USAF Strike Fighters

An analysis of range, stamina, turning, and acceleration

The Contenders

- There are currently slated to be three USAF strike aircraft in the 2020 timeframe
  - F-15E Strike Eagle
    - One of the largest and heaviest fighter aircraft
    - Massive fuel/weapons capacity
  - F-16C Fighting Falcon
    - One of the smallest and lightest fighter aircraft
    - Diminutive fuel capacity, but retains over half the weapons capacity of the F-15E
  - F-35A Lightning II
    - External dimensions similar to F-16, but weight similar to F-15C
    - Tremendous internal fuel/weapon capacity for it's size
  - Will also look at F-16C with conformal fuel tanks (referenced as F-16I)

Specs

F-15E

- Empty Weight: 38,700 lbs
- Box volume (LxWxH): 50,517 cubic feet
- Fuel
  - Internal: 22,300 lbs
  - External: 12,000 lbs
    - 3 – 600gallon tanks on heavy A2G stations
- A2A
  - AIM-120 up to 8
    - One each on four conformal heavy stations
    - One each on four dedicated AAM stations
  - AIM-9 up to 4
    - One each on four dedicated AAM stations
- A2G
  - Up to 7 heavy stations
    - One under each wing
    - One on centerline
    - Four conformal to the lower fuselage
- Targeting Pods - External

F-16C (I)

- Empty Weight: 20,300 lbs (22,300 lbs)
- Box volume (LxWxH): 25,898 cubic feet
- Fuel
  - Internal: 7,000 lbs (10,200 lbs)
  - External: 7,000 lbs
    - 2 – 370gallon tanks on heavy A2G stations
    - 1 – 300gallon tank on centerline station
- A2A
  - AIM-120 up to 6
    - One each on two heavy stations
    - One each on four dedicated AAM stations
  - AIM-9 up to 6
    - One each on two heavy stations
    - One each on four dedicated AAM stations
- A2G
  - Up to 4 heavy stations
- Targeting Pods – External

Specs

F-35A

- Empty Weight: 29,400 lbs
- Box volume (LxWxH): 25,546 cubic feet
- Fuel
  - Internal: 18,200 lbs
  - External: 5,800 lbs
    - 2 – 426gallon tanks on heavy A2G stations
- A2A
  - AIM-120 up to 14
    - Internal – 6
      - Two each per heavy station
      - One each on dedicated AAM station
    - External – 8
      - two each per heavy station
  - AIM-9 up to 10
    - Two each per external heavy station
    - One each on dedicated AAM station
- A2G
  - Up to 6 heavy stations
    - Two internal
    - Four external
  - Targeting Pods - internal

Specs – conclusion

- The considerable empty weight of the dimensionally small F-35 is accounted for by it's internal carriage of large fuel volumes, two heavy A2G stations, two A2A stations, and Targeting equipment
- Despite the F-35 only having 4 dedicated AAM stations, the ability to carry two missiles per heavy station gives it vast flexibility

Missions

500nm Endurance

- If tanks are carried then they are assumed to be carried throughout mission
- Assumed time/performance critical target appears as soon as aircraft is on station (most fuel remaining, worst performance)
  - Tanks are dropped
  - Instant/Sustained turn taken at cruise speed
  - .8M to 1.2M acceleration measured

Additional factors

- Max Range calculated as alternate mission plan
- Two flight profiles calculated
  - Optimum max range profile
  - Mission dictated 20,000ft at 0.8M

Drag

drag areas estimated from Max Endurance

F-15E

Base Drag Area: 21.71

- Mission based
  - AA – 23.33
  - AA with tanks – 25.00
  - AG – 24.54
  - AG with tanks – 26.52

F-16C (I)

Base Drag Area: 9.07 (9.21)

- Mission based
  - AA – 10.57 (10.71)
  - AA with tanks – 12.94 (13.08)
  - AG – 13.30 (13.44)
  - AG with tanks – 16.42 (16.56)

Drag

F-35

Base Drag Area: 9.75

- Mission based
  - AA – 9.75
  - AA with tanks – 12.42
  - AG – 9.75
  - AG with tanks – 12.42

Drag – conclusion

- Despite the natural low drag of the F-16 airframe the addition of missiles, bombs, pylons, tanks, and targeting pods nearly doubles it's base drag.
- The low drag of the F-35 will allow for higher cruise speeds and/or greater range, the two being a natural tradeoff.
- The drag areas of the clean F-16 and F-35 are consistent with the story of an F-35 with 9 tons of internal fuel/weapons (traditional T/W of .59) out climbing the F-16 chase plane that was carrying only a centerline gas tank (traditional T/W of .61) while in military power.

500nm CAP

Assumptions:

All aircraft are able to top off at the tanker right at their optimum altitudes.

Notes:

Cruise Speeds:

F-16C/CFT (EFT) - .84/.84 (.83/.82)

F-15E (EFT) - .87(.85)

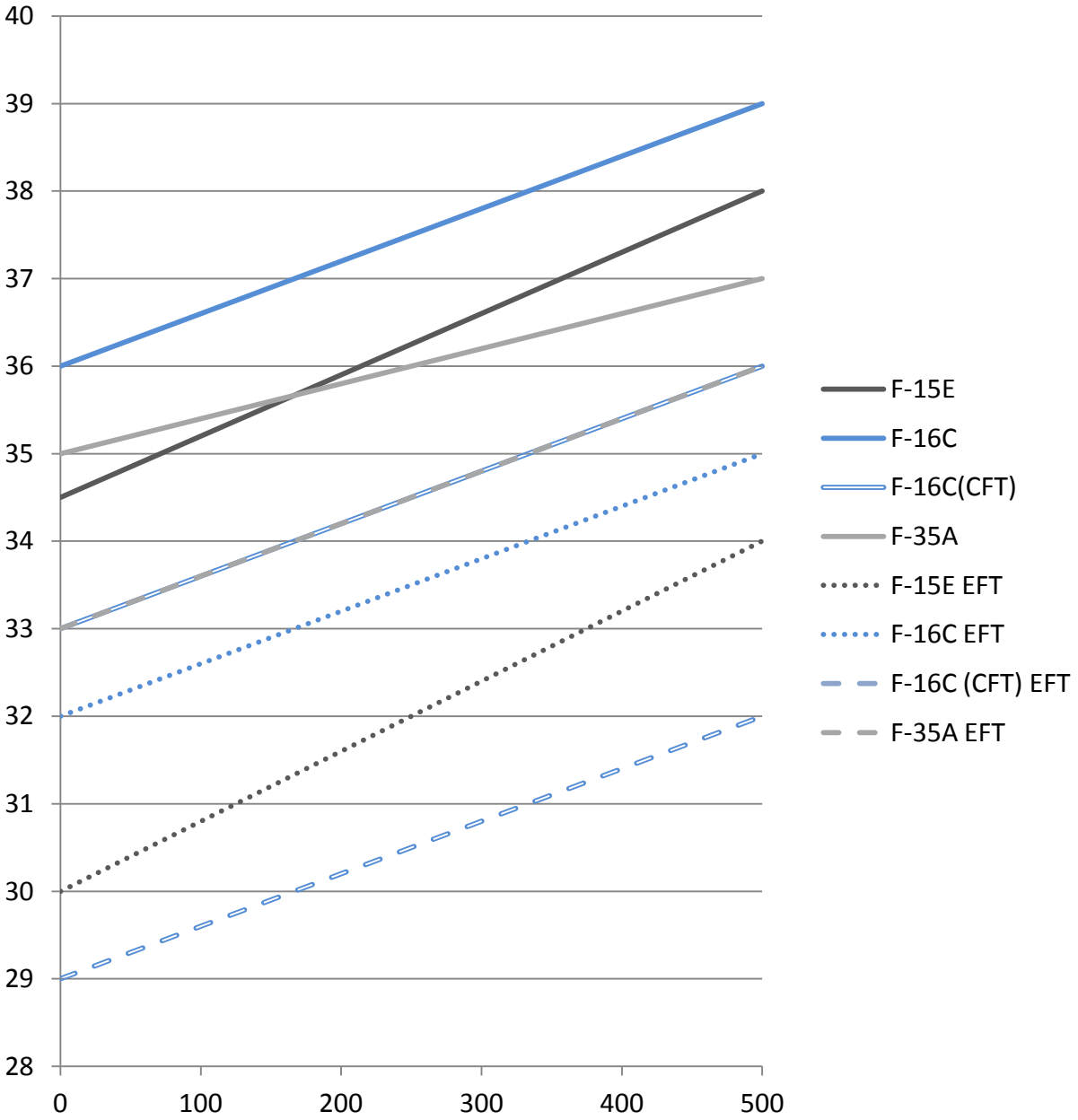
F-35A (CFT) - .87(.85)

The added weight of extra fuel (CFT and/or EFT has a huge impact on best cruise altitude

F-35A with EFT has same cruise altitudes as F-16C with CFT

For non-optimum cruise all aircraft are traveling at 0.8M at 20,000ft.

- Altitude with Distance



500nm CAP Endurance

Assumptions:

Optimum cruise data assumes constant climb as fuel is burned and all missiles are retained.

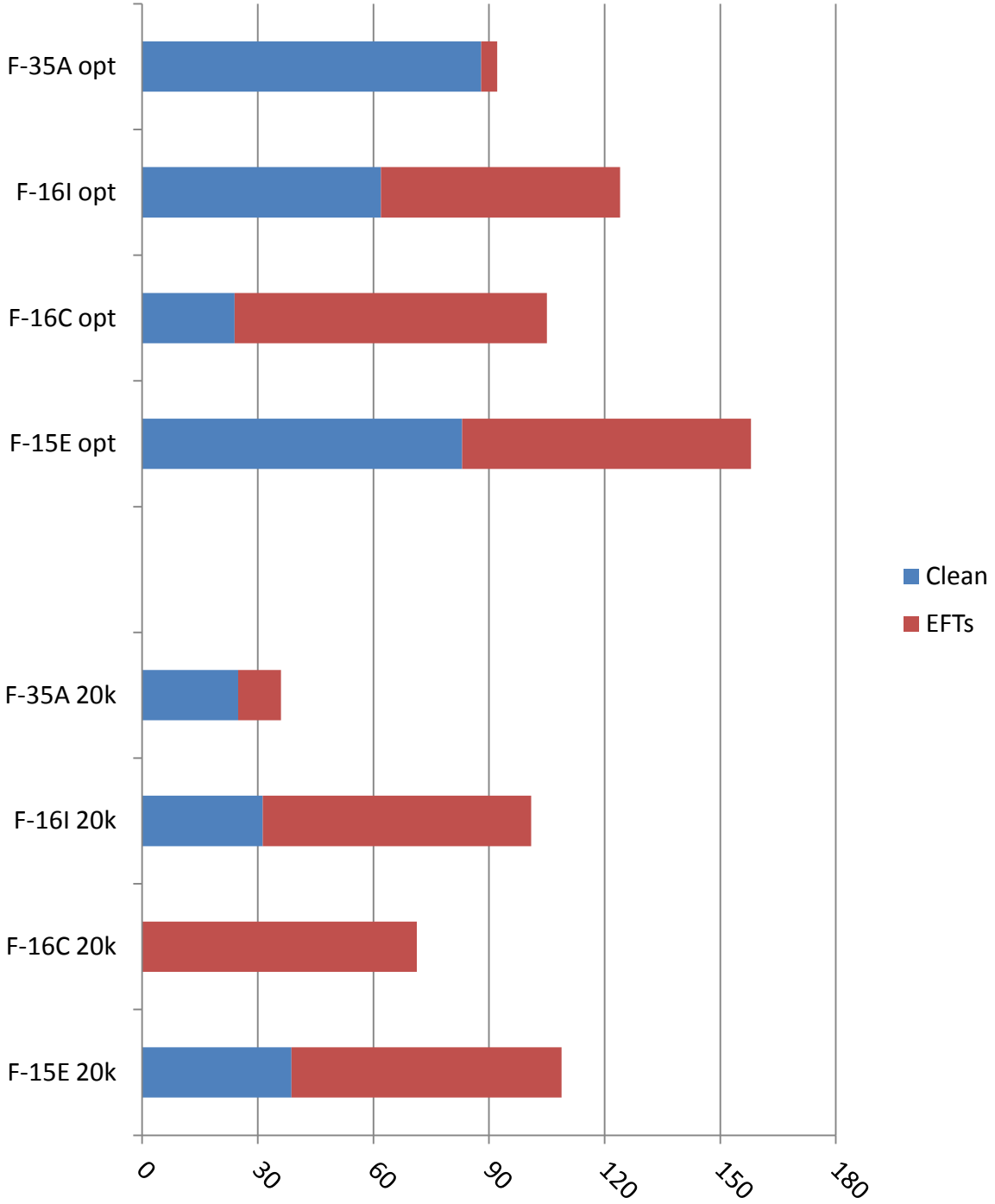
EFTs are retained for entire mission

Notes:

Under Optimum Cruise, the F-35 can loiter longer while clean than even a Strike Eagle.

Under a constrained flight plan most of the aircraft have around 30 minutes of clean endurance. The F-16C **cannot** make a 500nm cruise at 20kft without drop tanks

The two 426 gallon drop tanks on the F-35A provide such a small increase in fuel fraction but increase drag by about 27% The F-35 is the only aircraft that is out of fuel in the external tanks before reaching 500nm.



Dogfight 500nm out

Assumptions:

Aircraft get bounced as soon as they are on station, the most fuel on board gives the worst performance. Any EFTs are dropped.

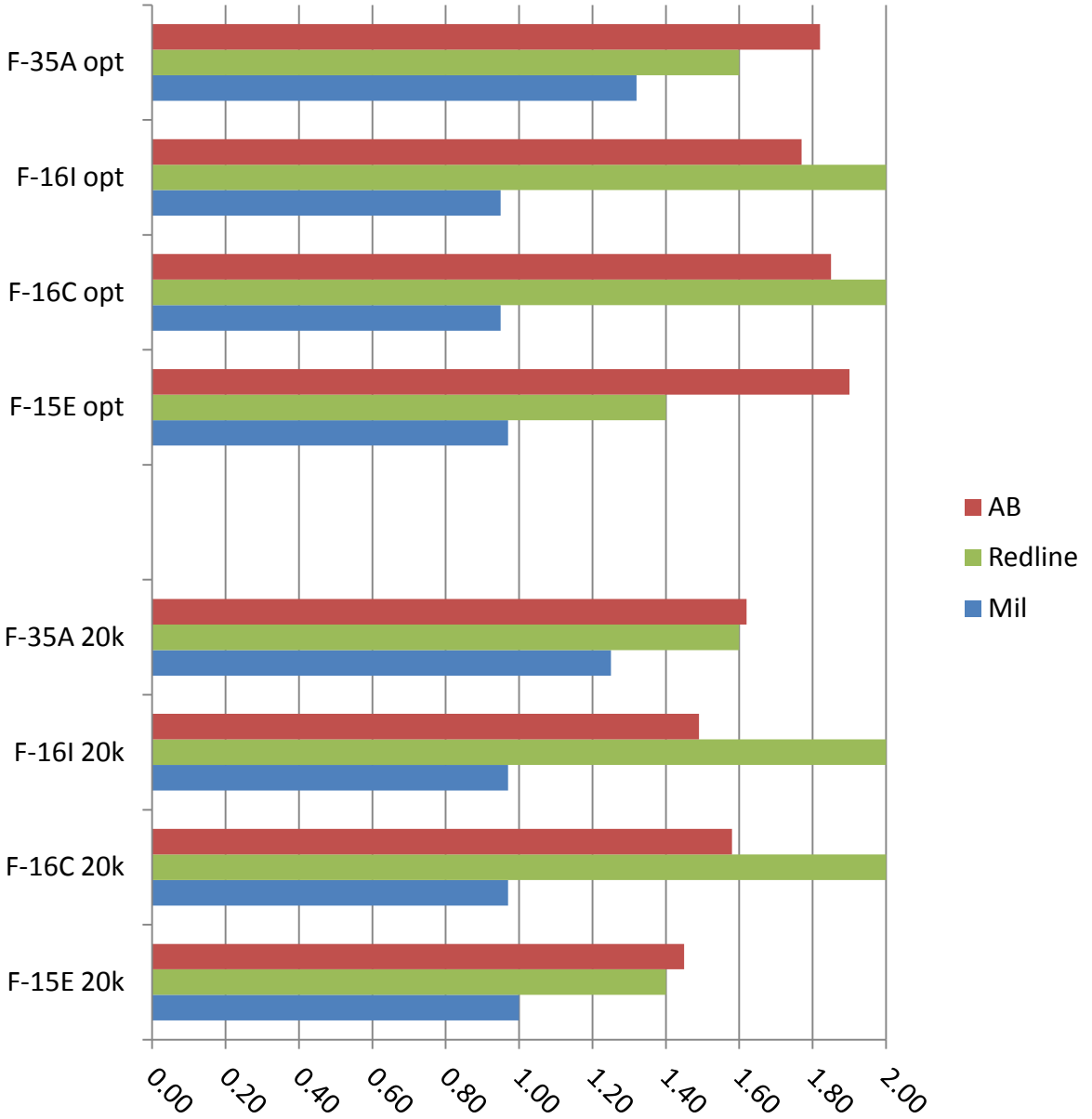
Notes:

The F-16 has very high placard limits under air to air loading and is drag limited

The F-15E and F-35 have more thrust than their placard limits allow

The F-35s placard limit is often above the placard/thrust limits of it's brethren, only A-A configured F-16 are faster.

- Speed



Dogfight 500nm out

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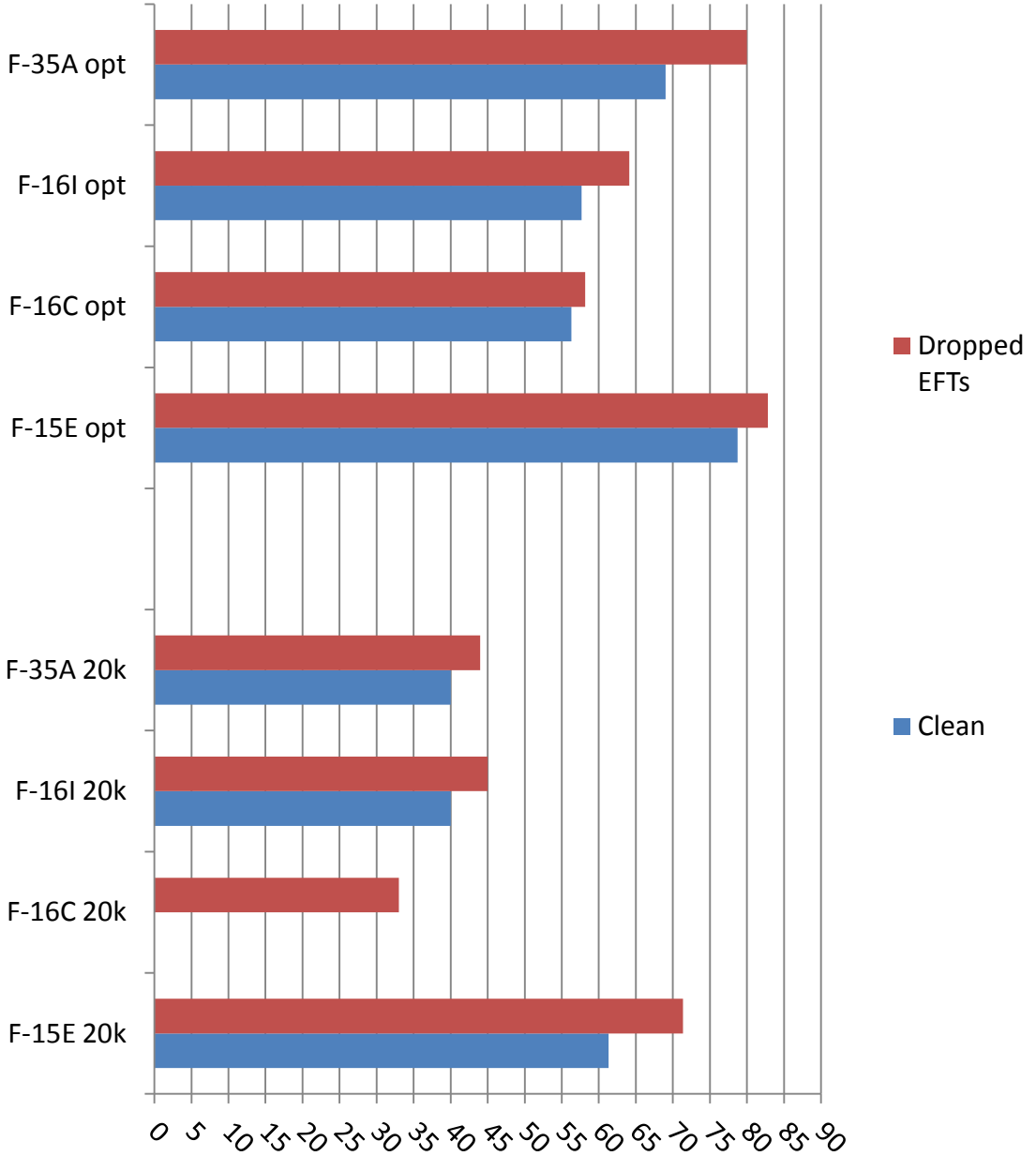
Notes:

In Optimum Cruise scenarios the added weight of the extra fuel in the dropped EFT group is mitigated by the lower altitude.

0.8-1.2M acceleration, while one of the standard JSF parameters, is rather arbitrary if flown at Optimum Cruise as it starts out between .84 and .87 depending on aircraft

- Cruise-1.2M acceleration



Dogfight 500nm out

Assumptions:

Aircraft get bounced as soon as they are on station, the most fuel on board gives the worst performance. Any EFTs are dropped.

Notes:

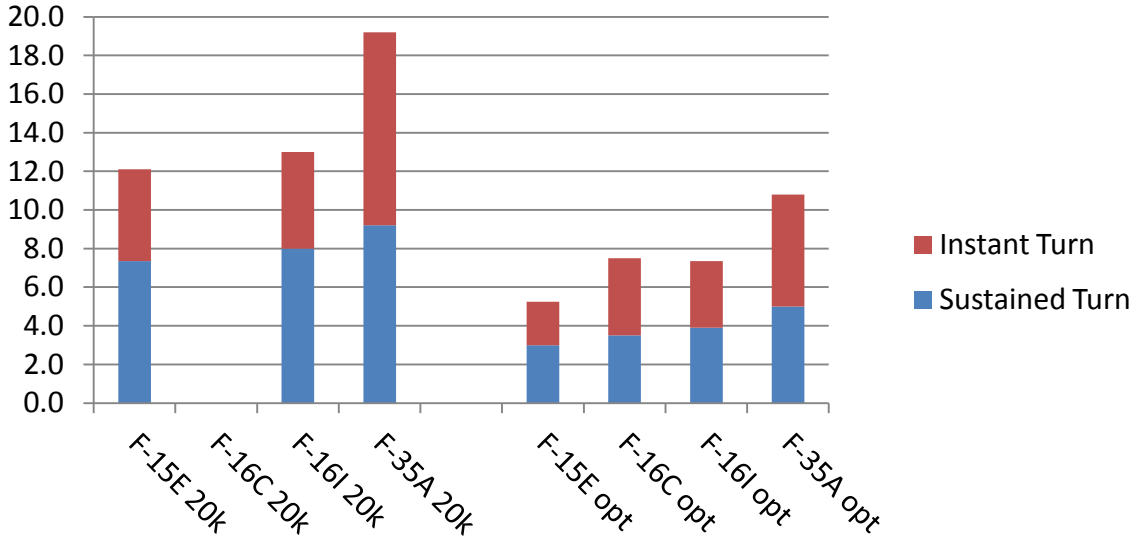
In Optimum Cruise scenarios the added weight of the extra fuel in the dropped EFT group is mitigated by the lower altitude.

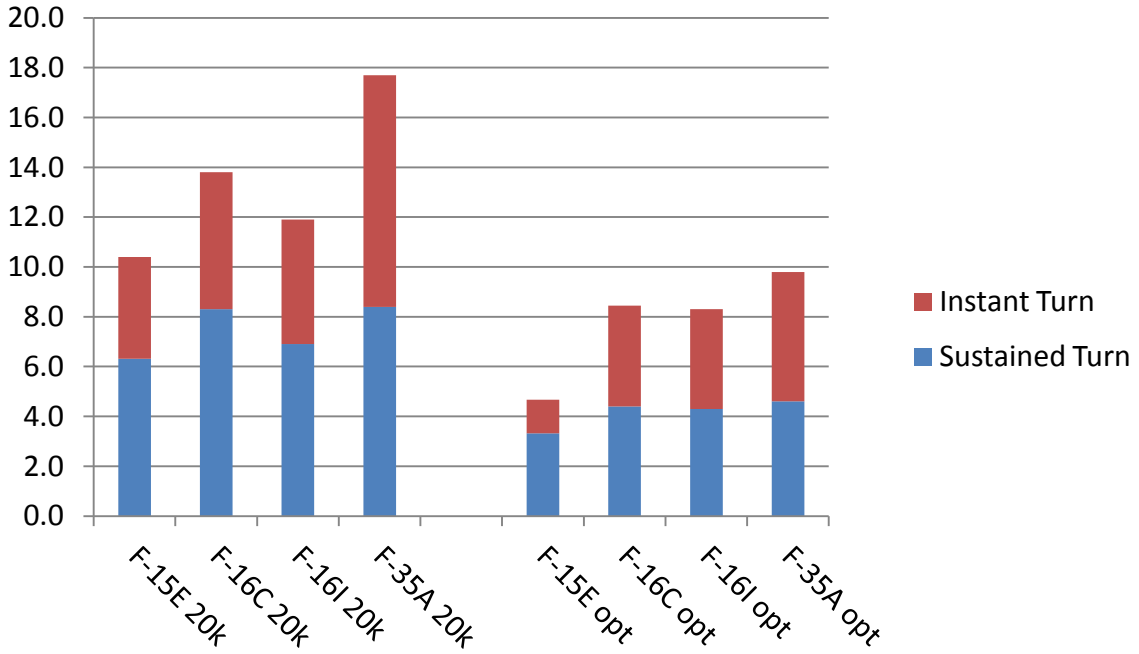
All aircraft are lift limited in these scenarios with the exception of the F-35 at 20kfeet and 0.8M in which it is right at corner velocity.

Data found coincides with statements of "Sustained Turns similar to F-16 with Instantaneous Turns similar to F/A-18". While lift limited the F-35 can out point the F-16 at the expense of energy.

This is a true apples-apples mission based performance, not "50% fuel with two AIM-120s"

- Turn rate at cruise speed (clean above dropped EFTs)





“Osirak” style escort mission

Max Range

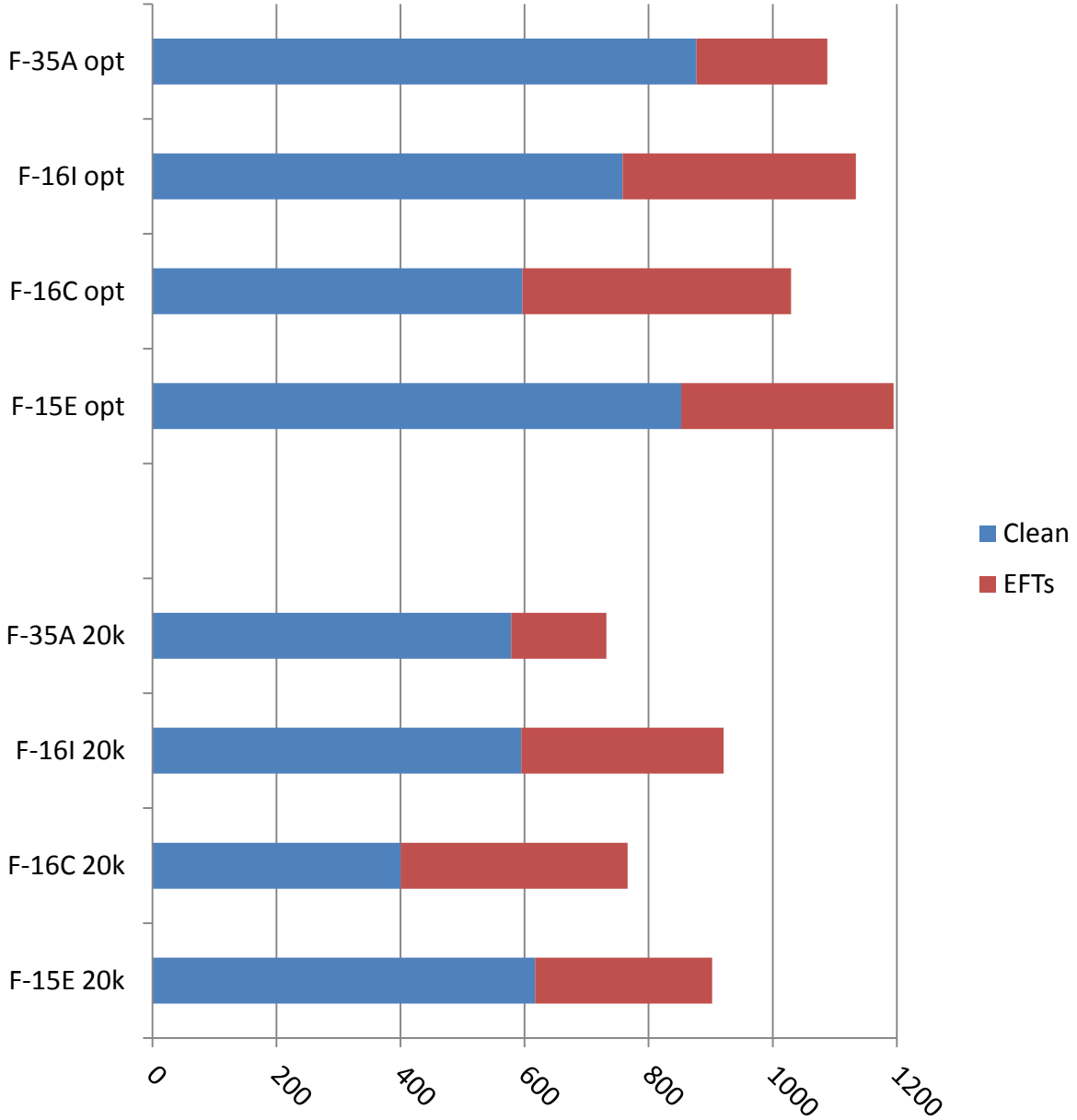
Assumptions:

EFTs are dropped as soon as they are empty

Notes:

The Constrained Flight Plan at 20,000ft shows results similar to the number compared to the KPP, but we can see that no clean strike aircraft is going to significantly exceed that range.

While the F-16 is a hotrod in acceleration, it suffers greatly in range compared to the heavier aircraft



500nm Interdiction

Assumptions:

All aircraft are able to top off at the tanker right at their optimum altitudes.

Notes:

Cruise Speeds:

F-16C/CFT (EFT) - .83/.81 (.80/.80)

F-15E (EFT) - .86(.83)

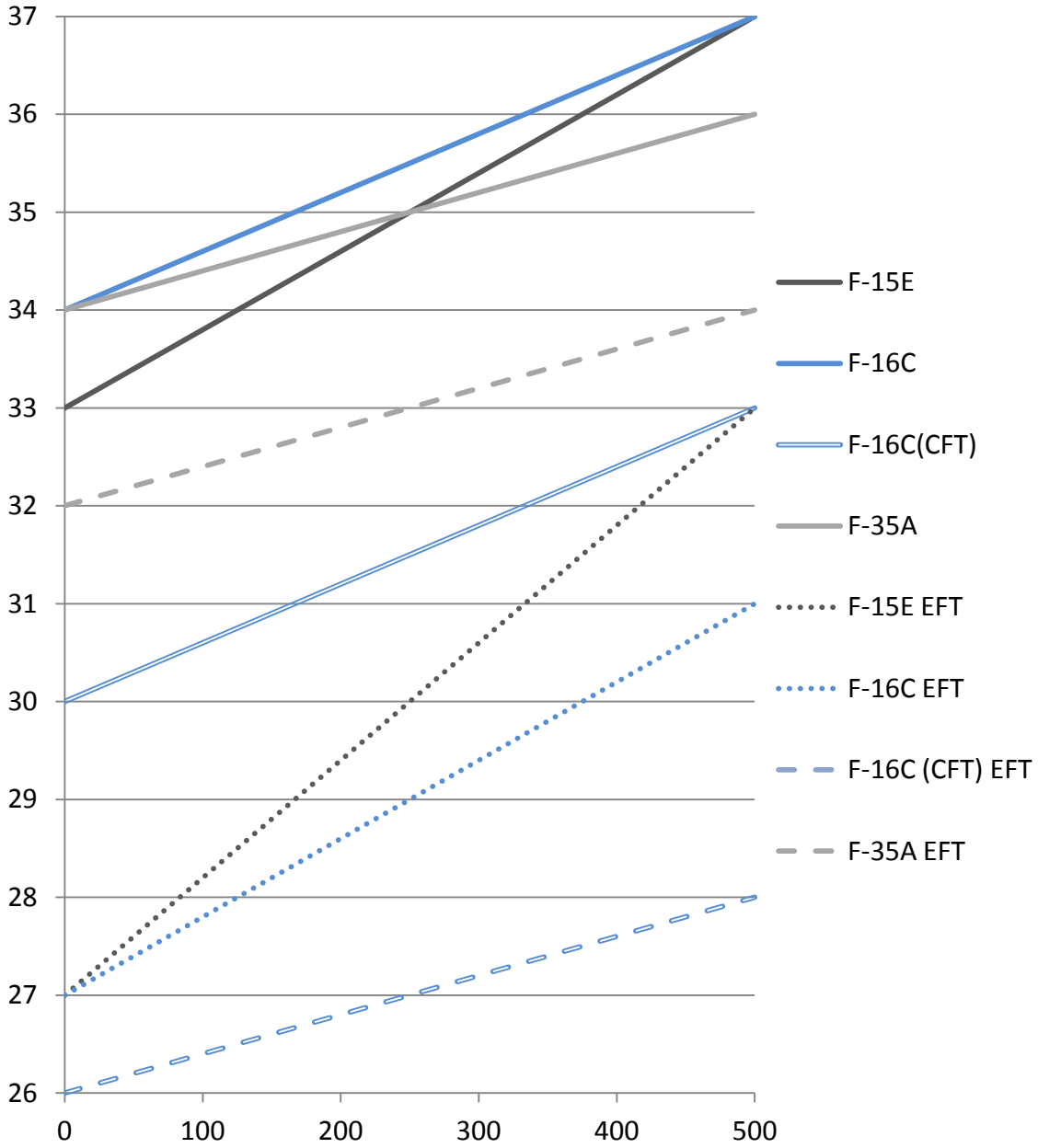
F-35A (CFT) - .87(.85)

The added weight of extra fuel (CFT and/or EFT has a huge impact on best cruise altitude

The added weight of targeting pods as well as the drag of the targeting pods and bombs (and interference drag between bombs and tanks) robs the 4th Gen aircraft of their performance

For non-optimum cruise all aircraft are traveling at 0.8M at 20,000ft.

- Altitude with Distance



500nm Interdiction Endurance

Assumptions:

Optimum cruise data assumes constant climb as fuel is burned and all missiles are retained.

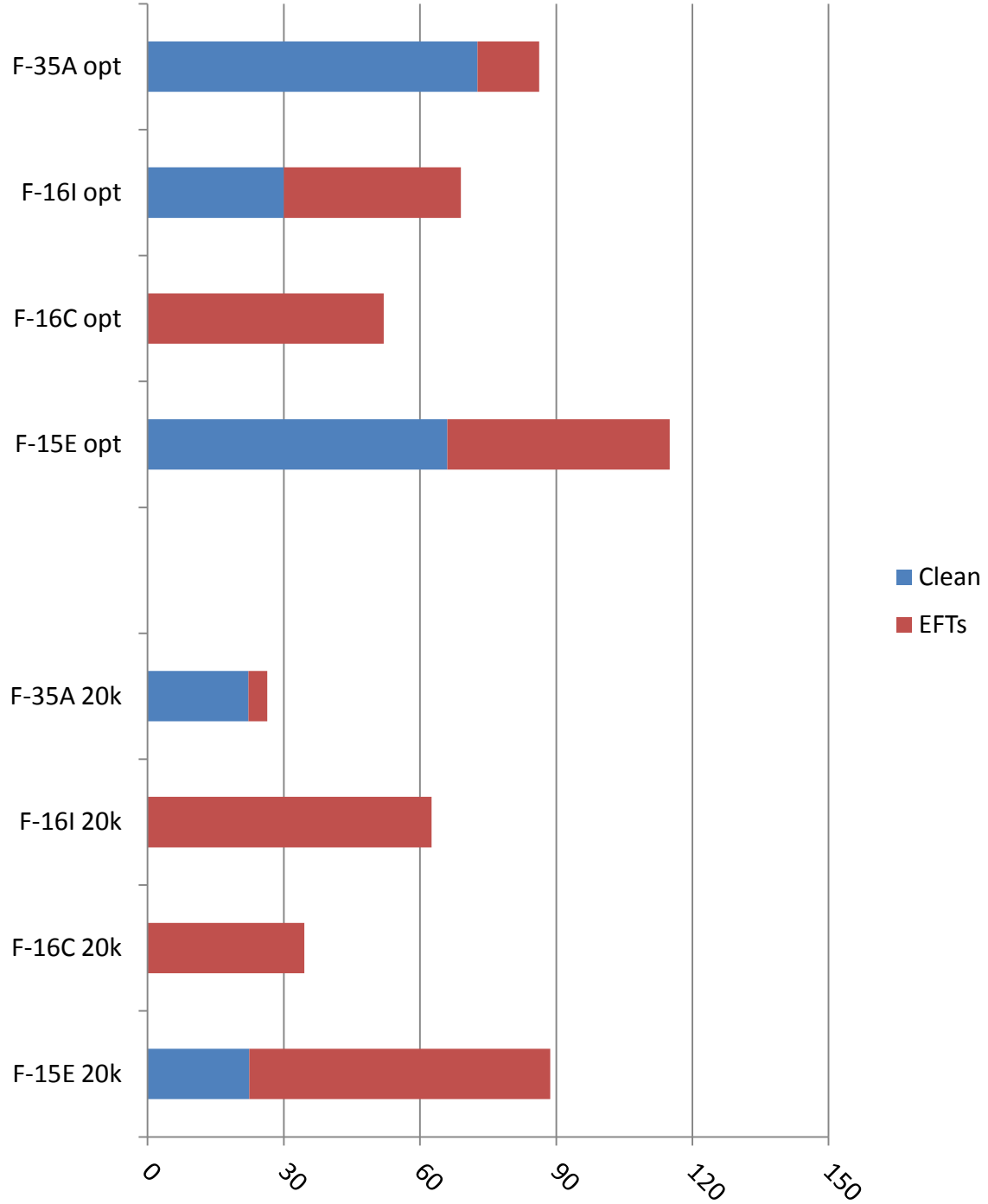
EFTs are retained for entire mission

Notes:

Under Optimum Cruise, the F-35 can loiter longer while clean than even a Strike Eagle.

The F-16C **cannot** make a 500nm cruise at any altitude without drop tanks, adding CFTs still requires an Optimum Cruise.

The two 426 gallon drop tanks on the F-35A provide such a small increase in fuel fraction but increase drag by about 27% The F-35 is the only aircraft that is out of fuel in the external tanks before reaching 500nm.



Dogfight 500nm out

Assumptions:

Aircraft get bounced as soon as they are on station, the most fuel on board gives the worst performance. Any EFTs are dropped.

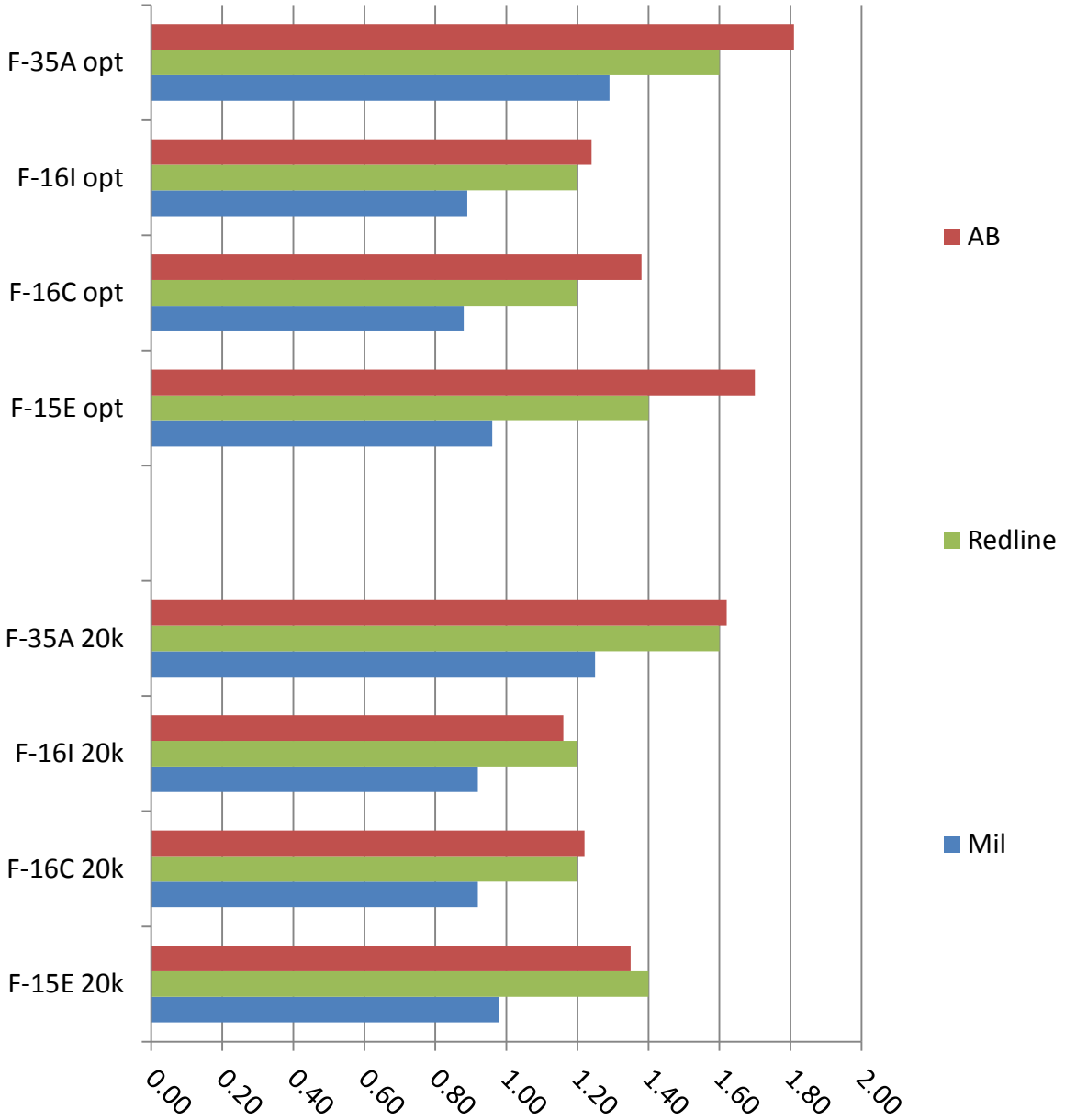
Notes:

Both placard and drag limit speeds are reduced drastically for the F-16

The F-15E and F-35 have more thrust than their placard limits allow

The F-35s is unquestionably the fastest strike aircraft of the group.

- Speed



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Notes:

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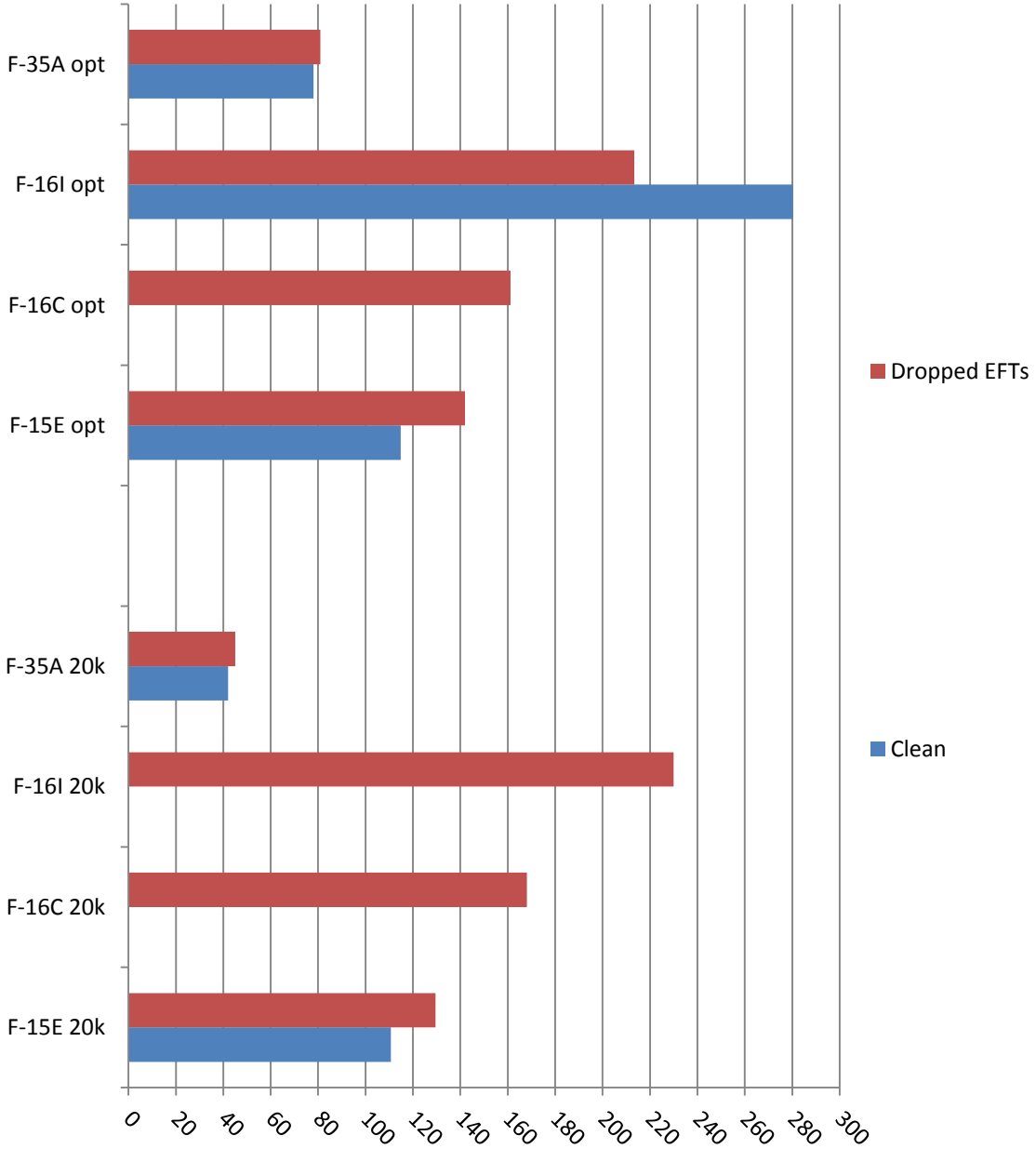
0.8-1.2M acceleration, while one of the standard JSF parameters, is rather arbitrary if flown at Optimum Cruise as it starts out between .80 and .87 depending on aircraft

F-16 with CFT cannot reach 1.2M at 20kft, time listed is to reach 1.17M

Compared to A-A loadouts, the F-35 goes from competitive to the hotrod of the group while the previous hotrod is pushing it's drag limits

- Cruise-1.2M acceleration



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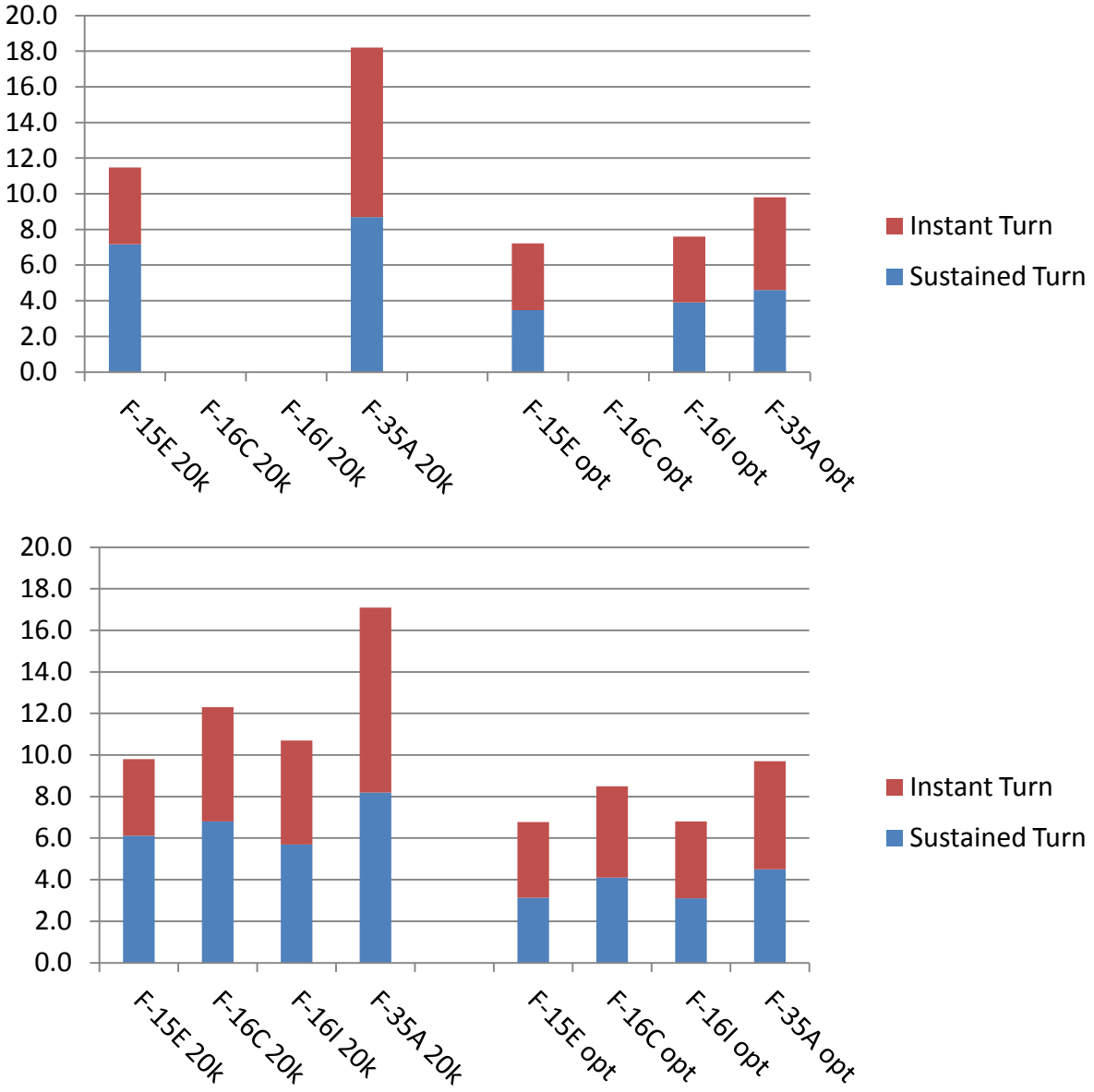
- Turn rate at cruise speed (clean above dropped EFTs)



Max Range

“Osirak” style strike mission

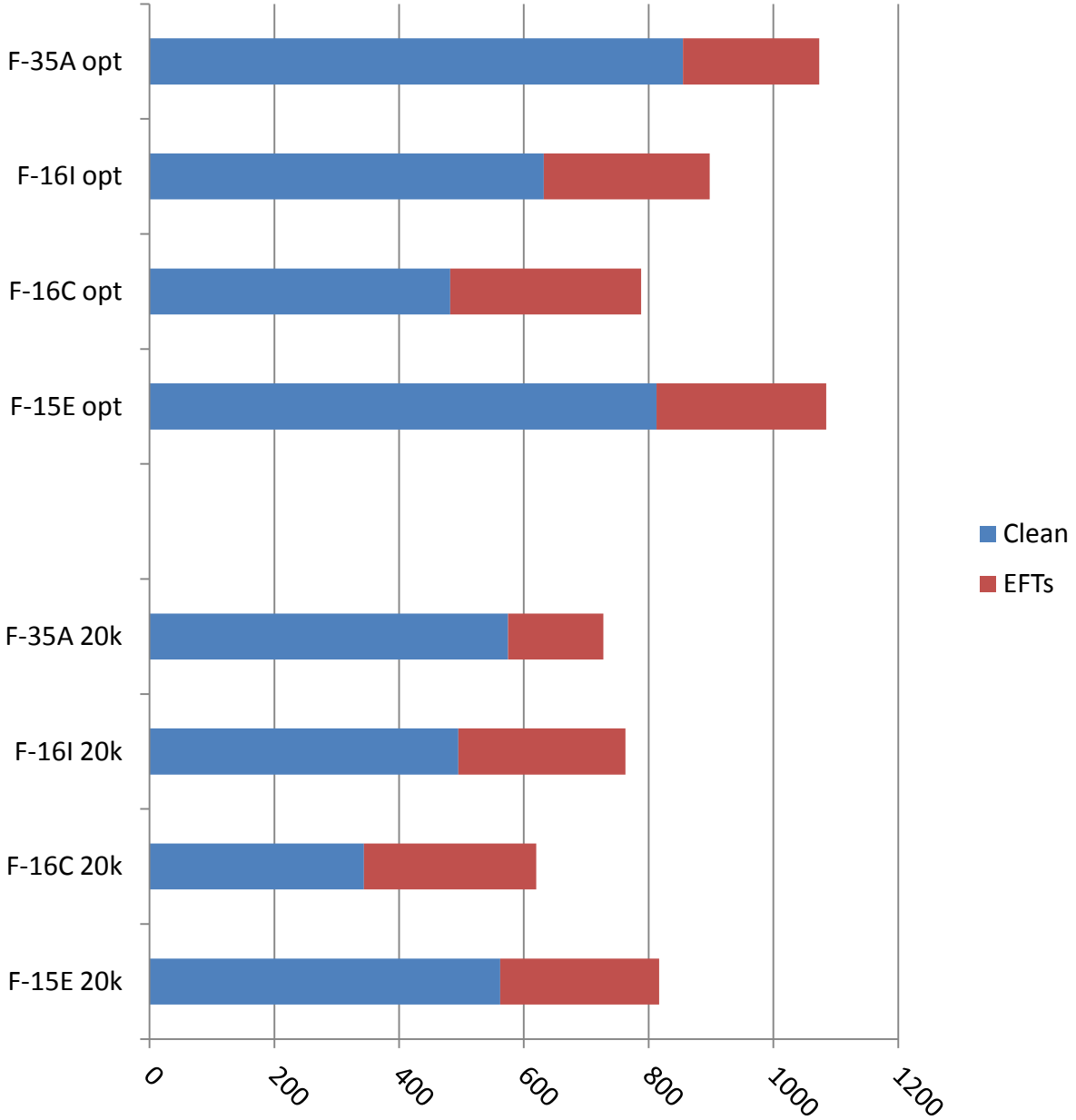
Assumptions:

EFTs are dropped as soon as they are empty

Notes:

The Constrained Flight Plan at 20,000ft shows results similar to the number compared to the KPP, but we can see that no clean strike aircraft is going to significantly exceed that range.

In the Strike role, the F-35 clean has range similar to F-16s with EFTs (sometimes greater still) and comparable to the significantly larger Strike Eagle



Conclusions

- We see that under actual combat conditions the F-35 can climb, run, and turn as well as or better than it's stable mates. It does this while having a better ECM/EA suite, full IR targeting and spherical tracking, secure LPI networking, and all aspect X-Band VLO. In short it is more capable than anything that has ever been used in combat before
- Optimum Profile was done to show how "Max Range" mission data could be gathered as these represent leaving a tanker and returning to a tanker with reserves based on aircraft weight, a true best case scenario.
- Constrained Profile was done to show how mission planners and battlespace managers may not want aircraft going across so many altitudes, and max range at 20kft was at much lower speeds than the 0.8M calculated but the mission planners also can't afford to simply wait around
- When looking at the F-35s clean range at altitudes above 30kft it is easy to see how the last 75nm in and out could be done as 1.25M and still make a 500nm+ range, which falls in line with the statement "150nm of cruise at 1.25M". I may do a case study on this in the future.