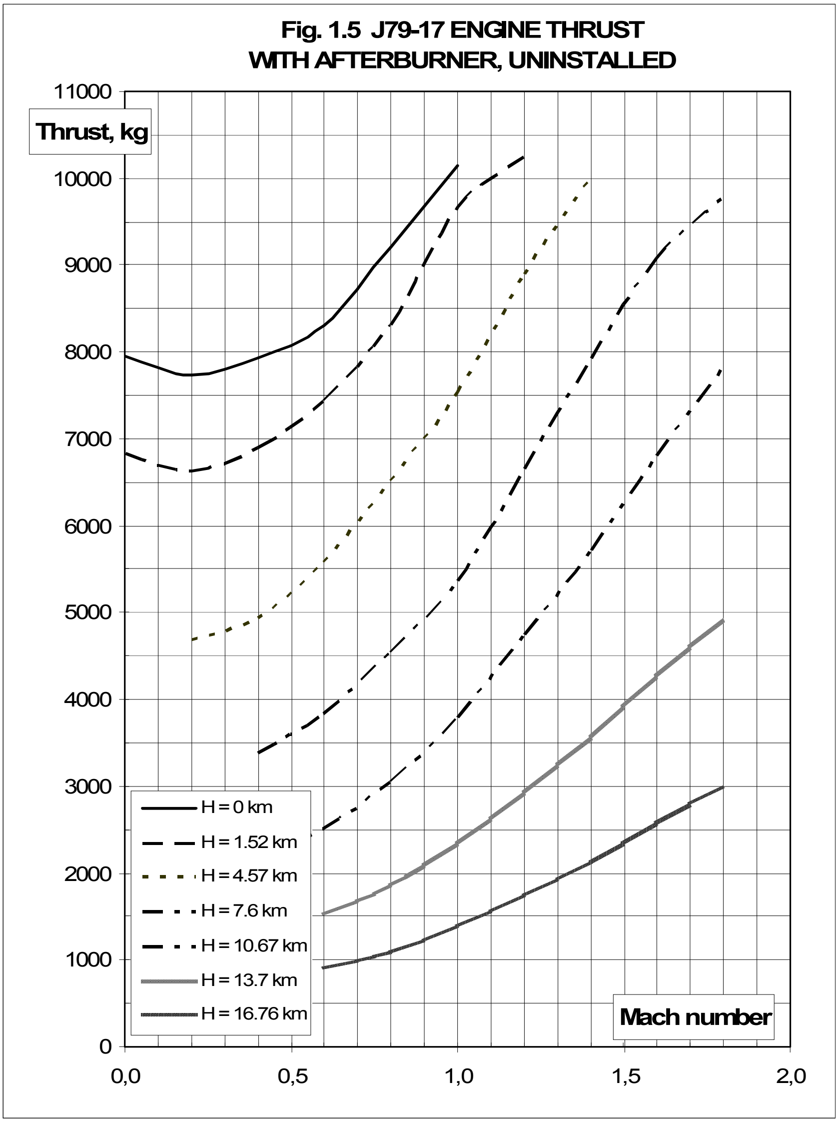
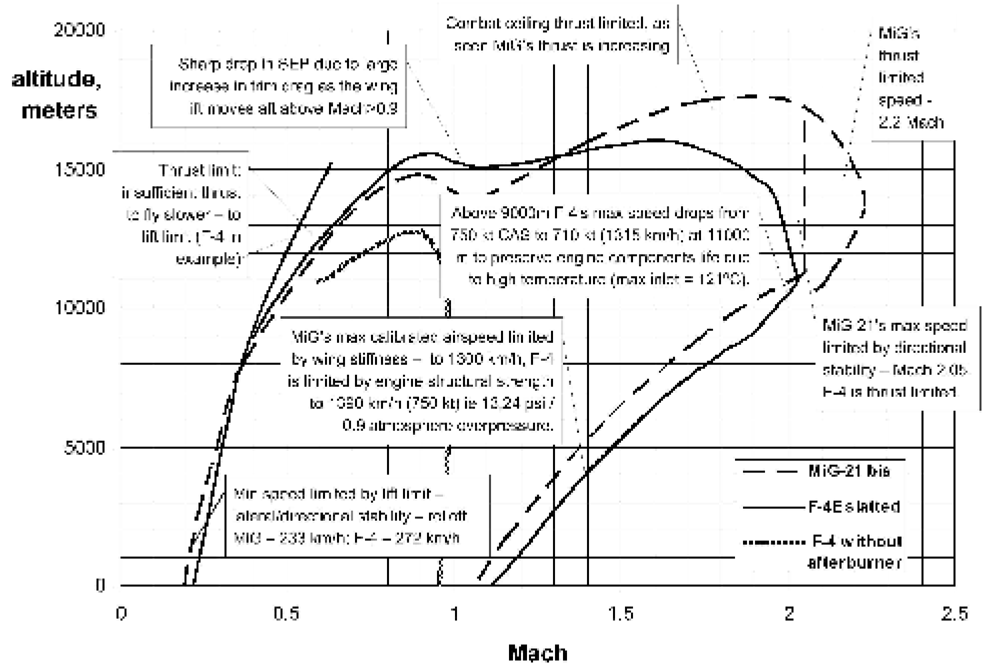


Fig. 1.5 J79-17 ENGINE THRUST
WITH AFTERBURNER, UNINSTALLED
Thrust, kg
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
H = 0 km
H = 1.52 km
H = 4.57 km
H = 7.6 km
H = 10.67 km
H = 13.7 km
H = 16.76 km
Mach number
0,0
0,5
1,0
1,5
2,0

Fig. 3.2 Flight envelope

International standard atmosphere,

F-4E with 4 AIM-7 weight 19400 kg / MiG-21bis with 2 IC AAMs weight 7500 kg (7000 supersonic)



6. Turn performance

As said, maneuverability is the ability to quickly change velocity vector, in other words, direction of flight and magnitude of aircraft speed.

Most missiles, having cruciform configuration (two pairs of wings and tails or without wings at all) can equally maneuver in any plane, without any bank angle. Since airplanes have wings in one plane, they can make significant turns only in one plane. Lateral turns with fuselage lift is possible but with not more than about 1.5 (g) load factor because of limited rudder (and aileron) control power and tail structural strength to trim that sideforce. Some of the most maneuverable missiles depend just on fuselage lift to turn at 30 g at high speed. At very high angle of attack body lift is significant as is vertical component of thrust which augments lift.

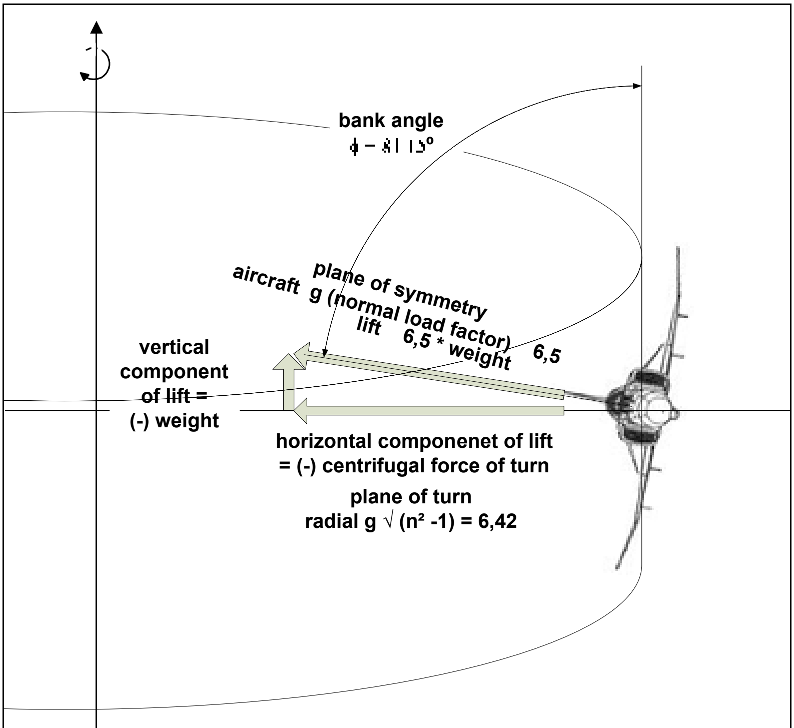
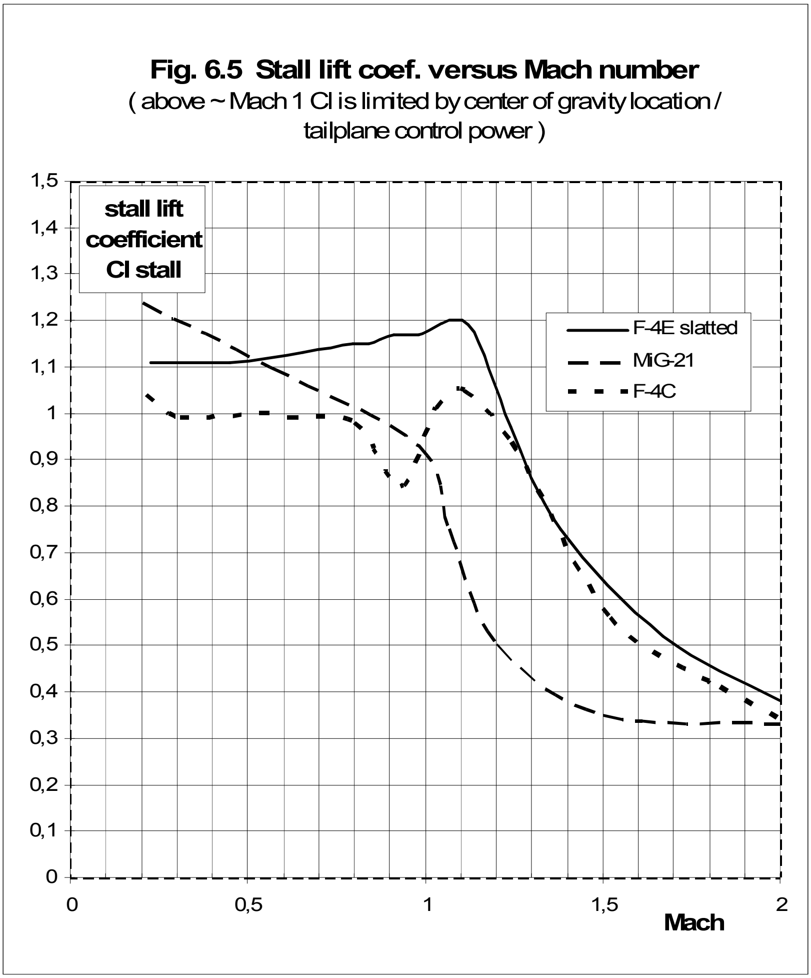


Fig. 6.1 Sample steady horizontal turn



Lift coefficient is used to cover wing form factor and the lift of other surfaces.

Stall can be defined as breakdown in dynamic directional stability.

Although static directional stability ($Cn\beta$) can be negative at 10-20º α depending on Mach number, directional (yaw) divergence and subsequent roll off may still not occur. When aircraft starts sideslipping, the lateral stability will produce rolling moment due to sideslip (and due to yawing velocity) which will develop opposing yawing moment due to rolling velocity (adverse yaw). In other words lateral stability could compensate the loss of directional stability depending on aircraft inertial and lateral-directional characteristics. The response of the aircraft to static directional instability would be Dutch roll combined rolling-yawing oscillation (rocking) which will not result in roll off if parameter related to the Dutch roll frequency referred to as $Cn\beta_{dynamic}$ or dynamic directional stability is positive.

$Cn\beta_{dyn}$ (dynamic directional stability) = $Cn\beta - (I_Z / I_X) * Cl\beta \sin \alpha$

($Cn\beta$, $Cl\beta$ – static directional and lateral stability; I_Z, I_X – aircraft moments of inertia about vertical and longitudinal axis)

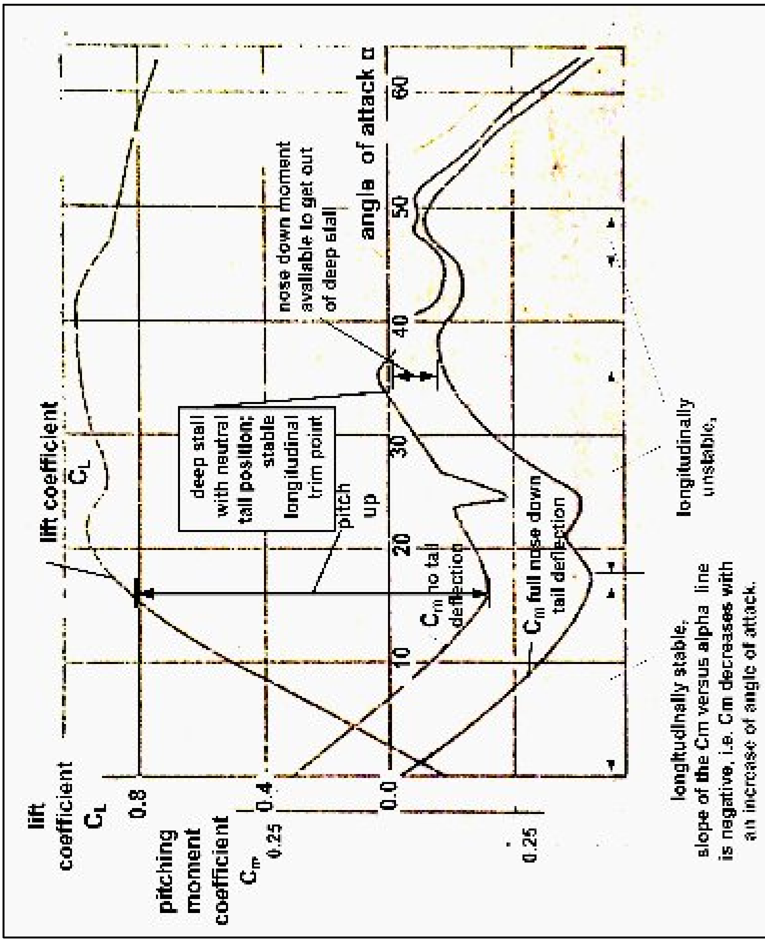


Fig. 6.6 Sample swept wing aircraft lift and pitching moment vs. angle off attack

At very high α the most important contributor to directional stability is nose (radome) shape. The depth to width ratio of the forebody and the curvature of the lower portion of the nose cross section determine whether vortex emanating from nose will be symmetrical.

Lift does not stop at stall angle of attack. Lift of supersonic configurations peaks at about 30-35º α and declines to zero at about 90º. Changes in longitudinal and lateral-directional stability are what defines max allowable angle of attack.

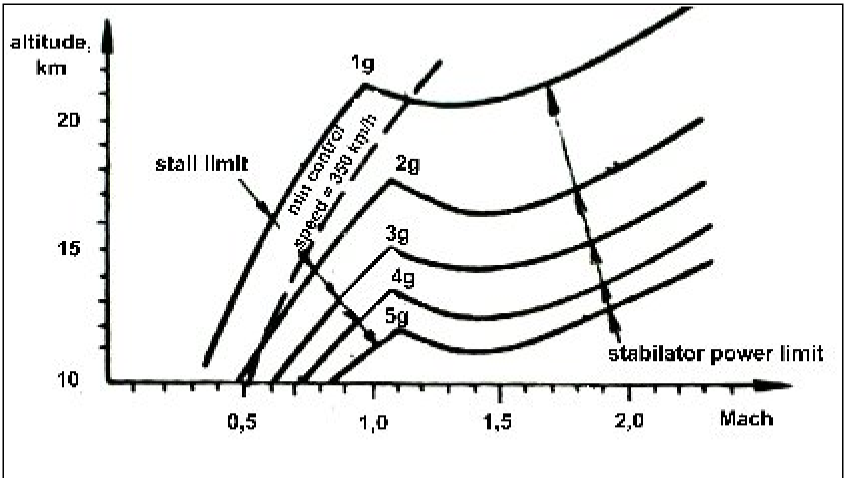


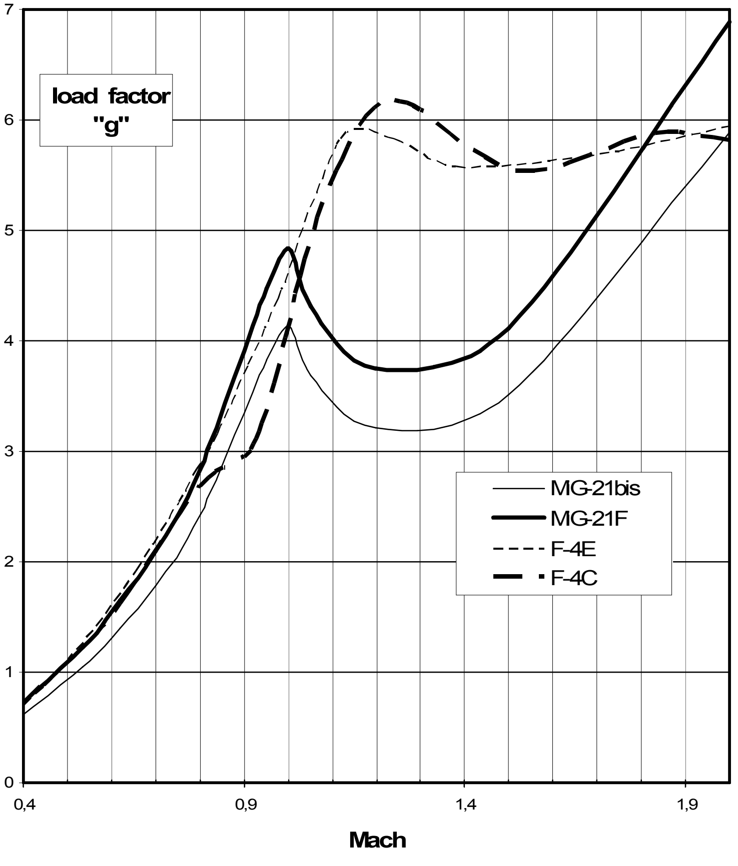
Fig. 6.7 MiG-21F-13 Instantaneous turn capability rough official diagram

Assuming max lift coefficient is constant, at double the stall speed, F-4E will be capable aerodynamically to produce two squared i.e. four g.
The speed which will result in limit load factor, when aircraft flies at max α is called maneuver speed or corner velocity.

Corner velocity = stall speed EAS * √(limit load factor)

For example: corner velocity of slatted F-4E: 265 km/h * √7.8 = 740 km/h (about 400 kt)
For comparison, air to air missiles of that age (AIM-9 or K-13) had stall speed of 420 km/h at Mach 2 and α < 10º (380 km/h at Mach 1.5) when motor burns out. Because of their proportional navigation laws that chase the predicted point of collision, large missile/target speed difference and the

Fig. 6.8 Instantaneous load factor, altitude 12 km
weight 1/2 fuel+2 IC AAMs, **max allowed angle off attack**



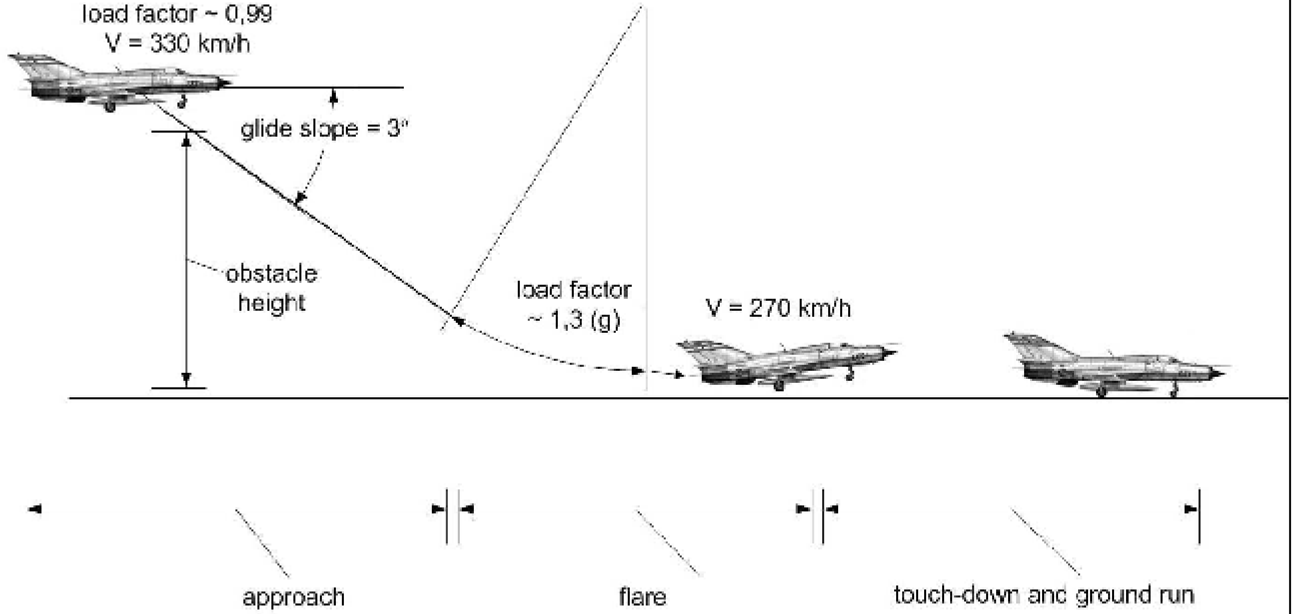


Fig. 8.1 Sample landing scenario (with flare)