F -22

Logan Thomas – Steve Pace – Zach Parson

General Dimensions of Interest

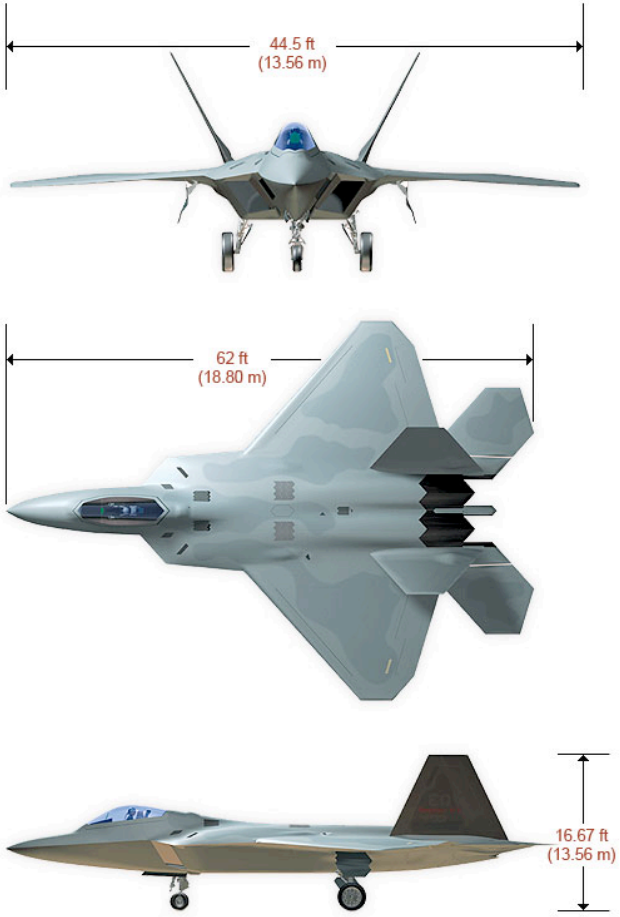
T/W = 1.26 (with .5 fuel), 1.08 (fully internally loaded), 0.84 (with external stores)
W/S = 66 to 98 lb/ft^2 (varies depending on mission)
MGTOW = 66000 lbs (standard stealth mode) 83500 lbs (with external tanks)
Fuel = 18000 lbs (or 26000 lbs with two fuel tanks)
Wempty = 31500 lbs

Span = 42.5 feet
Length = 62 feet, 1 inch
Wing Area = 840 feet^2
AR = 2.10
LE sweep = 42 degrees
Taper Ratio = 0.155

http://forcesdz.forumactif.com/armes-et-autres-materiels-f5/f-a-22-raptor-t1325.htm

Stealth

- Radar dependent on reflecting waves off of a surface top which they are nearly normal.
- Parallel lines minimize the number of angles normal to a surface of the airplane
- Curved surfaces reflect radar waves away from the receiver
- Varying radius of curvature creates fluctuating radar signatures, largely indistinguishable from static
- Chines prevent perpendicular reflection from the sides of the nose.
- No 90 degree angles
- S curve inlets to hide fan blades



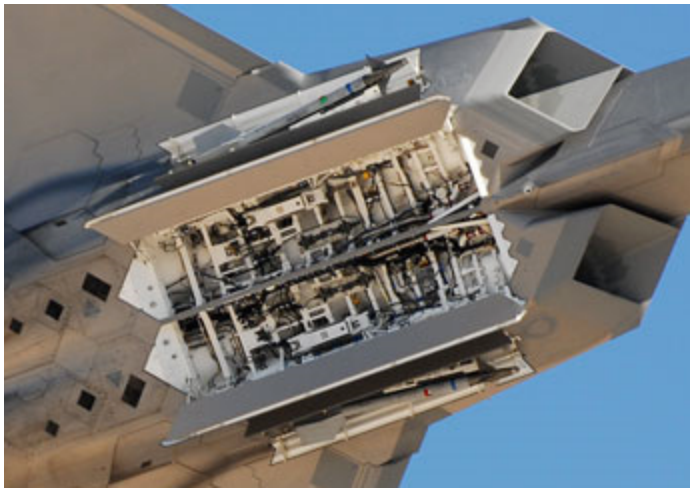
http://hillairshow.com/has_003.htm

Stealth (cont'd)

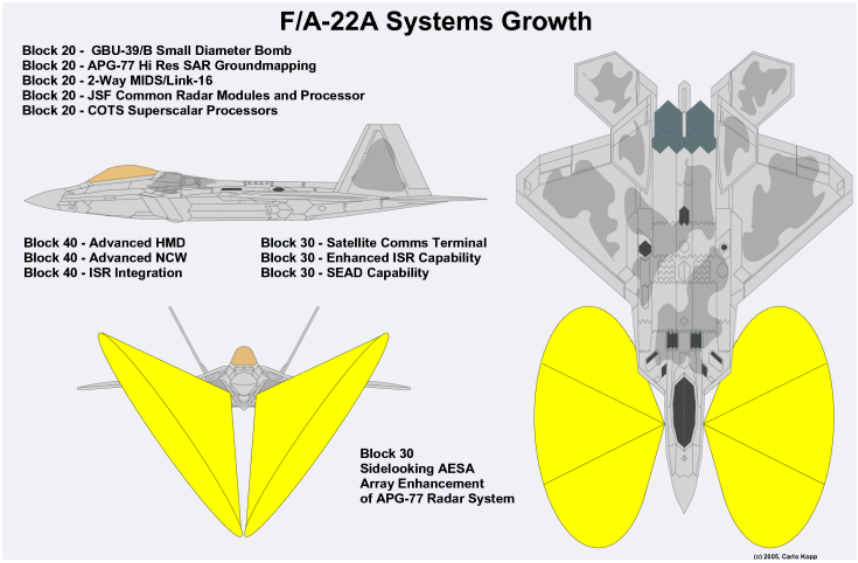
- "Sawtooth" edges on doors, effectively creating a wedge shaped edge for further wave reflection
- No external weapons

Additional Measures

- Specific materials absorb radar
- second skin creates interference
- Plasma stealth ionizes surrounding air
- Active signal cancellation creates interference

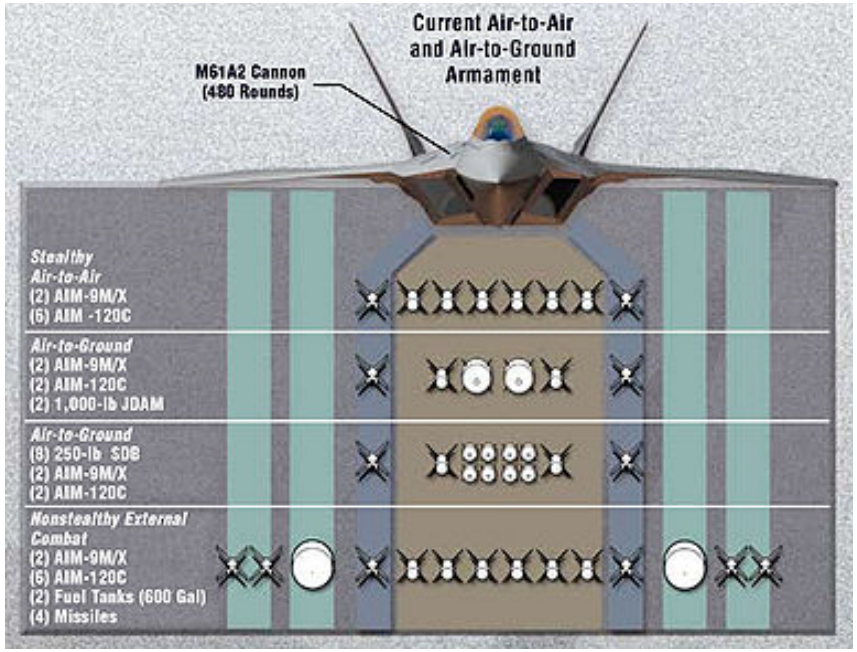


http://home.comcast.net/~bzee1b/Nellis08/F22/F22.html



http://forcesdz.forumactif.com/armes-et-autres-materiels-f5/f-a-22-raptor-t1325.htm

Mission: Dominate



- Knowing the major parameters of the F22 such as:
  - Takeoff Weight
  - Fuel Weight
  - Payload (Armament) Weight
  - T/W
  - W/S
  - Combat Radius (Range)

we can estimate its mission performance by running a mission program

- Used Engauge Digitizer to Measure area of F22 in 3-view drawing and estimate Swet of each component for input into Friction.M to get Cd0

- Input Cd0 vs alt vs Mach into RDS mission sizing module

- Engine Data:

  Tmax dry @ SL, : 25,000lbs sfc = 0.69

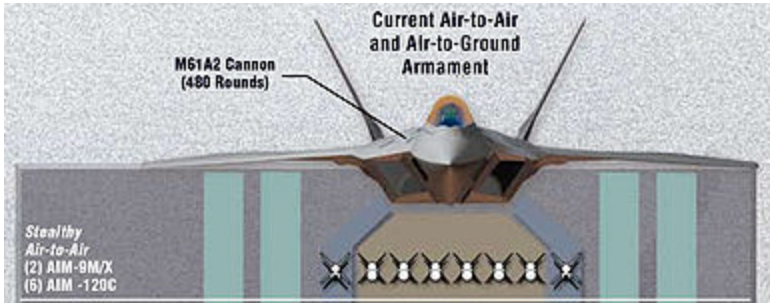
  Tmax afterburn : 35,000lbs sfc = 2.00

  Tmax dry @ 50kt @ M = 1.8 : 10000lbs sfc = 1.19

- Assume: CL max = 1.5

  Combat Radius = 500nmi

Mission: Air Dominance



MISSION SEGMENT	MISSION SEGMENT WEIGHT	Wi/WO	FUEL BURN (lbs-m)

F22.DAT SIZING/MISSION ANALYSIS FPS Units

MISSION FILE : f22ai2.DMS T/W = 0.952 W/S = 78.57
AIRCRAFT SIZING WITH FIXED-SIZE ENGINE RUBBER-ENGINE AIRCRAFT SIZING

Seg. 6	CRUISE :	1031.7 kts at	45000.0 ft	RANGE =	500.0 nmi
Seg. 10	CRUISE :	1031.7 kts at	45000.0 ft	RANGE =	250.0 nmi
Seg. 11	CRUISE :	515.9 kts at	40000.0 ft	RANGE =	250.0 nmi
Seg. 12	LOITER :	300.8 kts at	25000.0 ft	ENDURANCE =	0.2 hrs

TOTAL RANGE =	1000.0	TOTAL LOITER TIME =	0.17
FUEL WEIGHT =	17911.6	EMPTY WEIGHT =	31083.3
USEFUL LOAD (-Wf)=	17200.0	AIRCRAFT GROSS WEIGHT =	66194.9

Reserve & trap : 1013.9
Total fuel : 17911.6

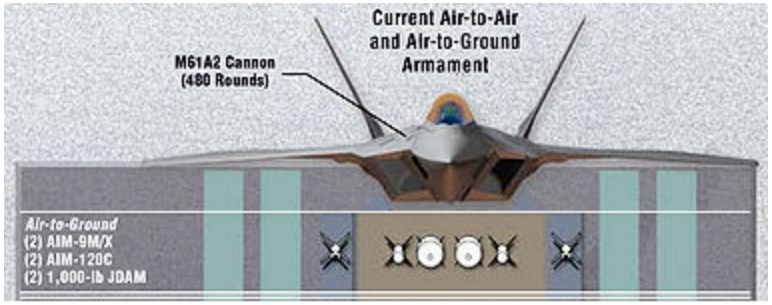
- Cruise h=40kft M = .9 R = 250nmi
- Loiter h = 25kft M = .5 E = 10min

#turns

M 1.8 Supercruise Performance : CL = .1065 Cdtotal = .0152 L/D = 7.00

M 0.9 Cruise Performance : CL = .2725 CDtotal = .0211 L/D = 12.9

Mission: Ground Attack



1. MISSION SEGMENT | MISSION SEGMENT WEIGHT / FRACTION OR DROPPED WEIGHT | Wi/WO | FUEL BURN (lbs-m) SEGMENT / TOTAL
2. F22.DAT SIZING/MISSION ANALYSIS — FPS Units
3. MISSION FILE : f22ground.dms — T/W = 0.995 W/S = 78.57
4. AIRCRAFT SIZING WITH FIXED-SIZE ENGINE — RUBBER-ENGINE AIRCRAFT SIZING
5. Seg. 5 CRUISE : 515.9 kts at 40000.0 ft RANGE = 250.0 nmi
6. Seg. 7 CRUISE : 1031.7 kts at 45000.0 ft RANGE = 250.0 nmi
7. Seg. 11 CRUISE : 1031.7 kts at 45000.0 ft RANGE = 250.0 nmi
8. Seg. 12 CRUISE : 515.9 kts at 40000.0 ft RANGE = 250.0 nmi
9. Seg. 13 LOITER : 300.8 kts at 25000.0 ft ENDURANCE = 0.2 hrs
10. TOTAL RANGE = 1000.0 — TOTAL LOITER TIME = 0.17
11. FUEL WEIGHT = 16277.0 — EMPTY WEIGHT = 29858.7
12. USEFUL LOAD (-Wf)= 17200.0 — AIRCRAFT GROSS WEIGHT = 63335.7
13. Total fuel : 16277.4

ni

ni

#turns

mi

50nmi

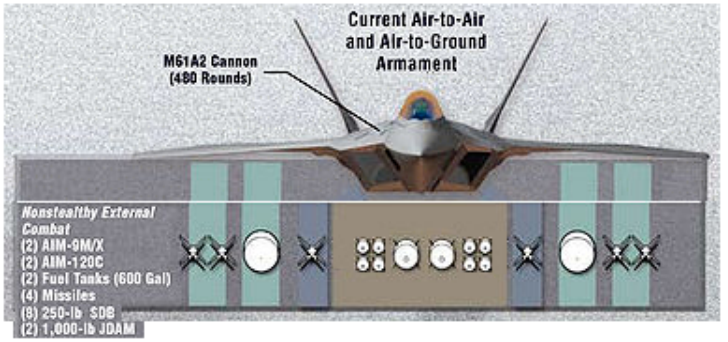
Loiter h=25kft M = .5 E = 10min

M 1.8 Supercruise Performance : CL = .100 Cdtotal = .0146 L/D = 6.79

Land

M 0.9 Cruise Performance : CL = .33 CDtotal = .0264 L/D = 12.5

Mission: Extended Range Supersonic Light Bomber



F22.DAT SIZING/MISSION ANALYSIS FPS Units

MISSION FILE : f22bombf.DMS T/W = 0.773 W/S = 78.57

AIRCRAFT SIZING WITH FIXED-SIZE ENGINE RUBBER-ENGINE AIRCRAFT SIZING

Seg. 6	CRUISE :	1031.7 kts at	45000.0 ft	RANGE =	800.0 nmi
Seg. 10	CRUISE :	1031.7 kts at	45000.0 ft	RANGE =	800.0 nmi
Seg. 11	LOITER :	300.8 kts at	25000.0 ft	ENDURANCE =	0.2 hrs

TOTAL RANGE =	1600.0	TOTAL LOITER TIME =	0.17
FUEL WEIGHT =	26736.1	EMPTY WEIGHT =	37557.5
USEFUL LOAD (-Wf)=	17200.0	AIRCRAFT GROSS WEIGHT =	81493.7

Reserve & trap : 1513.4
Total fuel : 26736.4

1.
2.
3.
4.
5.
6. nmi
7.
8. #turns
9. Climb/Accel h=15kft to 45kft M=0.9 to 1.8
10. Supercruise h=45kft M = 1.8 R = 800nmi
11. Loiter h=25kft M = .5 E = 10min
12. Land

M 1.8 Supercruise Performance: CL = .1068 Cdtotal = .0158 L/D = 7.01

RDS Field Length Performance

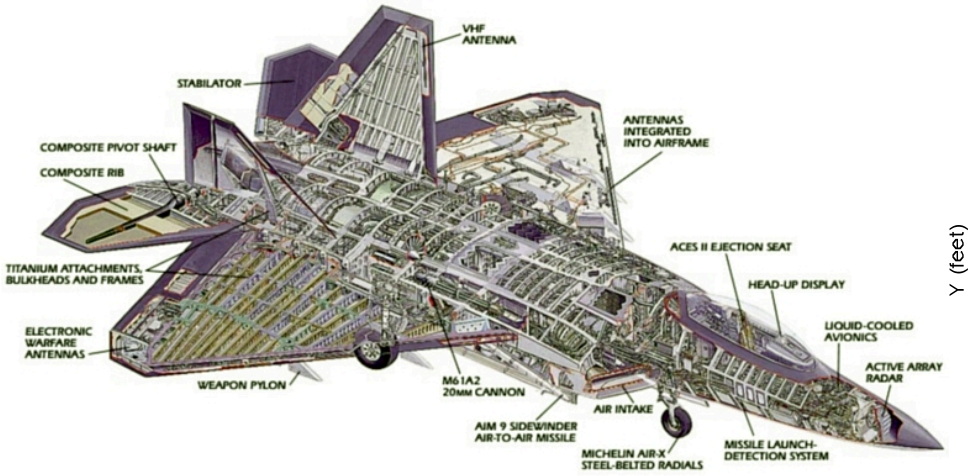
F22.DPA	2-LANDING
Wi/Wo or Wi	0.7200
ALTITUDE	0.0000
OBST HT	50.0000
BRAKING COEFF	0.1000
*CL-ground	0.2000
*CLmax-LND.	1.5000
BRAKE DELAY	1.0000
*GEAR δCd	0.0463
Vtd/Vstall	1.1000
BRAKING COEFF	0.1000

Takeoff Performance Input

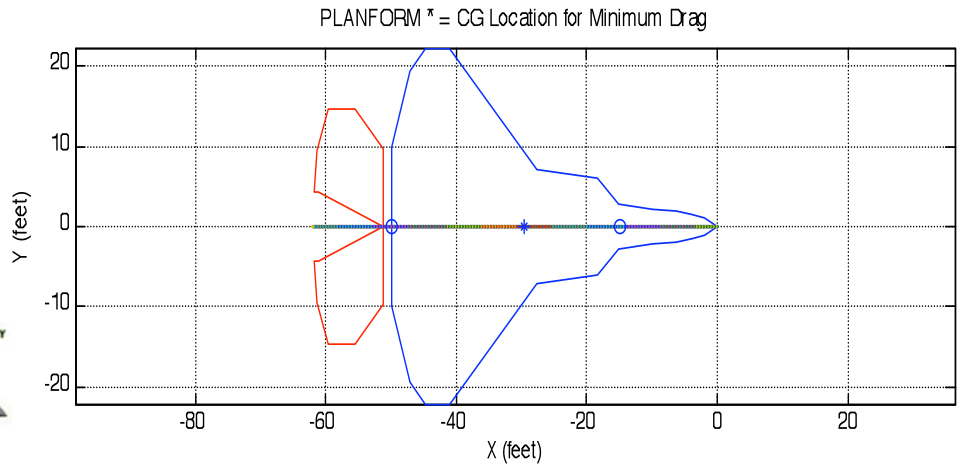
Landing Performance Input

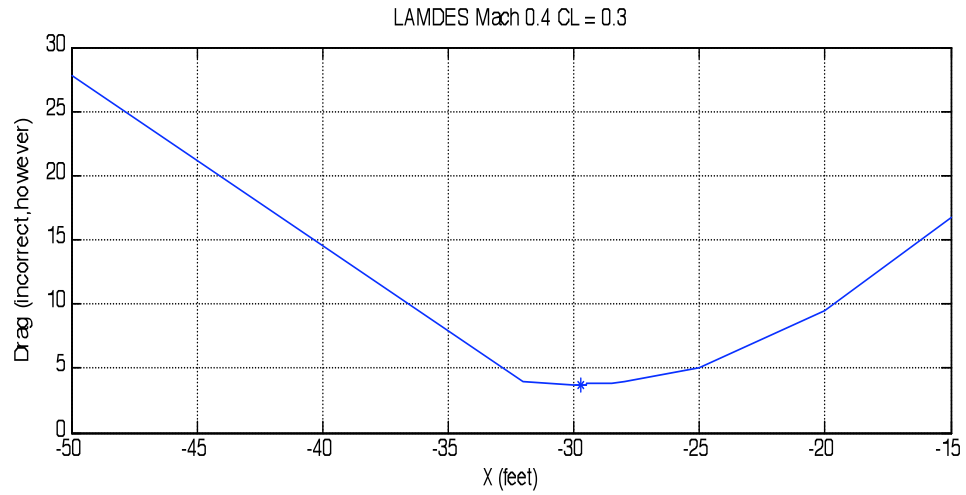
```
2  LANDING
        AIRCRAFT OPERATING WEIGHT     (Wi) =   47520.0
  AIRCRAFT OPERATING WEIGHT RATIO  (Wi/WO) = 0.720
  ROLLOUT  THRUST-TO-WEIGHT RATIO    (T/W) = +0.000
               LANDING WINGLOADING  (W/S) =  56.57
              Vstall = 105.47 kts
           Vtouchdown = 116.02 kts
            Vapproach = 121.29 kts

             APPROACH ANGLE = -3.00  (deg)
              APPROACH  CD0 =  0.0526
                        CL =  1.35
                         K =  0.3245
                 APPROACH L/D =  2.41
-------------------------------------------------
             APPROACH DISTANCE =    782.9
                FLARE DISTANCE =    342.6
     TOTAL IN-FLIGHT DISTANCE =   1125.6
        FREE GROUND ROLL DIST =    196.0
              BRAKING DISTANCE =   5139.5
   TOTAL GROUND ROLL DISTANCE =   5335.4
    NO-FLARE LANDING DISTANCE =   6289.5
       TOTAL LANDING DISTANCE =   6461.0
FAR PART 25 LANDING DISTANCE =  10768.3
```

LAMDES Calculations



http://img165.imageshack.us/img165/6264/f22acutaway3sto0.jpg

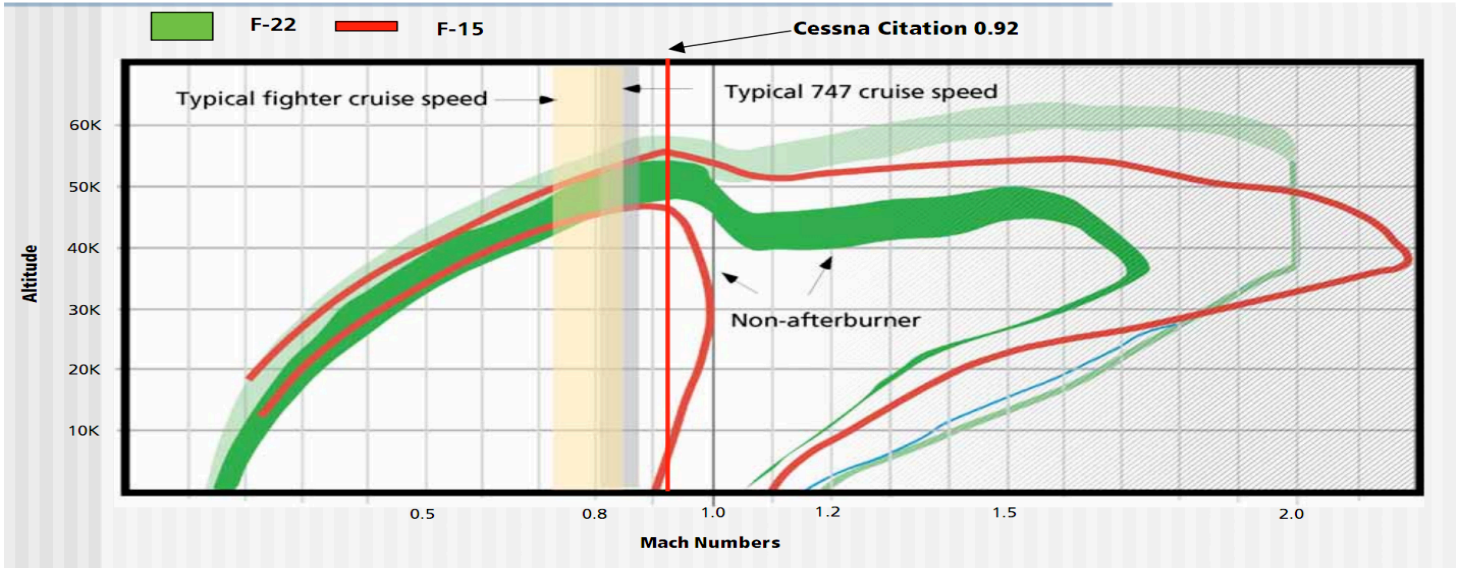


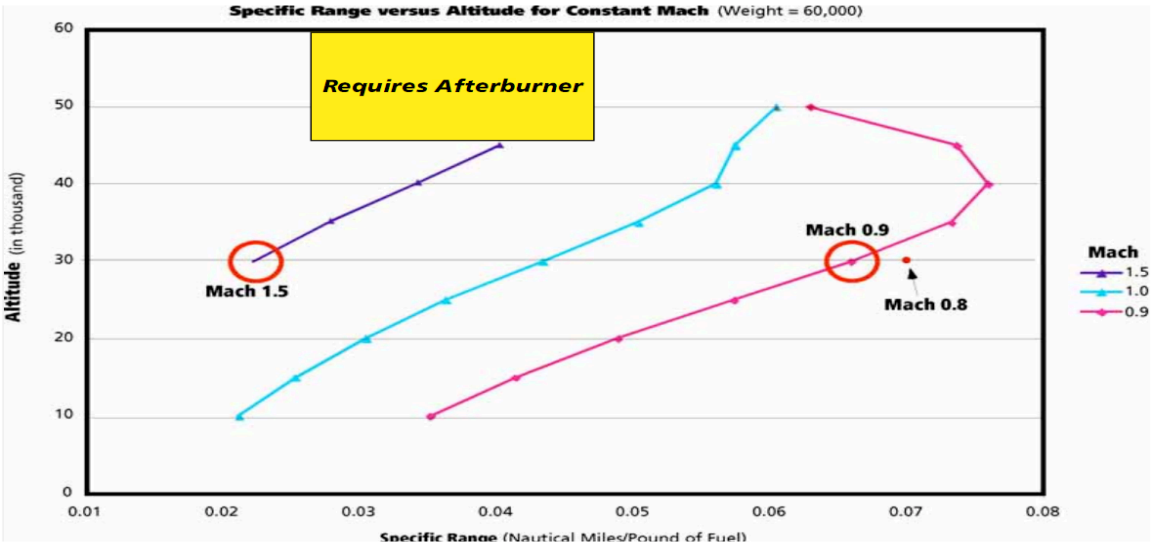


Should add -10 feet to account for fuselage. This puts CG for min drag at 39.5 feet from the apex of the aircraft

F-22 Performance

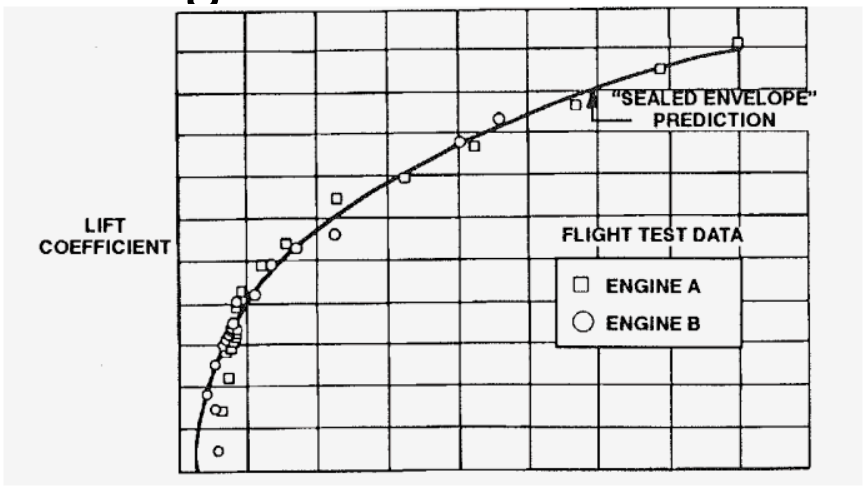
*www.cdi.org/pdfs/**stevenson**%20**f-22**%20brief.pdf*





More Published Performance Data

Drag Polar Mach 0.9



AIAA 92-53999

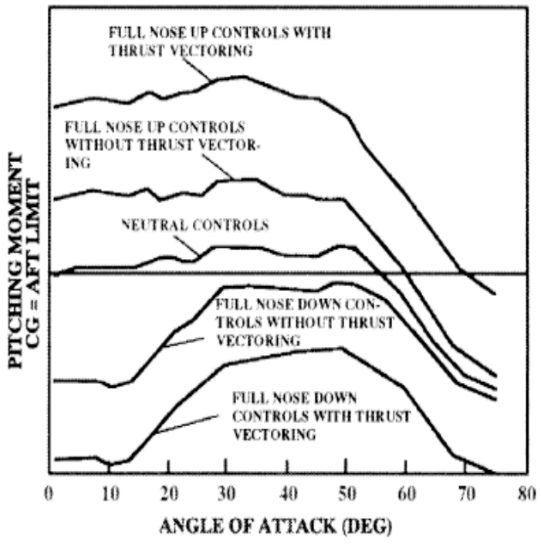


Figure 8. Pitching Moment vs. Angle of Attack

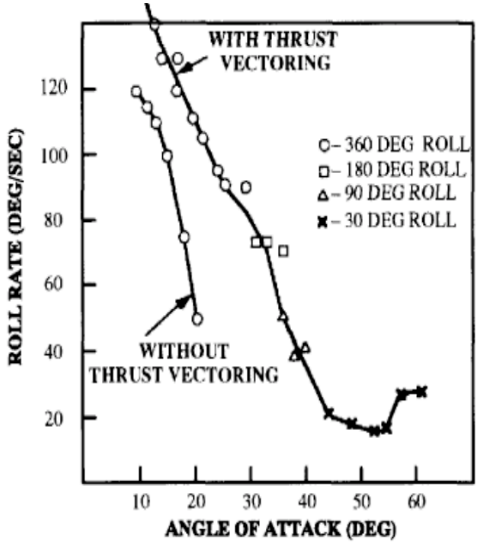
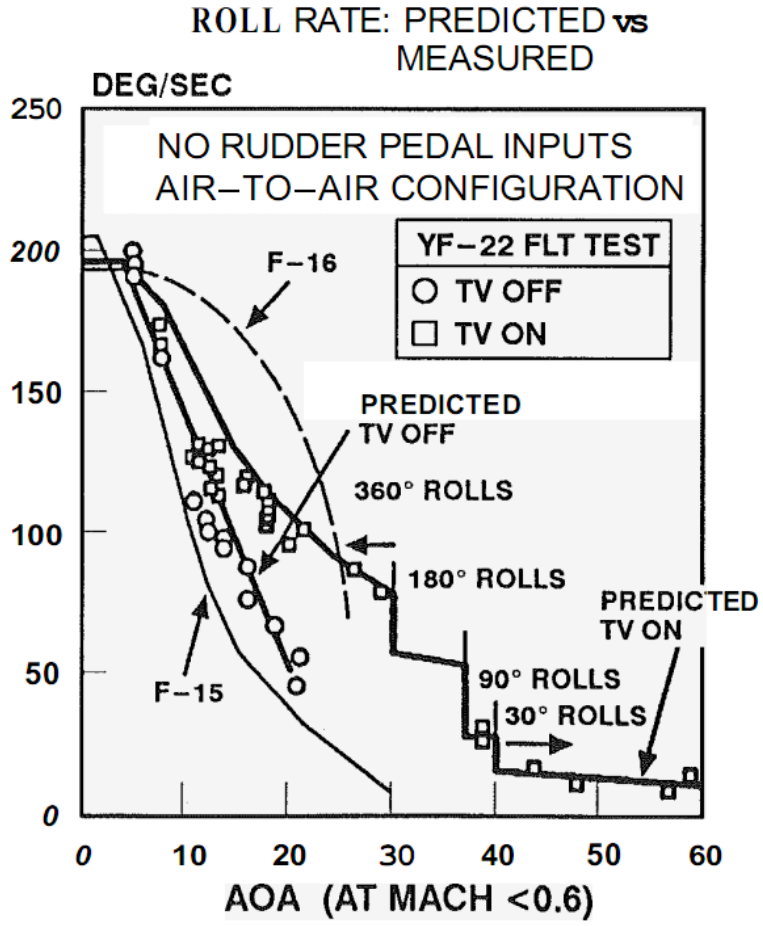


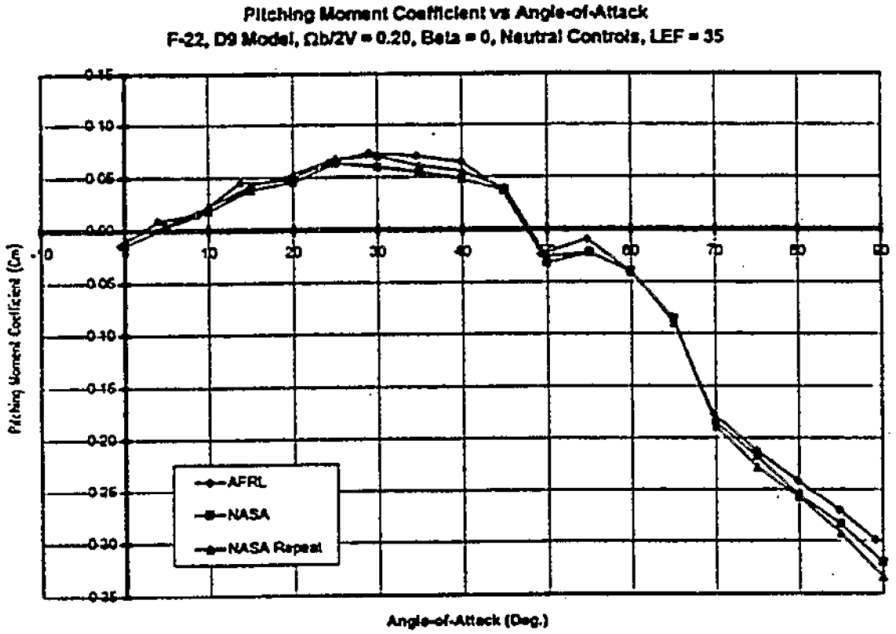
Figure 12. YF–22 Roll Rate vs. Angle of Attack

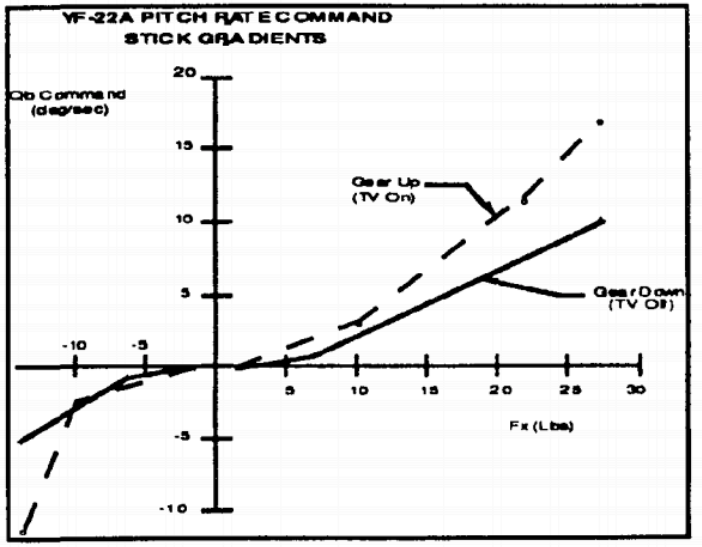
AIAA 2105-832

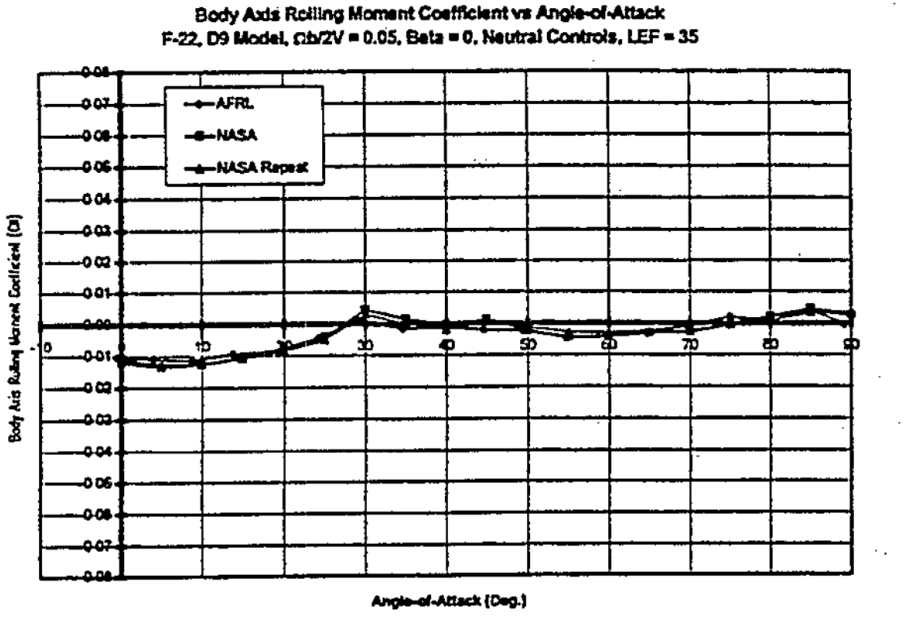


AIAA 92-5399

Some Performance Plots



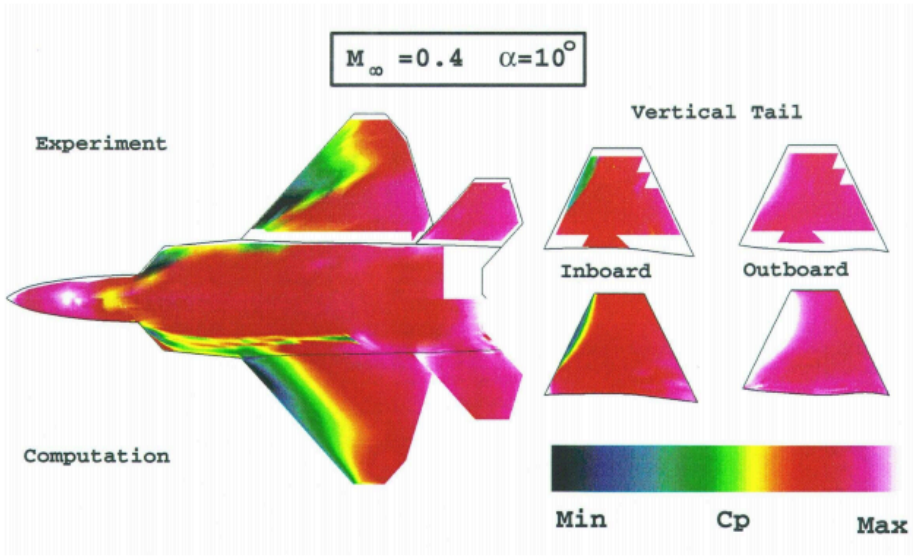


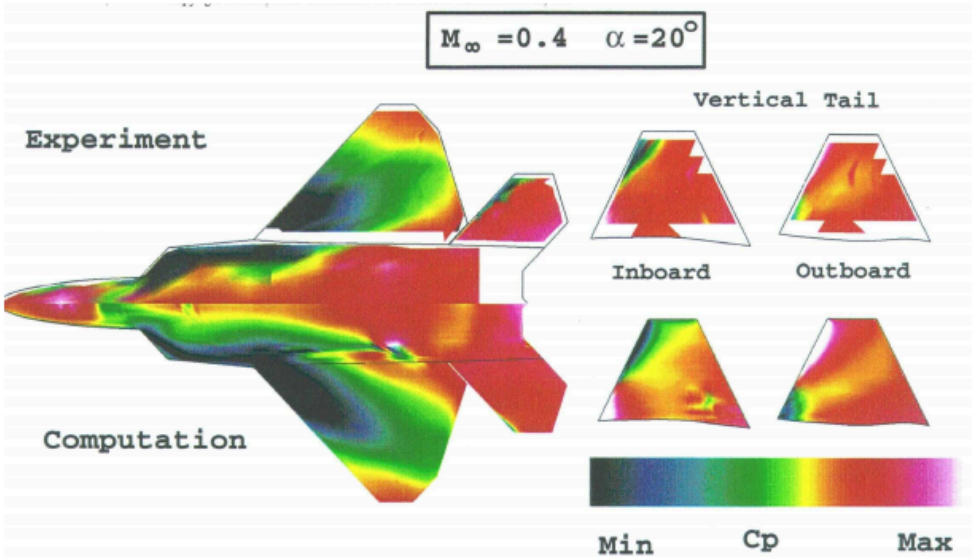


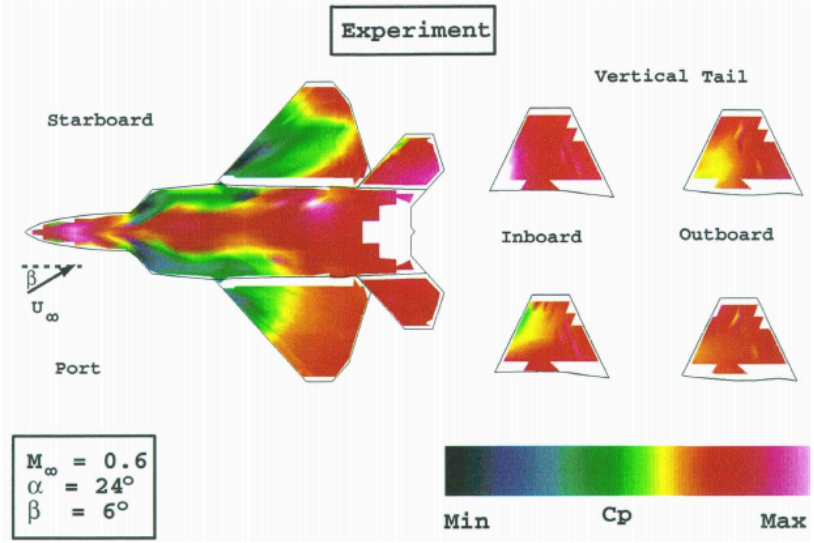
Above: Pitching Moment vs AoA
AIAA 99 4015
Top Right: Pitch Rate vs Stick Force
AIAA 96-3379
Left: Rolling Moment vs AoA
AIAA 99-4015

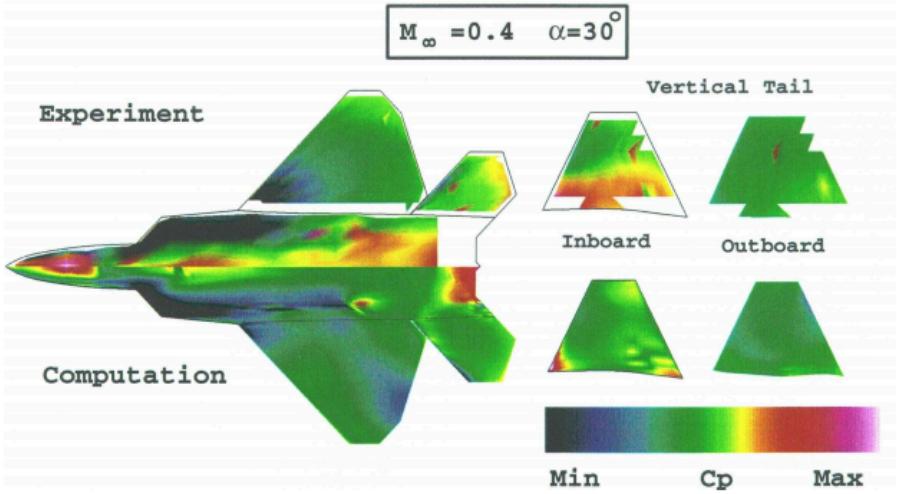
Computational Simulation of the F-22

AIAA 1997 Josyula & Gordnier









Front CFD

Computational Simulation of the F-22
AIAA 1997 Iosyula & Gordnier

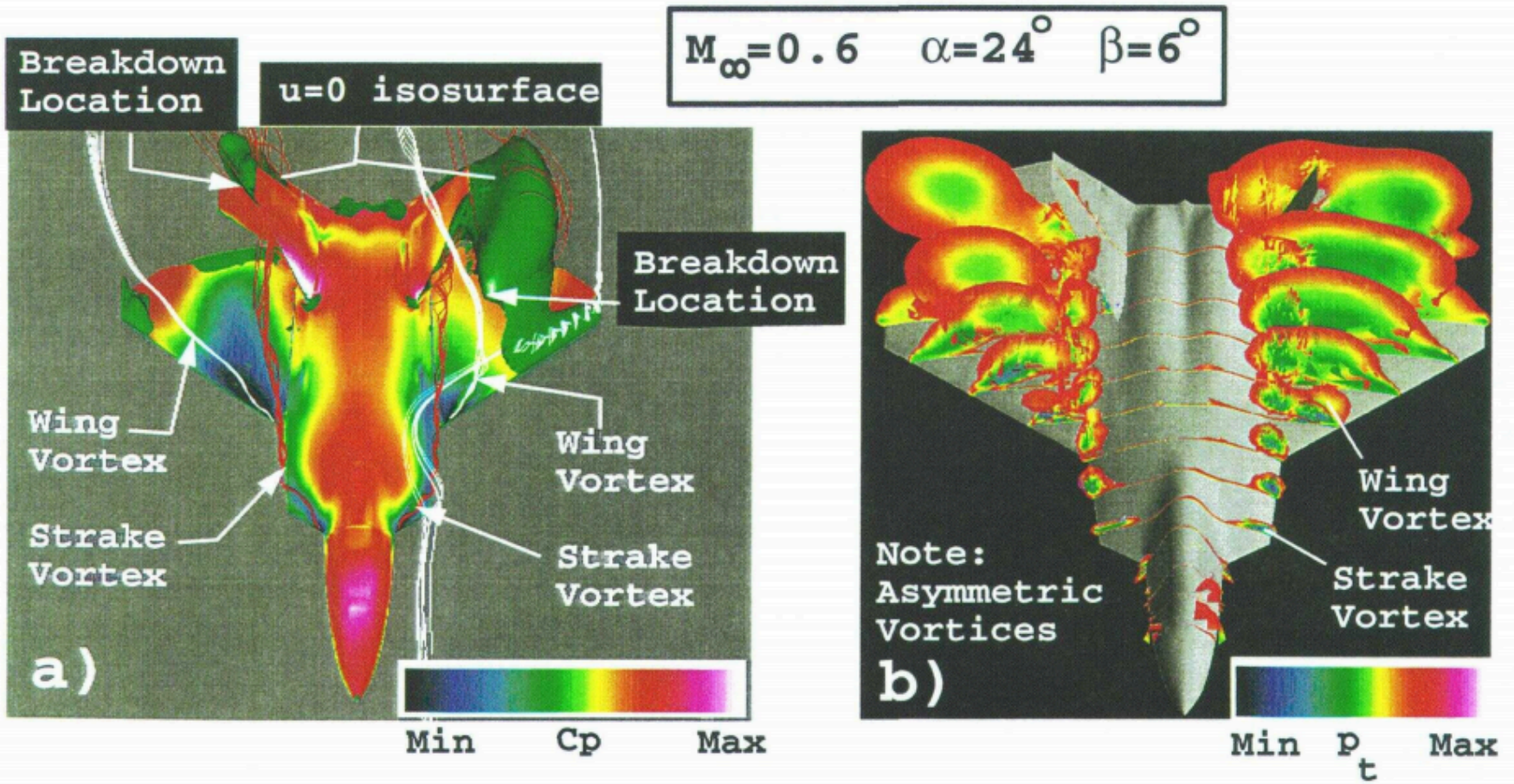


Figure 9a Top View of Particle Traces, Surface Pressure, and 3D Representation of Vortex Breakdown

Figure 9b Stagnation Pressure Contours

Typical Fight Manuevers

AIAA 91-3170

$\dot{\psi} = g(n-1) / V$ (equation 5)

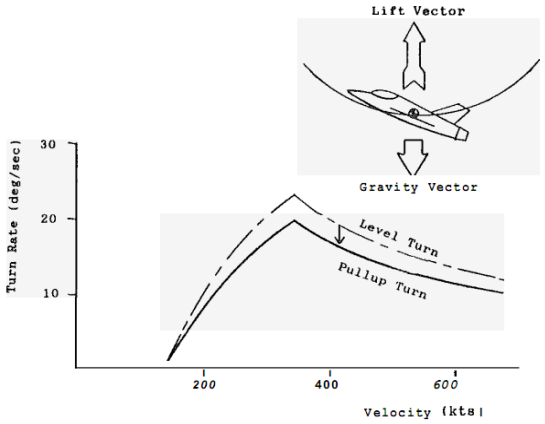


fig 6. Effect of Gravity - Pullup Turn

$\dot{\psi} = g(n+1) / V$ (equation 4)

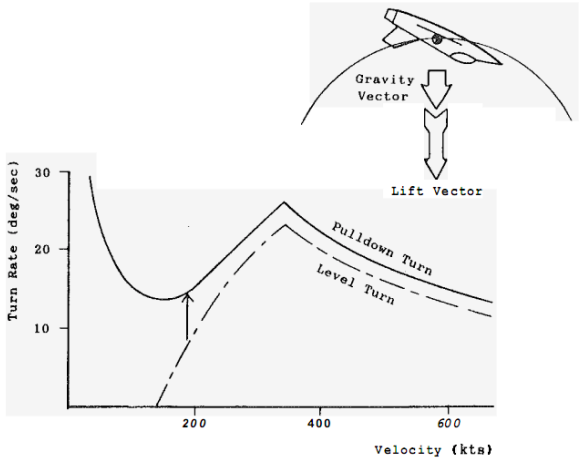


fig 5. Effect of Gravity - Pulldown Tu

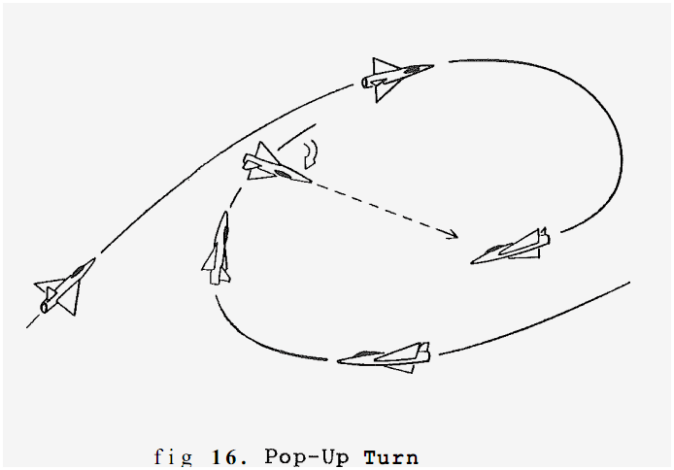


fig 16. Pop-Up Turn

$\dot{\psi} = g(n) / V$ (equation 6)

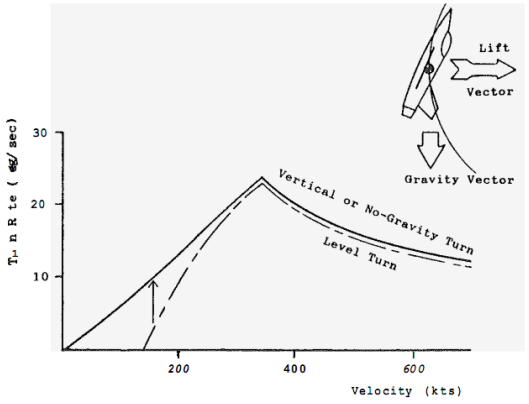


fig 7. Vertical Turn

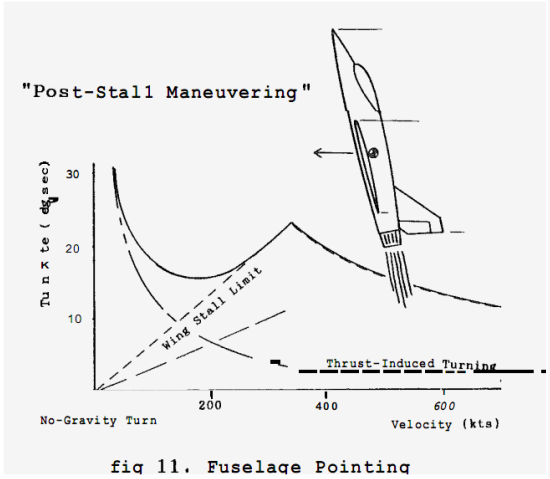


fig 11. Fuselage Pointing

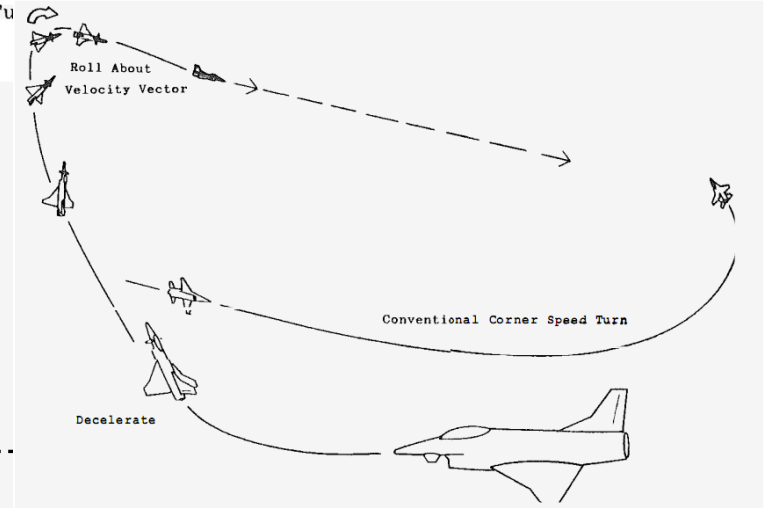
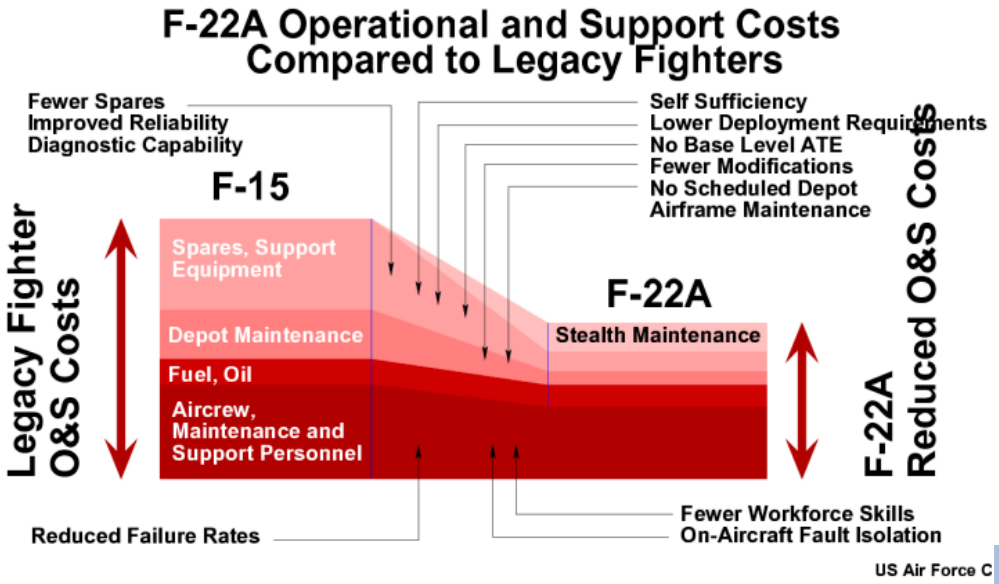


fig 17. X-31 Supermaneuver

Some Cost Analysis♪



http://forcesdz.forumactif.com/armes-et-autres-materiels-f5/f-a-22-raptor-t1325.htm

http://www.flygplan.info/images/f22_ryan_f16.jpg

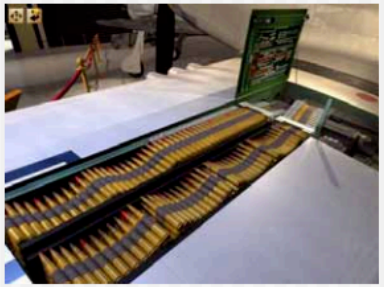
Round Numbers, Same $Costs

$

- **F-22**
  - 190 airplanes
  - Weapons
    - 1,140 AMRAAM missiles
    - 280 heat-seeking missiles
    - 190 guns
  - Sustained sortie rates of 133 F-22s
- **F-16**
  - 1,800 airplanes
  - Weapons
    - 7,200 AMRAAM missiles
    - 3,600 heat-seeking missiles
    - 1,800 guns
  - Sustained sortie rates of 2,160 F-16s

http://www.flightglobal.com/airspace/photos/precision/images/21708/f-22-p-51-f-16.jpg

F-22….Dominance?

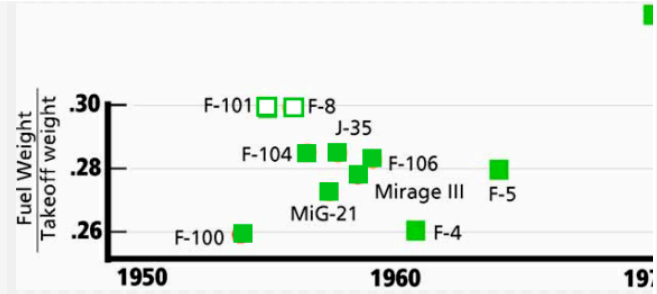


P-51 .50 caliber gun and 400 rounds

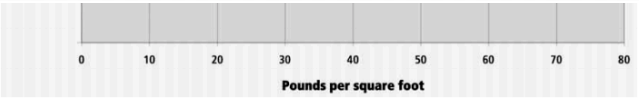
- **.50 caliber of World War II had quicker:**
  - **Time to first shot**
  - **Time of flight**
  - **Cumulative lethality**
- **Today's 20mm has**
  - **Longer start up time**
  - **Less range**
  - **Longer time to target than 20mm of World War II**

Higher T/W, better acceleration

Higher fuel fraction, persistence



- **F-22 requires gun door to open**
- **M61A2 requires $^1/_2$ second start up time**
- **Missiles require 10-15 seconds electronic acquisition time for cooperative threat**
- **After acquired, missile launch requires opening missile bay doors**



Stealth References

- References
- Mason, W.H. “Fifteen minutes of Stealth in Aircraft Design” Jan. 17, 2006 http://www.aoe.vt.edu/~mason/Mason_f/ConfigAeroStealth.pdf

- Malfitano, Bernardo. “Low-observable ‘Invisible’ Airplanes- Radar Stealth” http://www.airplanedesign.info/52-radar-stealth.htm