

Comparing a Quarter Century of Fighters

F-100 to F-18

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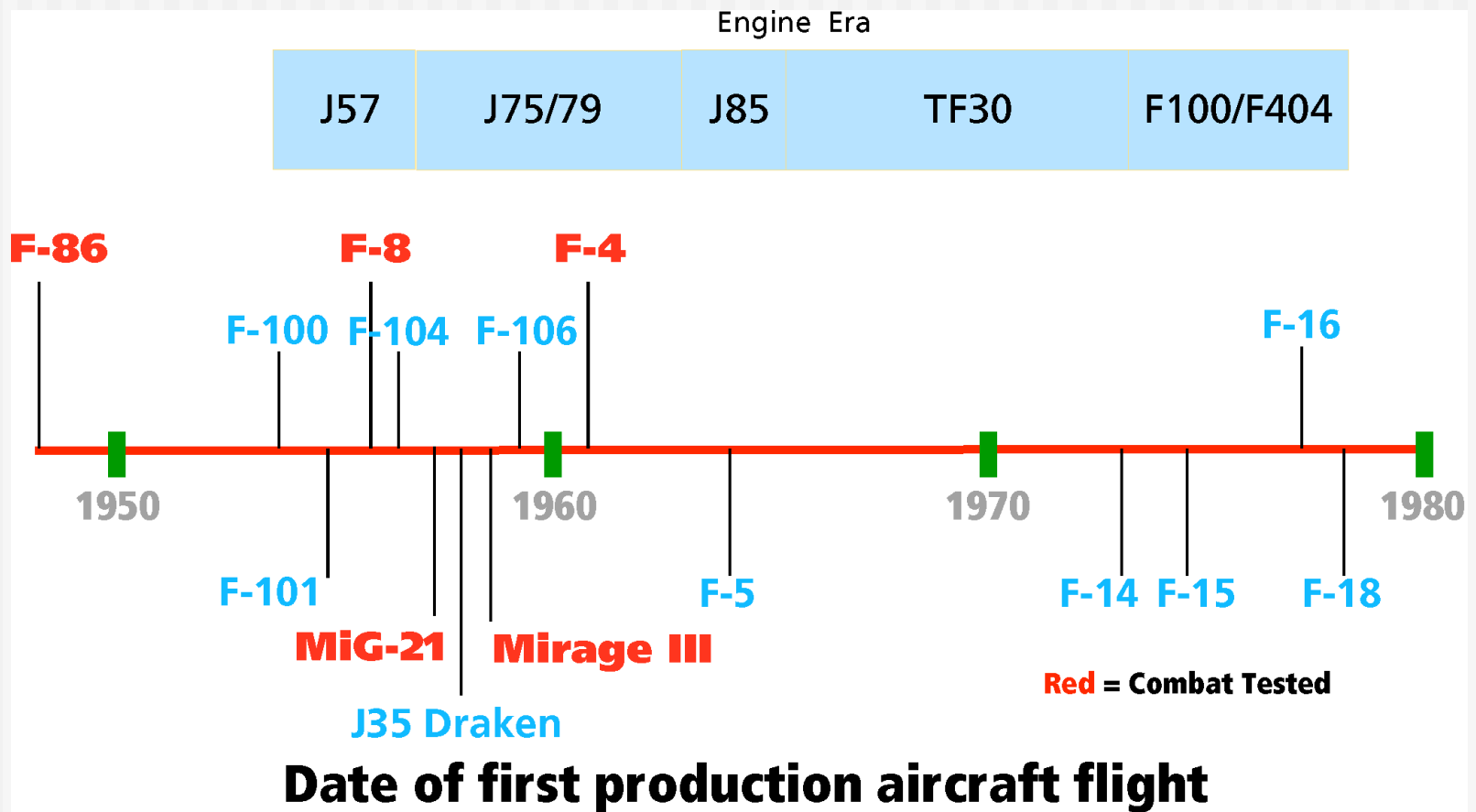
Outline

- **Purpose**
- **The fighters to be compared**
- **Criteria for comparing fighters**
- **Fighter effectiveness estimates**
- **Combat and test results**
- **Some lessons learned**
- **Applying the lessons learned**

Why review old fighters?

- **“Those who cannot remember the past are condemned to repeat it.”**
 - **G. Santayana**

Which fighters to compare?



Basis for comparing fighters

- **Compare combat results, where available**
- **Compare combat-derived effectiveness criteria**
- **Use F-86 as the point of reference for all comparisons**
 - **Combat is the ultimate (and the unkindest) judge**

Combat-derived effectiveness criteria in priority order

- **1. See him first**
- **2. Outnumber him**
- **3. Outmaneuver 'em to fire**
- **4. Kill 'em quick**

1

■ Criterion

- **Achieve surprise bounces without being surprised**

■ Why?

- **From WWI to Vietnam, 65% to 95% of all air-to-air losses were shot down unaware**

2

■ Criterion

- Outnumber the enemy **in the air**

■ Why?

- 70 vastly superior Me 262s were ground down by 2,000 inferior P-47s and P-51s

3

■ Criterion

- **When surprise fails, out-maneuver the enemy to gain firing position**

■ Why?

- **Always dominated by pilot ability & training**

4

■ Criterion

- **Achieve reliable kills during any split-second opportunity**

■ Why?

- **The more aircraft engaged, the more fleeting the firing opportunities & the more dangerous the firing delays**

Combat-derived effectiveness criteria: 1

Desired Effect	Necessary effectiveness characteristics	Measure
Achieve surprise bounces and without getting bounced	Invisibility	<ul style="list-style-type: none"> • Presented area • Smoke or no smoke • Electronic emissions or no emissions
	Sustained speed advantage in combat area	ΔV Cruise
	Rearward visibility	Angle obscured

Combat-derived effectiveness criteria: 2

Desired Effect	Necessary effectiveness characteristics	Measure
Outnumber the enemy in the air	<ul style="list-style-type: none">• Large force size (in aircraft and skilled pilots) within available budget• High sortie rates	Sorties per day per procurement \$

Combat-derived effectiveness criteria: 3

Desired Effect	Necessary effectiveness characteristics	Measure
Outmaneuver enemy to: <ul style="list-style-type: none"> • Gain firing position • Deny/defeat his firing 	<ul style="list-style-type: none"> • Quick acceleration or climb 	<ul style="list-style-type: none"> • $1g P_s$ (subsonic, transonic)
	<ul style="list-style-type: none"> • Quick deceleration and high instantaneous g (or turn rate) 	<ul style="list-style-type: none"> • $C_{LMAX} \times \frac{\text{Area}}{\text{Weight}}$
	<ul style="list-style-type: none"> • Quick Transients 	<ul style="list-style-type: none"> • Time to roll 180° and back at max g • Time to pitch from 1g to max g and back to 1g
Outlast the enemy while <u>out maneuvering him</u>	<ul style="list-style-type: none"> • Adequate fuel to complete more combat tasks (maneuvers) in equal or less time than enemy 	<ul style="list-style-type: none"> • Number of accelerations/ decelerations available (at varying H, V, and R) • For rough comparisons, use fuel fraction

Combat-derived effectiveness criteria: 4

Desired Effect	Necessary effectiveness characteristics	Measure
Obtain a reliable kill during any split-second firing opportunity from 100 feet to max visual ID range	<ul style="list-style-type: none"> • High P_K versus close-in maneuvering targets 	<ul style="list-style-type: none"> • Kills/trigger squeeze in combat
	<ul style="list-style-type: none"> • Adequate ammo for multiple engagements 	<ul style="list-style-type: none"> • Number of on-board kills
	<ul style="list-style-type: none"> • Minimum time from recognition opportunity to breaking away (to attack new target or to avoid attack) 	<ul style="list-style-type: none"> • time from opportunity to breakaway
	<ul style="list-style-type: none"> • Minimum vulnerability to hardware ECM or tactical countermeasures 	<ul style="list-style-type: none"> • Weight/cost of enemy ECM • Penalty of enemy's tactical counters

What have the last 25 years contributed to effectiveness in air-to-air combat?

- **Lethality**
- **Dogfight performance**
- **Force size**
- **Achieving surprise bounces**

Findings: Surprise

- **Since the F-86, our aircraft (except F-5 and F-16) have significantly decreased in ability to achieve surprise bounces due to increases in size, smoke, and emissions**

Findings: force size

- **Unnecessary increases in complexity and cost have decreased the effective force size per constant \$ by factors of 25 to 100 since the F-86**

Findings: maneuvering performance

- **In dogfight performance, $1g P_s$ has not improved significantly since the F-104A.**
- **Large deterioration in max g is somewhat reversed by the F-15 and F-16**

Findings: transient performance

- **Standard measures (or flight tests) of transient performance at high g do not yet exist. Only the F-86, F-5, and F-16 have attained excellent transient performance**

Findings: combat lethality

- **Combat gun lethality (and range) has deteriorated since World War II and Korean-era calibre .50 machineguns.**
- **IR missile lethality in combat was $1/2$ of gun lethality.**
- **Radar missile lethality was $1/2$ that of IR missiles—despite continuous missile R&D since 1948.**

1952-78 fighter era

- **Did the 1952-78 era produce any fighters as great as the P-51 and F-86?**

Five "almost great" fighters

Type	Shortcomings	Comment
F-5E	With 20% less weight, could have dominated any U.S. or foreign fighter up through F-14	Only twin-engine ever to become a first rate fighter
F-104A (J79-19)	With 25% more wing, low tail, and transonic inlet, could beat F-14, F-15, and match F-16.	Obsessive emphasis on Mach 2 burst speed ruined an otherwise brilliant design

Five "almost great" fighters

Type	Shortcomings	Comment
F-16	Addition of 3,000 pounds and \$3 million per unit to the F-16 changed a great fighter to an "almost great"	Showed that a single, fixed inlet F100 engine design can have significantly longer range, higher supersonic acceleration and better transient performance than a twin with movable inlets

Five "almost great" fighters

Type	Shortcomings	Comment
Mirage III	With J79 engine, would have been best fighter of the 1960-1976 era	Same performance as F-106 at one-half the size
J-35 Draken	With J79 engine, would have been best fighter of the 1960-1976 era	<ul style="list-style-type: none">• First double delta• First high performance delta• Outmaneuvers Mirage III and F-106

How much progress in combat effectiveness since F-86?

■ **Combat results**

- **Korea (1950-52) F-86 produced 14:1 kill-loss ratio against MiG-15**
- **North Vietnam (1967-72)**
 - F-4 obtained between 1:1 and 2:1 against MiG-21

How much progress in combat effectiveness since F-86?

- **Combat results (continued)**
 - **Israeli (1967 & 1973) Mirage III achieved better than 20:1 against MiG-21 (preferred by Israelis over F-4)**
 - **Indo-Pakistani War (1965)**
 - F-86 Mk VI (bought for \$100,000) attained better than 6:1 against Indian MiG-21, Su-7, and Hunter.
 - 90 F-86s + 75 others achieved air superiority in 7 days against force of 700

How much progress in combat effectiveness since F-86?

■ Test Results

■ 1965 Operation Featherduster air-to-air tests.

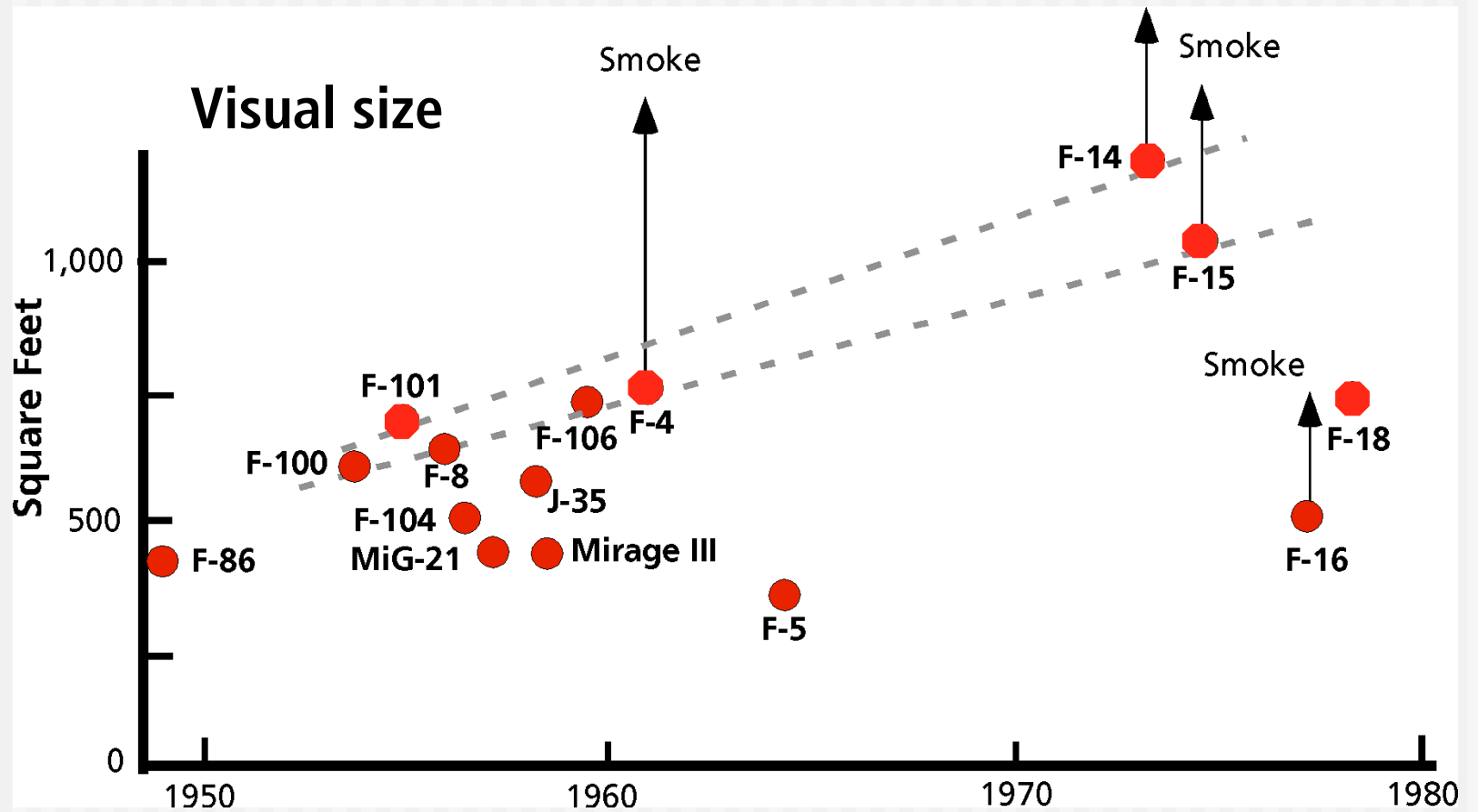
- F-86 had exchange ratio advantage over F-100, F-4, F-104, and F-105
- Matched 1:1 against F-5

■ 1977 AIMVAL/ACEVAL test.

- F-14 and F-15 could not achieve significant exchange ratio advantage over the F-5

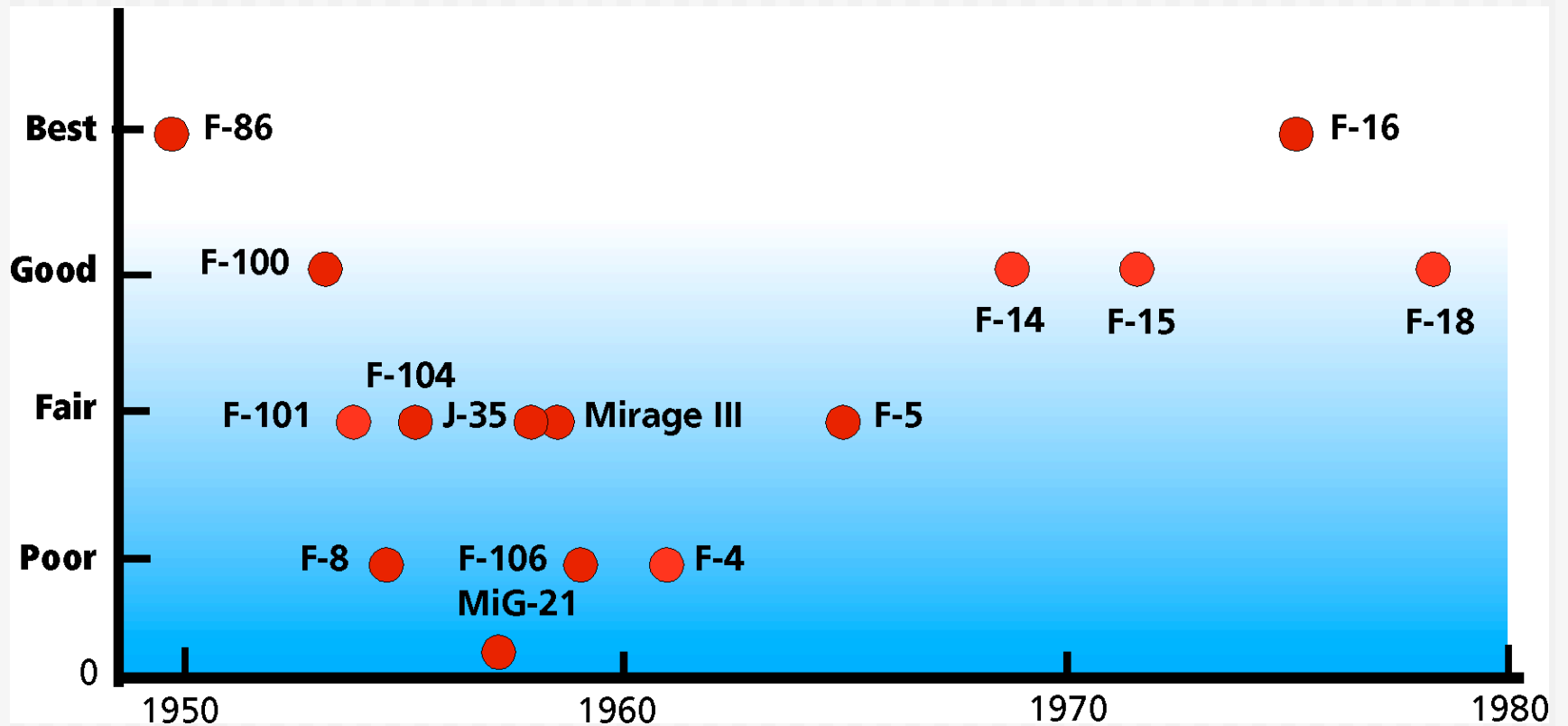
■ After 30 years and 12 new fighter programs, have we yet designed a fighter clearly superior to the F-86?

Progress: surprise bounces



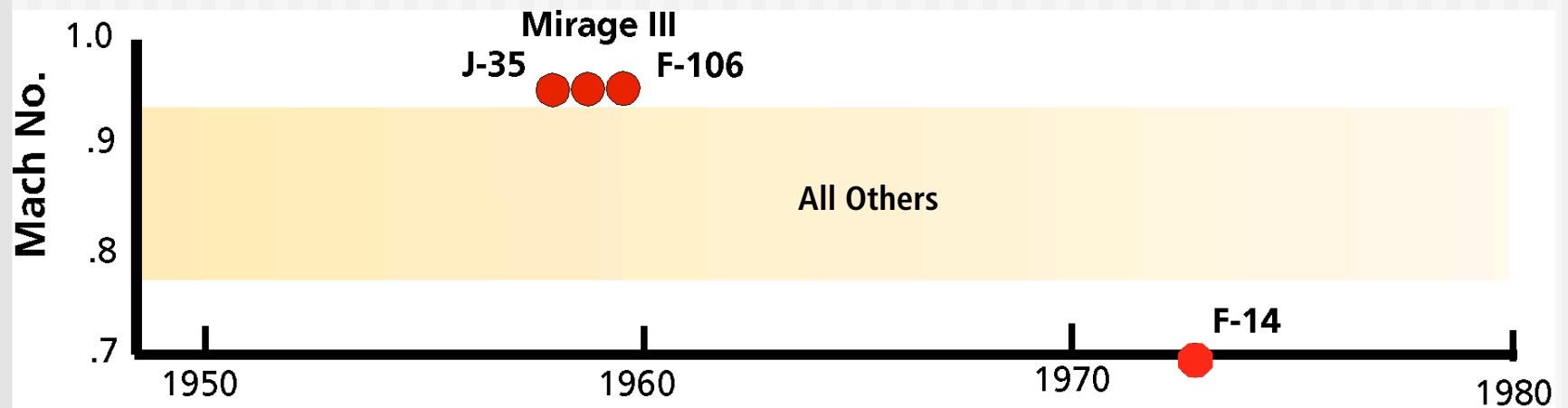
Progress: surprise bounces

Rearward visibility

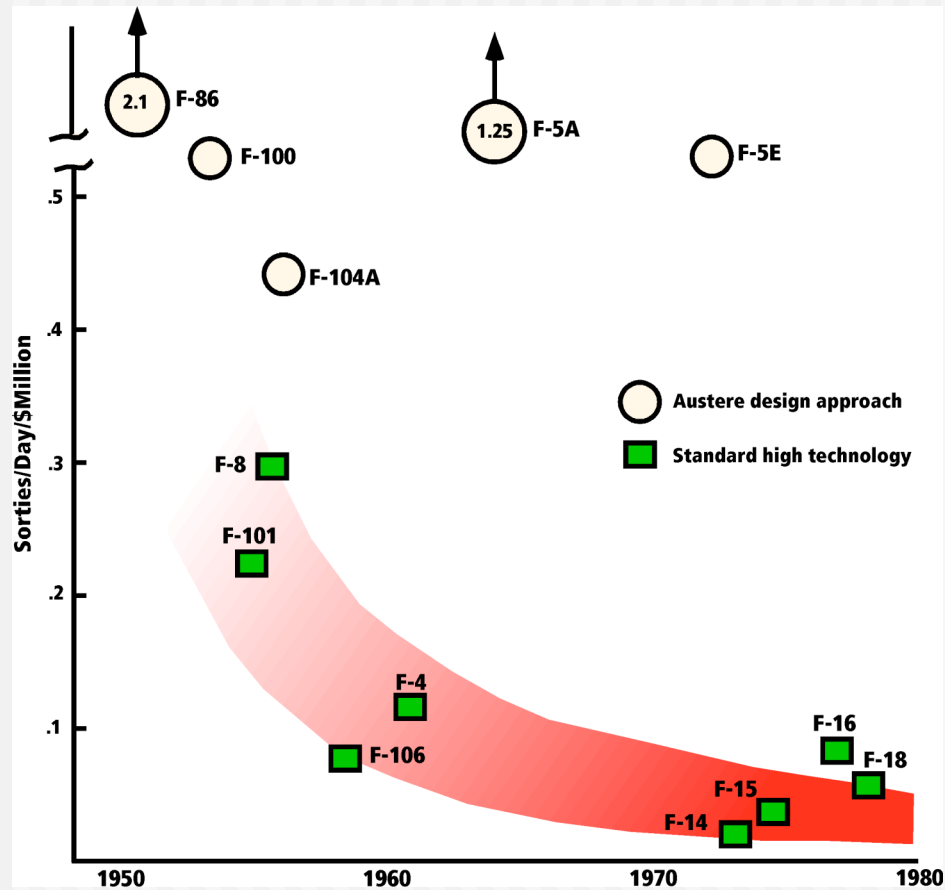


Progress: surprise bounces

Cruising speed



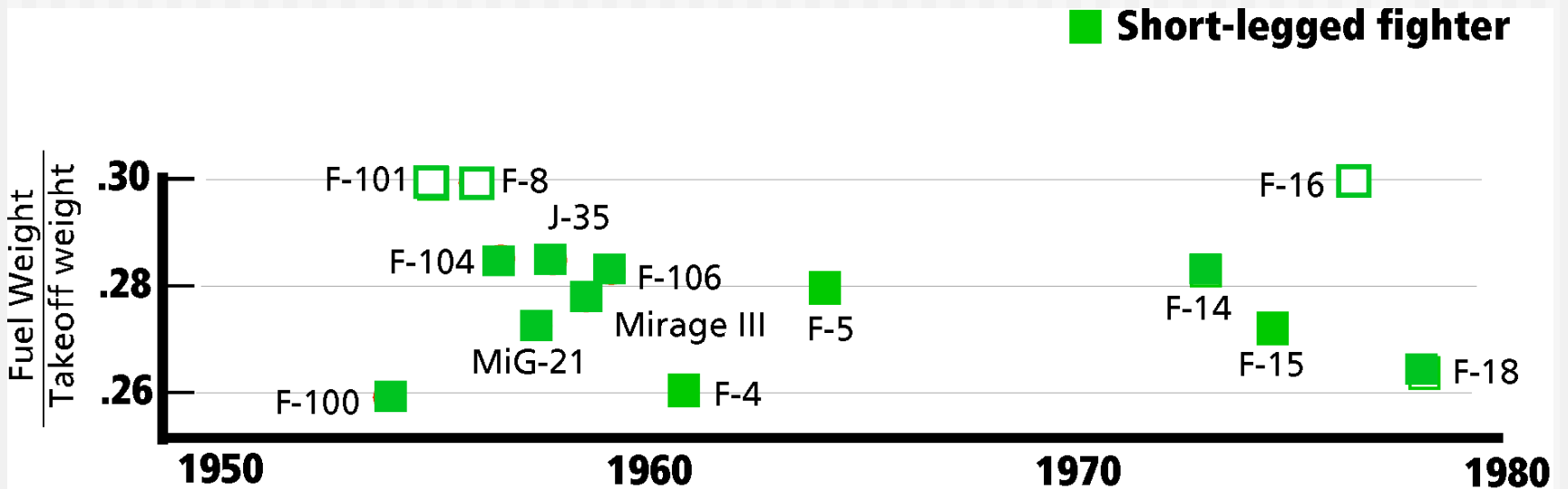
Progress: effective force size



Unit program cost@
750 a/c in FY \$79

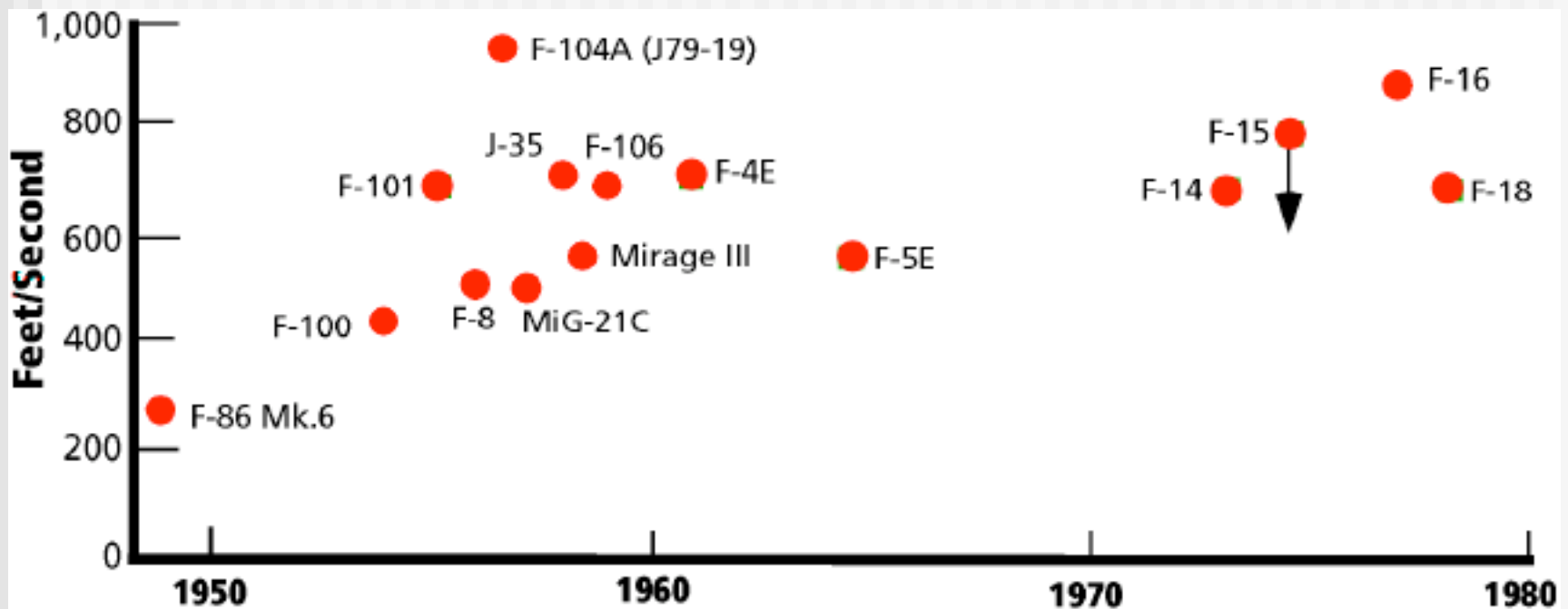
Progress: performance

Fuel Fraction



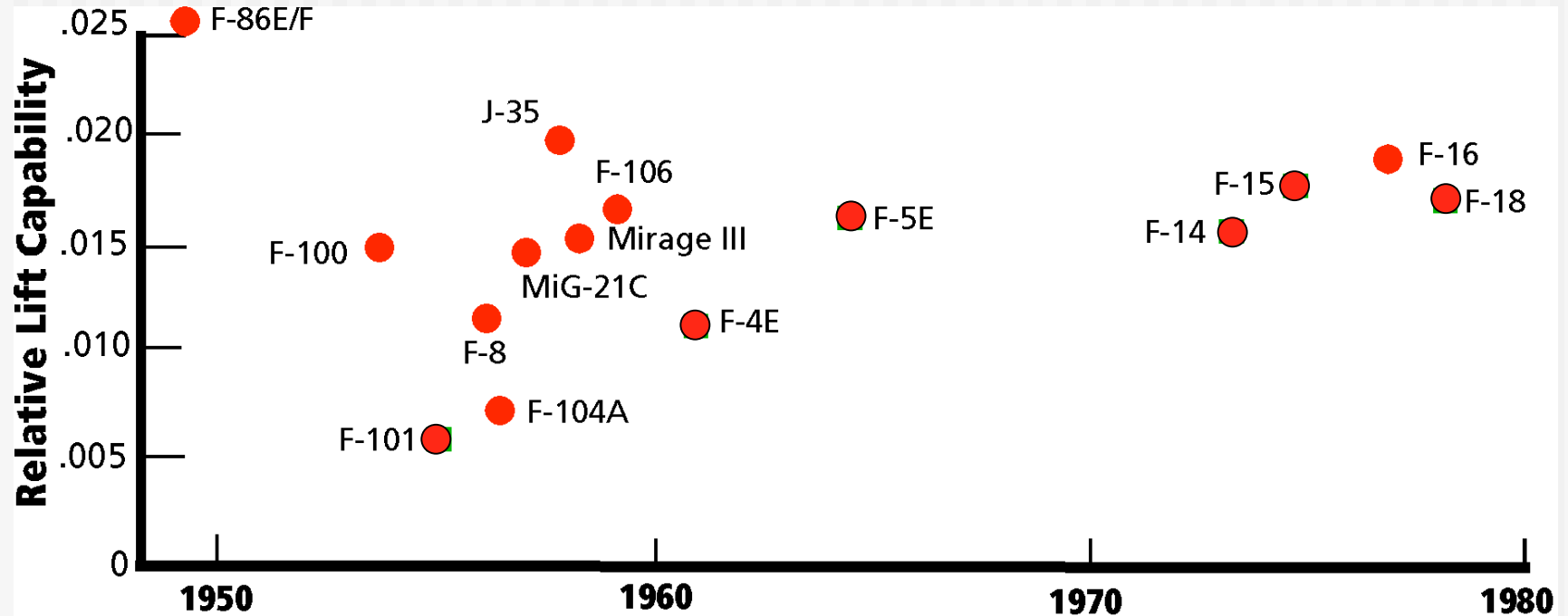
Progress: dogfight performance

Acceleration— P_s @ 1g or maximum rate of climb

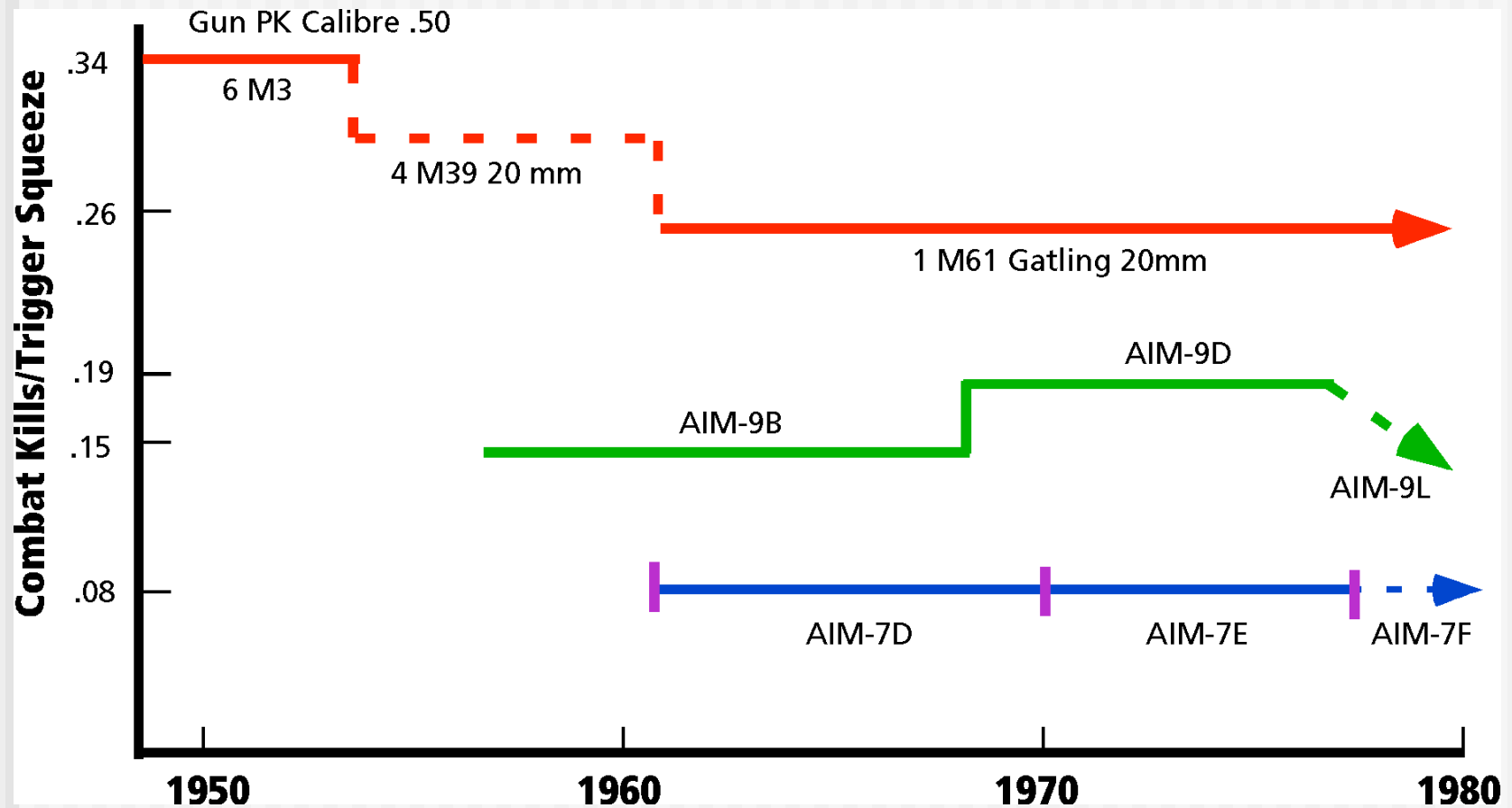


Progress: dogfight performance

Instantaneous turn $C_{L\ MAX}$ (S/W) @Mach 0.5



Progress: lethality



Some lessons

- **We have not been able to convert large U.S. advantages in engine, structural, aerodynamic, and microelectronic technologies into a fighter radically superior to all its predecessors and foreign competitors**

Some lessons

■ Some reasons

- **Lack of clear understanding of the critical components of fighter combat effectiveness**
- **Inability to enforce design discipline upon service and industrial bureaucracies**
- **Addition of heavy air-to-ground (and/or interceptor) compromises to every fighter since 1950—persistence of the World War II fighter-bomber mentality**

Some lessons

■ Some reasons

- **Failure to improve engine thrust-to-weight since the J85-21, due to misoptimization for excessive bypass, pressure, and temperature (and specification inflation)**
- **Refusal to recognize that Vietnam combat demonstrated the ineffectiveness of air intercept radars and radar missiles (for reasons that R&D cannot eliminate)**

Applying the lessons learned

- **A new air-to-air fighter to dominate all existing fighters would need to emphasize**
 - **20 minutes combat cruise above Mach 1.2**
 - **Subsonic maximum g and transients near F-16 level**
 - **Primary dependence on passive avionics/ anti-radiation missile**

Applying the lessons learned

- **Radical elimination of specifications and equipment**
- **Size smaller than F-5**
- **Cost below \$4 million (in FY79 dollars)**
- **More lethal gun (higher V_0 , smaller caliber)**
- **More reliable snap-shoot IR missile (head on unnecessary)**