General Dynamics
F-16 Fighting Falcon

http://www.globalsecurity.org/military/systems/aircraft/images/f-16c-19990601-f-0073c-007.jpg

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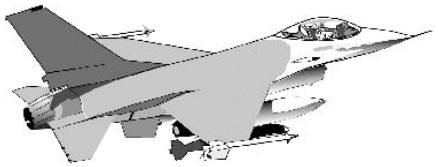
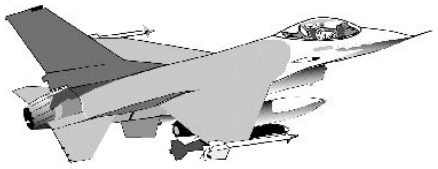


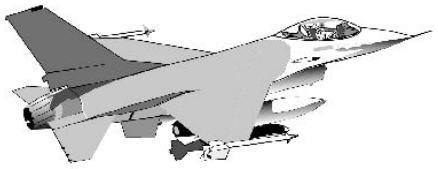
Outline

- Purpose/Mission
- Aerodynamic Configuration
- Lift
- Drag
- Planform Issues and Analysis
- Airfoil Issues and Analysis
- Trim
- Trim Drag
- Performance
- Pros/Cons
- F-16 Experimental Variants



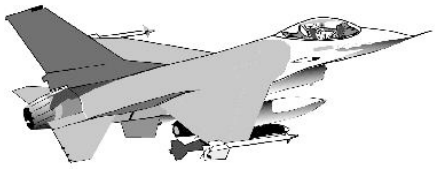
Purpose/Mission

- **RFP (issued Jan. 16, 1971)**
- **Provide an aircraft with maximum usable maneuverability and effectiveness in both the air-to-air and air-to-ground combat arenas but within the constraints of minimizing the cost and complexity**
  - **Superior maneuver performance and handling qualities at subsonic and transonic speeds (0.6<M<1.6)**
  - **Superior acceleration**
  - **The carriage of a variety of the latest air-to-ground weapons and their accurate delivery**
  - **A subsonic-cruise lift-to-drag ratio sufficient to provide effective mission radii with a variety of payloads**
  - **High T/W ratio**
  - **TOGW < 20,000lbs**
  - **Operate at altitudes between 30 and 40 thousand feet**



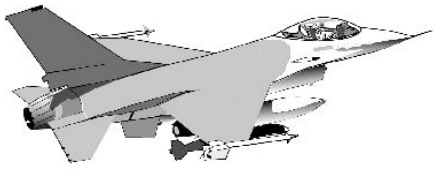
Aerodynamic Configuration

- **Leading Edge Extensions**
  - **Provide controlled vortex lift**
    - **Produces lift on the inboard portion of the wing and straightens the flow over the outboard portion of the wing**
  - **Strake geometry and its interface with the forebody and wing were developed over many hours of wind tunnel testing of more than 50 configurations**
  - **Net increase in lift at high angles of attack is over 25 percent**
  - **Reduces buffet intensity**
  - **Improves directional stability**
  - **Increases trimmed lift-to-drag ratio**
- **Tail**
  - **Chose single tail over twin**
  - **Less buffeting from strake vortices at high alpha**
- **Engine Intake**
  - **Located below the nose a**
  - **Avoids gun gas ingestion and landing FOD**



Aerodynamic Configuration

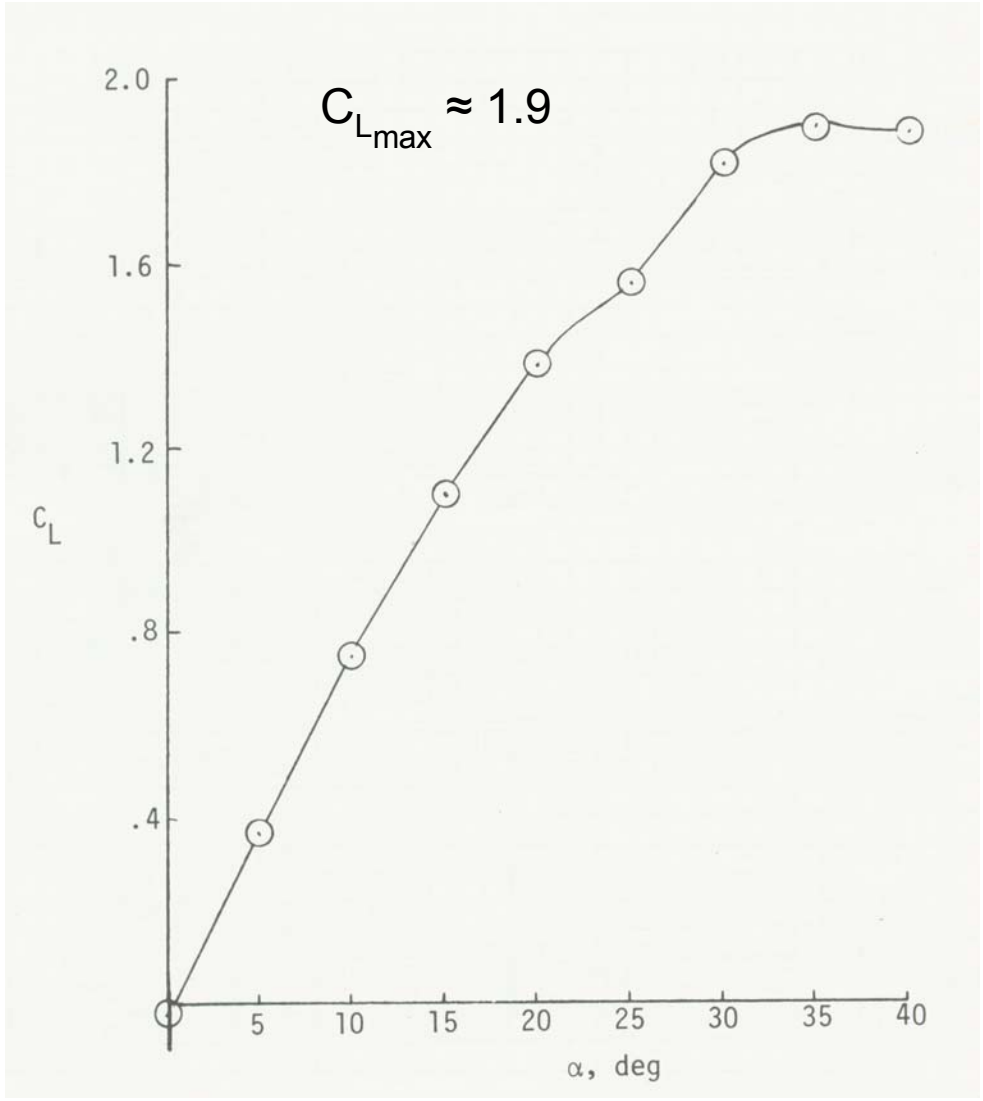
- **Automatic Variable Camber**
  - **Provides an aerodynamically efficient wing surface throughout the flight envelope**
  - **LE flap is automatically positioned to minimize drag and buffet at all flight conditions**
    - **Optimizes the wing camber for turning maneuvers, cruise, and acceleration**
  - **At M > 1, LE and TE flaps are fixed at -2 degrees**
    - **Reduces profile drag at low angles of attack**
    - **Improves acceleration characteristics**
  - **Improves directional stability at high lift coefficients**
  - **Increases sustained and instantaneous lift up to 12 percent**
  - **Reduces buffet intensity by almost 60 percent**



Aerodynamic Configuration

- **Relaxed Static Stability**
  - **Increases lift-to-drag ratios at subsonic and supersonic speeds**
  - **Reduces down-load on the horizontal tail required to trim at high lift coefficients and at supersonic speeds**
    - **Increases total lift available at sustained-turn conditions (2% at subsonic cruise, 4-8% at M = 0.9, and 8-15% at M = 1.2)**
- **Blended Wing/Body**
  - **Provides additional volume for fuel storage, increasing range**
  - **Reduces wetted surface area, reducing drag**
  - **Increases structure rigidity**
- **Supersonic Area Ruling**
  - **Decreases wave-drag**
  - **Particular attention was given to the bubble canopy in the final area ruling of the fuselage/strake/nacelle combination**

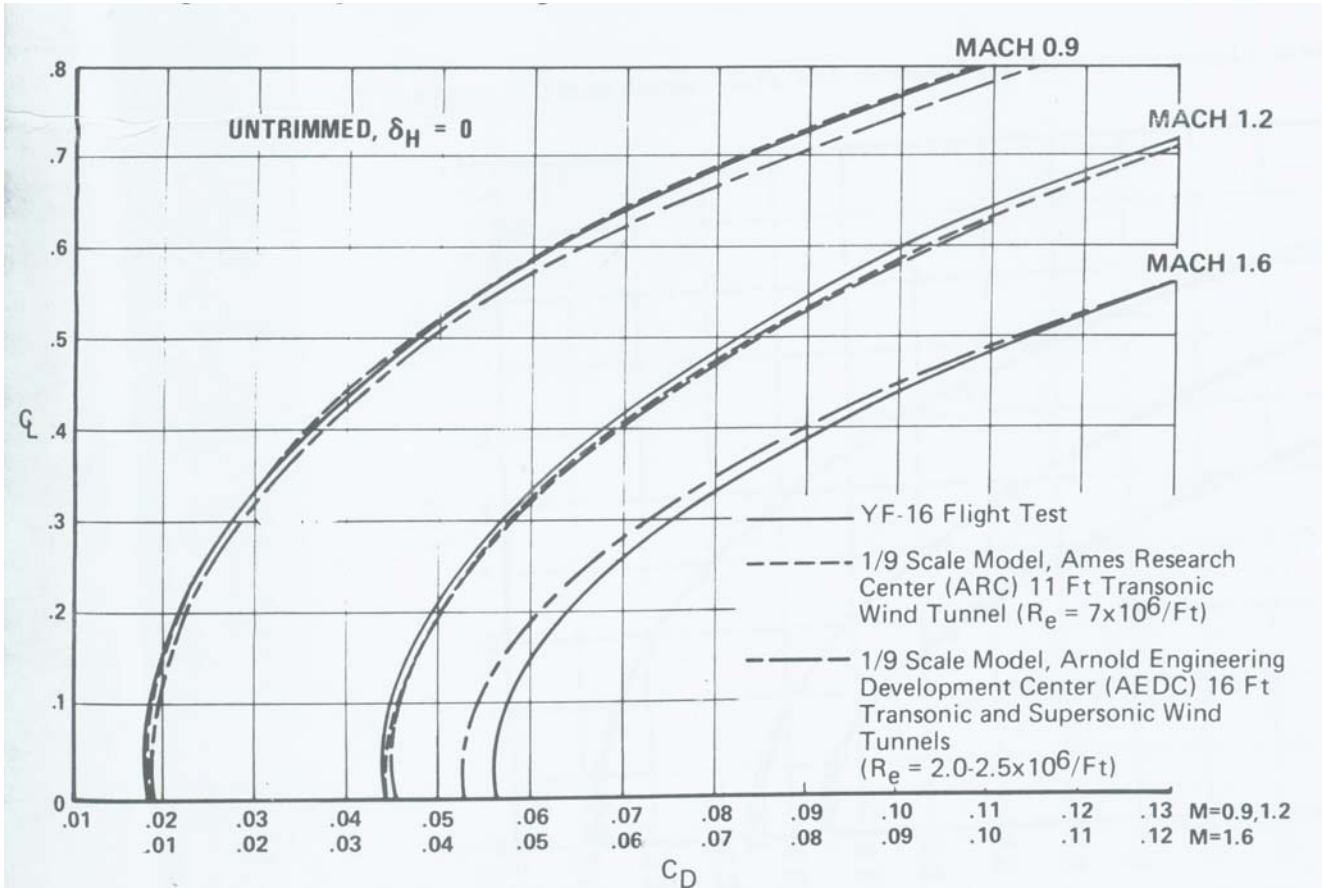
Lift



Nguyen, Luat T. et.al. Simulator Study of Stall/Post-Stall Characteristics of a Fighter Airplane With Relaxed Longitudinal Static Stability. NASA Technical Paper 1538. Dec. 1979.

Drag

$C_{D_0} \approx 0.0175$



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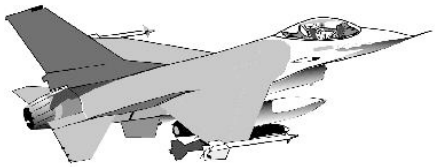
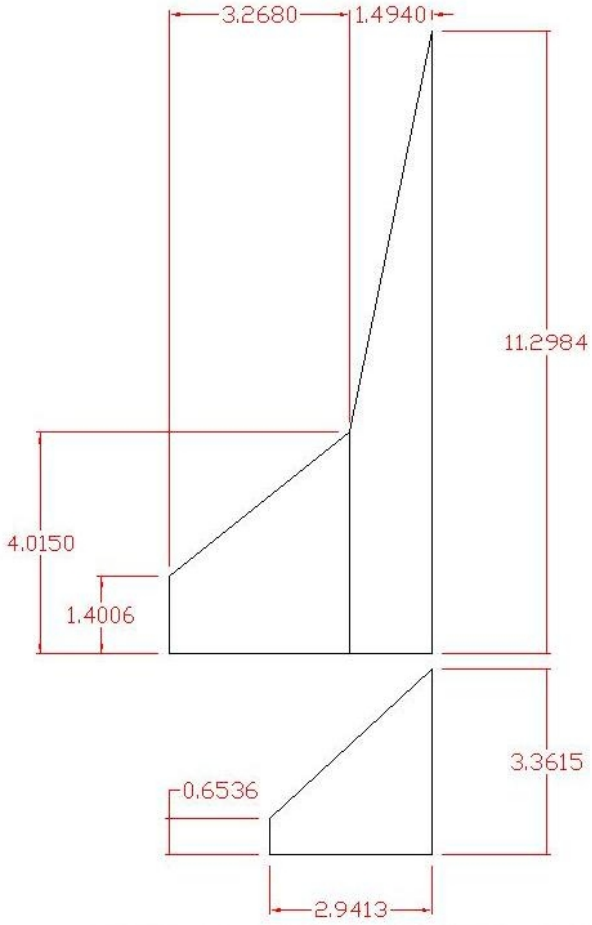


Planform Issues and Analysis

- **Span e**
  - **e ≈ 0.9084 at C_L = 0.4**
- **Vortex Lattice Method Results**

	Tornado (M=0.8)	VLMpc (M=0.8)	Wind Tunnel (M=0.9)
CL alpha (per deg)	0.0489	0.08104	0.09
Cm alpha (per deg)	-0.0284	-0.0448	-0.01125

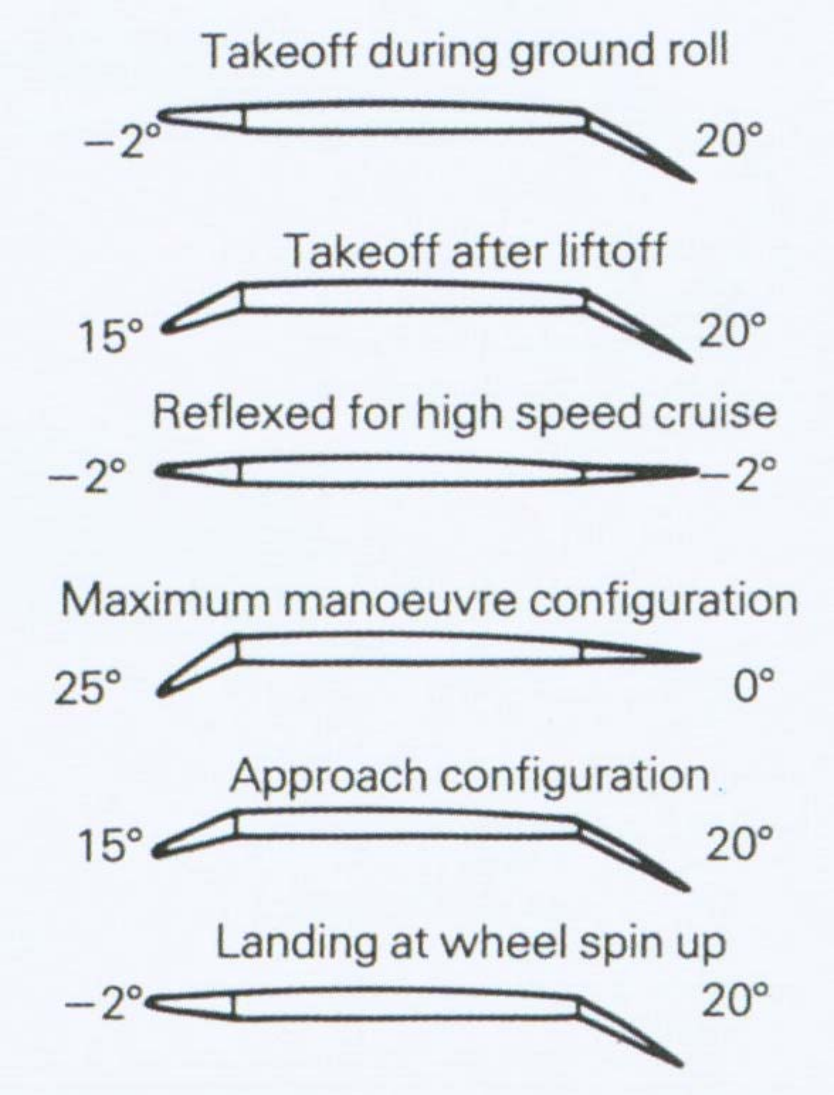


F-16 planform

dimensions in meters

Airfoil Issues and Analysis

- **Airfoil**
  - **NACA 64A204**
  - **Variable Camber**



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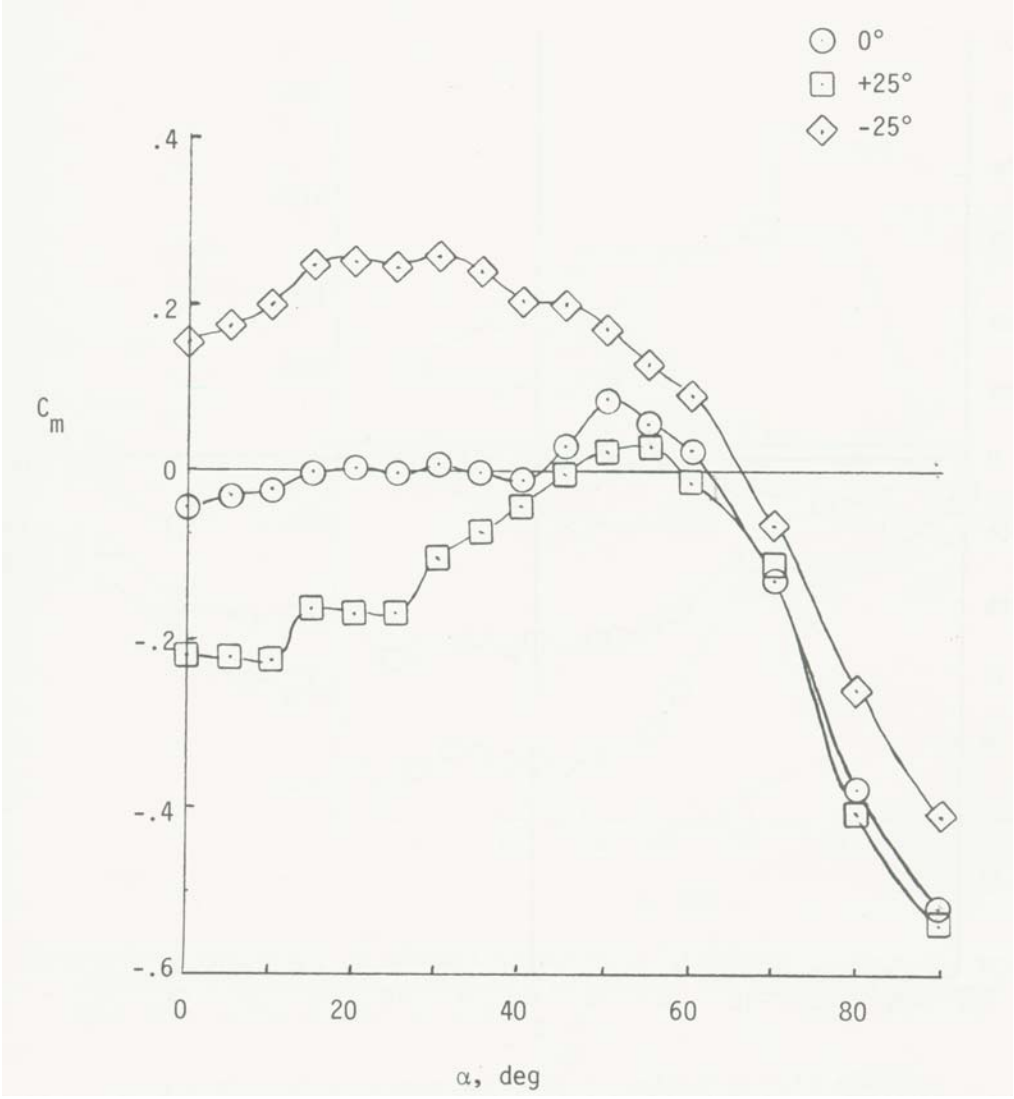
Trim



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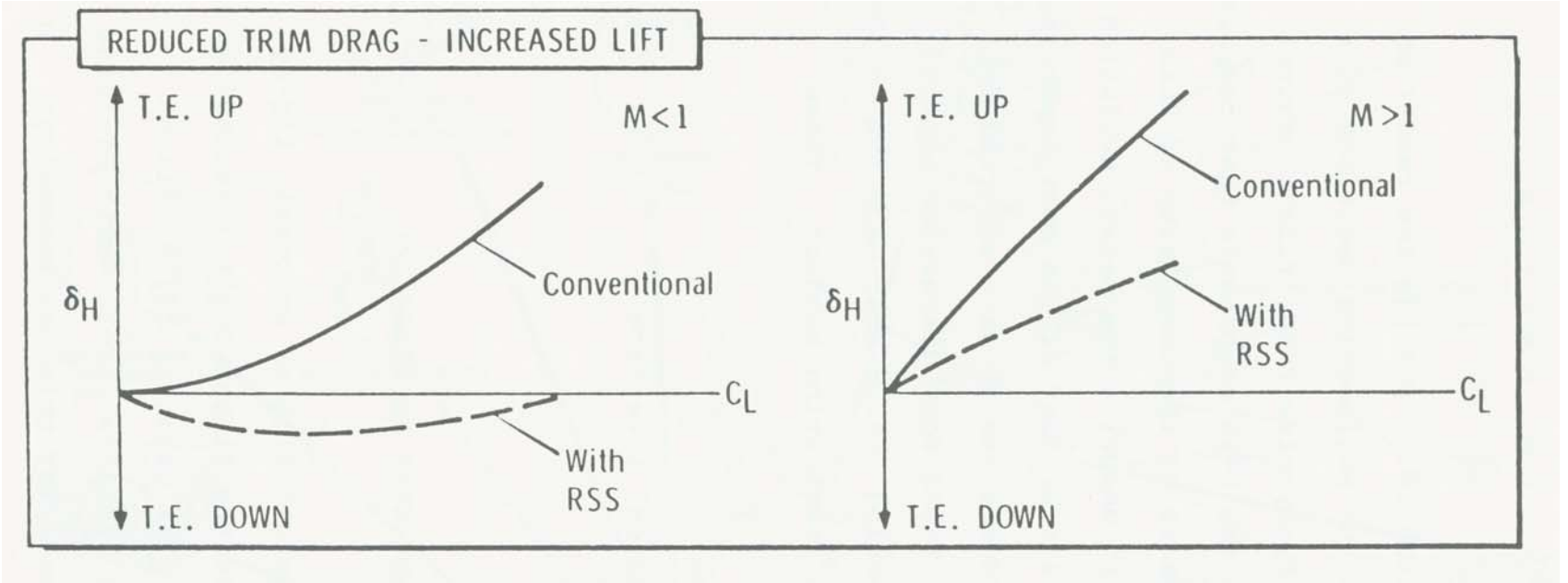
Trim Drag



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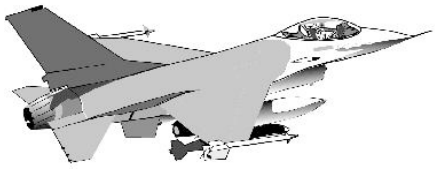
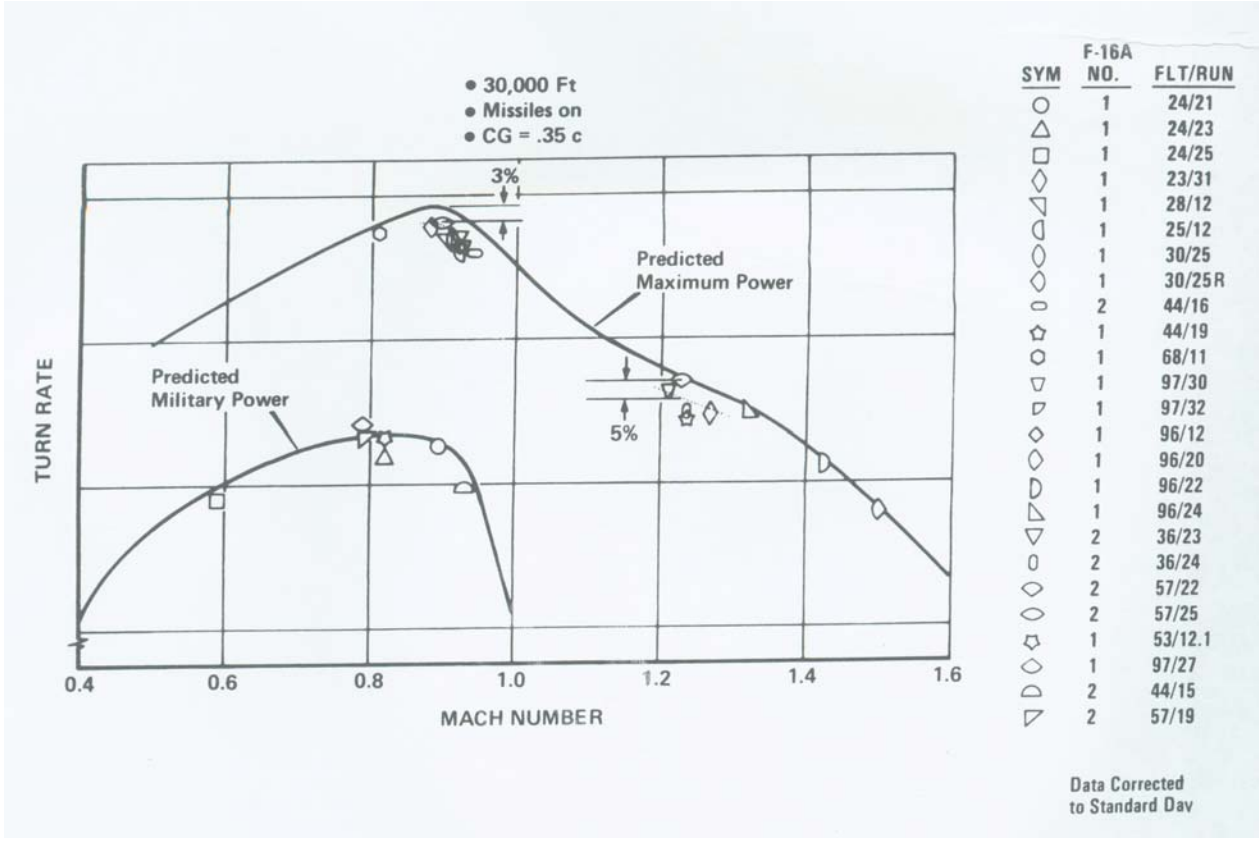


Performance

- **Empty Weight – 16,285 lb**
- **Combat Takeoff – 26,536 lb**
- **Maximum Takeoff Weight – 37,500 lb**
- **Wing Loading – 88 lb/ft^2**
- **Maximum Thrust – 23,830 lb (27, 000 lb for later models)**
- **Thrust/Weight Ratio – 0.94-1.08**
- **Maximum Velocity – Mach 2.0(+)**
- **Ceiling – 50,000 ft**
- **Climb Rate – 50,000 ft/min**
- **Maximum Range – 2,425 miles**
- **Max G-rating – 9g with 100% fuel (7.33g with 80% fuel)**
- **AOA Limiter (basic, roll rate, and yaw rate)**
- **ARI Schedule (-AOA, -Mach)**
- **Rudder Authority Limiting**

Performance



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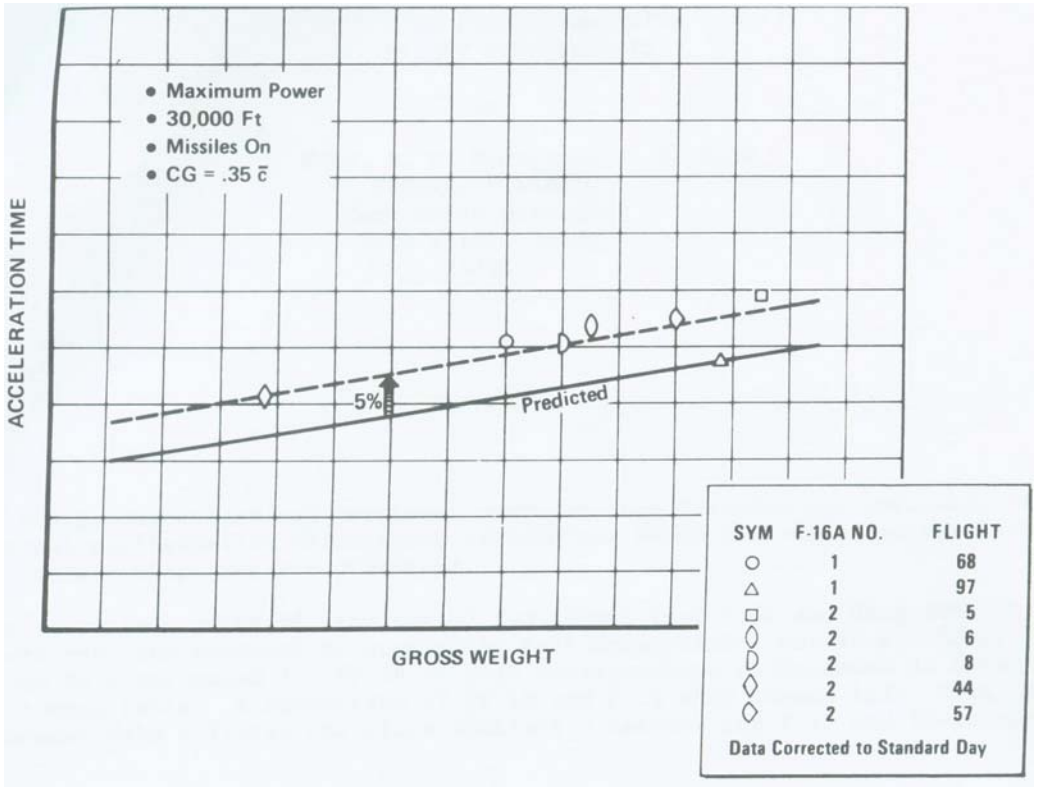

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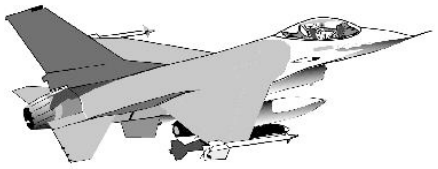


Pros/Cons

Pros

- Relatively long range
- Lower TOGW from various config. Option allows an increased turning rate (10%) and acceleration (30%)
- Small size = low radar returns
- Bubble canopy has large range of vision
- Designed to carry more missiles than specified
- Lower cost from using common components
- Upgradeable
- Increased life in airframe

Cons

- Deep stall possible at 60 deg AOA
- Fixed engine inlet geometry reduces TOGW, but limits M<2
- OEI is a problem with only one engine
- Possible problem with control system (fly-by-wire) when struck by lightning

F-16 Experimental Variants

F-16XL

http://www.brockmoore.com/images/military/F-16XL.jpg

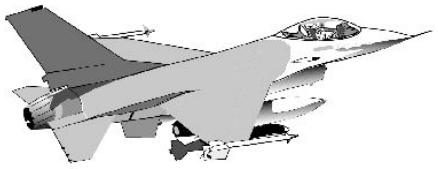
- **Optimized for supercruise**

F-16 Experimental Variants

AFTI/F-16

http://www.combatsim.com/archive/images/img_arc-13/aft002.jpg

- **Experimentation with decoupled flight**



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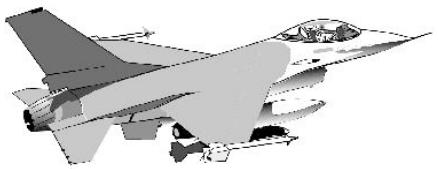

Questions

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