F-16 Fighting Falcon — Aircraft Performance & Design

Introduction

The performance of a fighter aircraft cannot be understood by looking at speed, range, or altitude separately.

During a real mission, these characteristics continuously interact with one another.

As fuel is burned, the aircraft becomes lighter. As the weight changes, its aerodynamic performance changes. The aircraft may climb to a higher altitude, accelerate to a different speed, release external stores, and then return to base with a specific amount of fuel remaining.

To understand this more clearly, let us follow an F-16C/D HI–LO–LO–HI example mission profile documented in the F-16 flight manual.

> **Important:** The mission used here is a documented performance-planning example from the F-16 flight manual. The manual states that its example missions are not necessarily actual or proposed operational missions and that assumed values are used for sample calculations.

F-16C/D HI–LO–LO–HI Example Mission Profile

The mission follows this general sequence:

Takeoff → Climb → Optimum Cruise → External Tank Drop → Descent → Sea-Level Dash → Weapons Release → Sea-Level Inbound Cruise → Climb → Cruise → Descent → Landing

The aircraft configuration in the example includes:

• 2 × AIM-9 missiles

• 2 × Mk-84 bombs

• 2 × 370-gallon external fuel tanks

The AIM-9 missiles are retained throughout the mission.

The external fuel tanks are dropped when empty, while the Mk-84 bombs are released over the target.

1. Weight — How the Aircraft Becomes Lighter During the Mission

Weight is one of the most important variables in aircraft performance.

At the beginning of the mission, the aircraft carries:

Fuel; Weapons; External fuel tanks; Pilot; Aircraft structure and equipment

As the mission continues, fuel is consumed by the engine.

Therefore: **Fuel Burn** → **Lower Aircraft Weight**

This change in weight affects almost every other performance characteristic.

A lighter aircraft generally requires less lift to maintain level flight and can have different climb, acceleration, maneuvering, and fuel-consumption characteristics.

Weight During the Mission

At one important point in the example mission, the aircraft reaches approximately 29,494 lb gross weight at a distance of 496 nautical miles from base.

At this point, the two external fuel tanks are dropped.

The tanks and their remaining unusable fuel account for approximately: **900 lb**

Therefore:

Before tank drop: 29,494 lb
After tank drop: 28,594 lb

The aircraft has immediately become lighter by approximately 900 lb.

The mission then continues with the aircraft becoming progressively lighter as fuel is consumed.

Distance from Base	Gross Weight
496 nm	28,594 lb
765 nm	27,000 lb
940 nm	26,000 lb
1,121 nm	25,000 lb

These values show an important idea: **Distance increases while aircraft weight decreases.** The aircraft is not operating at one constant weight throughout the mission.

Why Does Weight Matter?

Aircraft performance is strongly connected to weight.

A heavier aircraft generally requires more lift.

Lift can be expressed as:

$$L = \frac{1}{2}\rho V^2 S C_L$$

Where:
L = Lift
ρ = Air density
V = Airspeed
S = Wing area
CL = Lift coefficient

During steady level flight:
Lift ≈ Weight

Therefore, when aircraft weight changes, the aerodynamic conditions required to support the aircraft also change.

This is one reason why the aircraft does not perform exactly the same way at the beginning and end of the mission.

A Question for the Reader

What happens if an aircraft has to land at a weight higher than the permitted landing weight?

Think about it before looking for the answer.

What could be affected first?

Aircraft structure?
Tires?
Brakes?
Landing distance?
Overall landing performance?

■ Share your answer in the comments.

2. Speed — The Aircraft Does Not Fly at One Speed

The F-16 changes speed according to the mission phase.

Different phases require different speeds because the aircraft has different objectives.

For example:
Takeoff requires controlled acceleration.
Climb requires an efficient climb speed.
Cruise requires efficient long-distance flight.
Descent uses a different speed regime.
The dash phase requires high speed at low altitude.
Landing requires a much lower controlled speed.

The F-16 manual's example specifies several important speed conditions.

During the climb, the example uses approximately:
385 KIAS / Mach 0.83

During the descent toward the penetration altitude, the aircraft uses:
300 KIAS

The aircraft then accelerates to the required dash condition.

During the sea-level outbound dash:
Mach 0.85

This shows that speed is not simply a maximum-performance number. It is selected according to the mission.

3. Range — How Far Can the Aircraft Travel?

Range is not simply the maximum distance an aircraft can fly.

It depends on:
Aircraft weight
Fuel quantity
Speed
Altitude
Engine efficiency
Drag
Payload
External stores
Mission profile

In the HI–LO–LO–HI example, the aircraft first travels away from its base at high altitude.

It then descends toward the low-altitude penetration phase.

The aircraft performs the low-altitude dash toward the target, releases its weapons, and begins the return journey.

The outbound and inbound portions are planned as a radius mission.

This means that the aircraft must not simply reach the target. It must also preserve enough fuel and performance capability to return safely to base.

4. Altitude — Why Does the Aircraft Change Altitude?

Altitude is another variable that changes throughout the mission.

The aircraft does not remain at one altitude from takeoff to landing.

A simplified mission sequence is:
Takeoff
↓
Climb
↓
High-Altitude Cruise
↓
Descent
↓
Low-Altitude Penetration
↓
Target
↓
Low-Altitude Return
↓
Climb
↓
High-Altitude Cruise
↓
Descent
↓
Landing

The F-16 example includes cruise altitudes around the high 30,000-ft range during portions of the mission.

For example, the planning data gives cruise altitudes of approximately:
36,700 ft
37,900 ft
38,700 ft
39,500 ft

These values are associated with different aircraft weights and mission positions.

This demonstrates another important relationship:
Aircraft Weight + Mission Phase → Required Flight Condition

5. Time — Every Mission Phase Has a Cost

Distance alone does not tell us how long the mission takes.

Time depends on:
Speed
Distance
Climb performance
Descent performance
Acceleration
Aircraft weight
Engine performance

For example, one of the documented descent and acceleration segments begins at approximately 28,594 lb.

The descent portion consumes approximately:
460 lb of fuel
and covers approximately:
49 nm
in about:

7.8 minutes

The following acceleration phase consumes approximately:
231 lb of fuel
over approximately:
9 nm
in about:
1.2 minutes

The combined time for these two phases is approximately:
9.0 minutes

This is a useful example because it connects several variables at the same time:
Weight → **Fuel Burn** → **Distance** → **Speed** → **Time**

6. The Same Mission Seen as One Complete System

Now we can look at the mission as a complete system.

The aircraft begins with a high fuel load and a relatively high gross weight.

It takes off and climbs.

During the climb, fuel is consumed.

During cruise, fuel continues to decrease.

The aircraft eventually reaches the point where its external fuel tanks are empty.

The tanks are released.

The aircraft becomes lighter.

It then descends toward the low-altitude penetration phase.

The aircraft accelerates for the dash toward the target.

The weapons are released.

The aircraft turns toward home.

Fuel continues to decrease.

The aircraft climbs again for the return cruise.

Finally, it descends and lands with a planned fuel reserve.

The mission is therefore not a collection of independent numbers. It is a continuously changing engineering system.

Mission Performance Summary

Mission Variable	How It Changes
Weight	Decreases as fuel is consumed and stores are released
Speed	Changes according to mission phase
Range	Increases continuously from takeoff to landing
Altitude	Changes between takeoff, cruise, penetration, return and landing
Time	Accumulates throughout every mission phase
Fuel	Continuously decreases

Mission Variable	How It Changes
External Stores	Fuel tanks and weapons are released according to the mission plan
Aerodynamic Performance	Changes as weight, altitude and speed change

Engineering Factors Behind the Performance

Engineering Factor	Why It Matters
Aircraft Weight	Determines the lift required and affects acceleration, climb and maneuverability
Wing Area	Influences wing loading and lift capability
Wing Loading	Affects takeoff, landing, maneuvering and high-speed performance
Thrust-to-Weight Ratio	Strongly influences acceleration and climb performance
Lift	Supports the aircraft against gravity
Drag	Opposes the aircraft's motion and affects fuel consumption
Lift-to-Drag Ratio	Indicates aerodynamic efficiency
Engine Performance	Determines available thrust and fuel consumption
Fuel Quantity	Determines how much energy is available for the mission
Altitude	Changes air density, engine performance and aerodynamic conditions
Airspeed	Strongly affects lift, drag and fuel consumption
Payload	Increases aircraft weight and affects mission performance
External Stores	Add weight and aerodynamic drag
Center of Gravity	Influences stability and control
Structural Limits	Restrict allowable loads and operating conditions

Why Aircraft Design Is a Balance

The F-16's performance is not produced by one component.

The wing cannot be designed independently from the engine.

The engine cannot be selected without considering aircraft weight.

The aircraft weight cannot be separated from fuel and payload.

The fuel requirement cannot be separated from range.

Range cannot be separated from drag and engine efficiency.

And maneuverability cannot be considered without considering wing loading, thrust-to-weight ratio and aerodynamic design.

This is why aircraft design is a system-level engineering problem.

A change in one parameter can influence many others.

Final Perspective

By following one complete mission, we can see how an aircraft's performance changes continuously.

The F-16 does not have one fixed:

Weight

Speed

Altitude

Range

or

Fuel state

throughout the mission.

Instead, all of these variables change together.

That is the real meaning of aircraft performance.

It is not simply a list of numbers.

It is the interaction between aircraft design, aerodynamics, propulsion, weight, fuel, payload, altitude, speed and mission requirements.

Want to Explore More?

Want to learn more about the remaining F-16 performance characteristics and engineering factors?

If you are interested in a deeper analysis of aircraft performance, aerodynamic design and engineering factors, contact us for more detailed analysis.