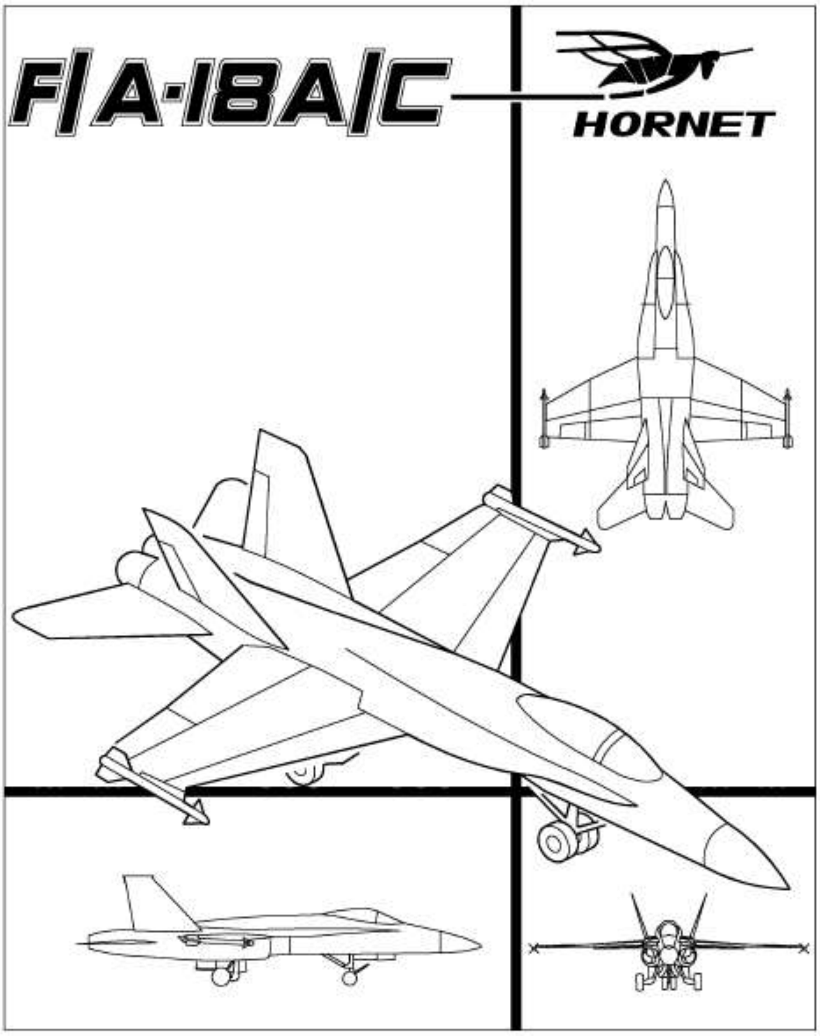
# BMS FLIGHT MODEL
# F/A-18A & C AIRCRAFT

McDonell Douglas Corporation.




Manual reference: BMS-A1-F18AC-NFM-210

Changes: Draft Version

CAUTION STATEMENT: This document is to be use only for simulation. Do not try to apply the procedures and or advices contained in it if you have the opportunity to fly this plane in real life. By the way, if you had (or still have) flew this aircraft, your comments, criticism and more are welcome.

# PART XI: PERFORMANCE DATA

## Contents

# PART 1: STANDARD DATA

**LIMITATIONS**

This section deals with speed and load factor limitations for the different documented configurations.

**CONFIGURATION DEFINITION**

The performance data are described for various aircraft configurations (loads, weight…). Each configuration is defined by the set of loads (internal or external) and the fuel fraction. For all weapons or loads, contribution to the aircraft configuration is its weight and its drag.

***DRAG INDEX SYSTEM***

Drag of loads is modeled through the general BMS Drag Index mechanism: each object has its own Drag Index value (DI) that is converted into Drag coefficient ($C_D$) by a ratio specific to the aircraft and depending form the Mach number. This allows the definition of the Drag coefficient of a given configuration from the one of the reference configuration (clean).

The Drag Index of a configuration is the sum of the Drag Index of each external load of the configuration. This means that the interactions between loads are not managed by BMS DRAG INDEX SYSTEM: if the same load set (pylon, rail, launcher and missile) is installed twice under each wing, the drag contribution is twice the drag contribution of one set installed under each wing.

Let's call

- DI the drag index of the configuration.
- $C_{D\ CONF}$ the Drag coefficient of the aircraft in the identified configuration
- $C_{D\ REF}$ the Drag coefficient of the aircraft in the reference (clean) configuration, depending on Mach number and Angle of Attack (AoA)

$C_{D\ CONF} = C_{D\ REF} + DI \cdot R(Mach)$

For the F/A-18, up to Mach 0.9, R*(Mach)* = 0.000075, over Mach 1.0, R*(Mach)* = 0.000150, between these values, R = 0.00075 + (Mach-0.9).0.00075

A consequence of this definition is that the Drag contribution of a configuration does not depend on the angle of attack (AoA).

***STATION DEFINITION***

The external stores of the F/A-18A & C are located on the 9 available stations described in the figure bellow:


***CONFIGURATION 0***

This configuration is the reference configuration, with

- two AIM-9 on wing tip (1 & 9)
- two AIM-120 on fuselage (4 & 6)
- A gross weight of 32,000 lbs. For an aircraft with a standard equipped pilot and its full load of gun shells, it means a remaining fuel load of 5,124 lbs, 47.4% of the internal fuel capacity.

Subsonic load factor (Ngz) limit (w/o OVERRIDE) enforced by FLCS is 7.50 G

The BMS Drag Index of this configuration is 17.

The NATOPS TOTAL BASIC STORE DRAG INDEX (as defined page 11-4 of A1-F18AC-NFM-210 is 8.0

***CONFIGURATION 1***

This configuration is the regular Combat Air Patrol configuration, with

- two AIM-9 on station wing tip (1 & 9),
- two AIM-120 on fuselage (4 & 6), two AIM-120 on external wing (2 & 8) with LAU-115 and LAU-127,
- one 330 Gal external tank on Center line station (5)
- A gross weight of 35,000 lbs. For an aircraft with a standard equipped pilot and its full load of gun shells, it means a remaining fuel load of 5,492 lbs, 42.4% of its fuel capacity.

Subsonic load factor (Ngz) limit (w/o OVERRIDE) enforced by FLCS is 7.05 G

Maximum allowed speed is Mach 1.60

The BMS Drag Index of this configuration is 80.

The NATOPS TOTAL BASIC STORE DRAG INDEX (as defined page 11-4 of A1-F18AC-NFM-210 is 39.5

***CONFIGURATION 2***

This configuration is defined by external stores being:

- two AIM-9 on station wing tip (1 & 9),
- two 330 Gal external tank on internal wing pylon (3 & 7)
- one 330 Gal external tank on Center line station (5)
- one AAS-38 FLIR & LTD(R) pod on right fuselage pylon (6)
- four GBU-12 on external wing pylon (2 & 8) with SUU-63 and BRU-33/A VER
- A gross weight of 40,000 lbs. For an aircraft with a standard equipped pilot and its full load of gun shells, it means a remaining fuel load of 7,808 lbs, 45.3% of its fuel capacity.

Subsonic load factor (Ngz) limit (w/o OVERRIDE) enforced by FLCS is 6.19 G

Maximum allowed speed is Mach 1.60 or 635Kts (CAS) whichever is less.

The BMS Drag Index of this configuration is 184.

The NATOPS TOTAL BASIC STORE DRAG INDEX (as defined page 11-4 of A1-F18AC-NFM-210 is 124.5

***FLCS load factor limiter.***

The FLCS of the F/A-18 A/C protect the aircraft from exceeding load factor operational limitations during symmetrical flight and if the aircraft is clean of with only A/A loads.

Maximum normal load factor (NgZMax) allowed by the FLCS is continuously computed from the following input:

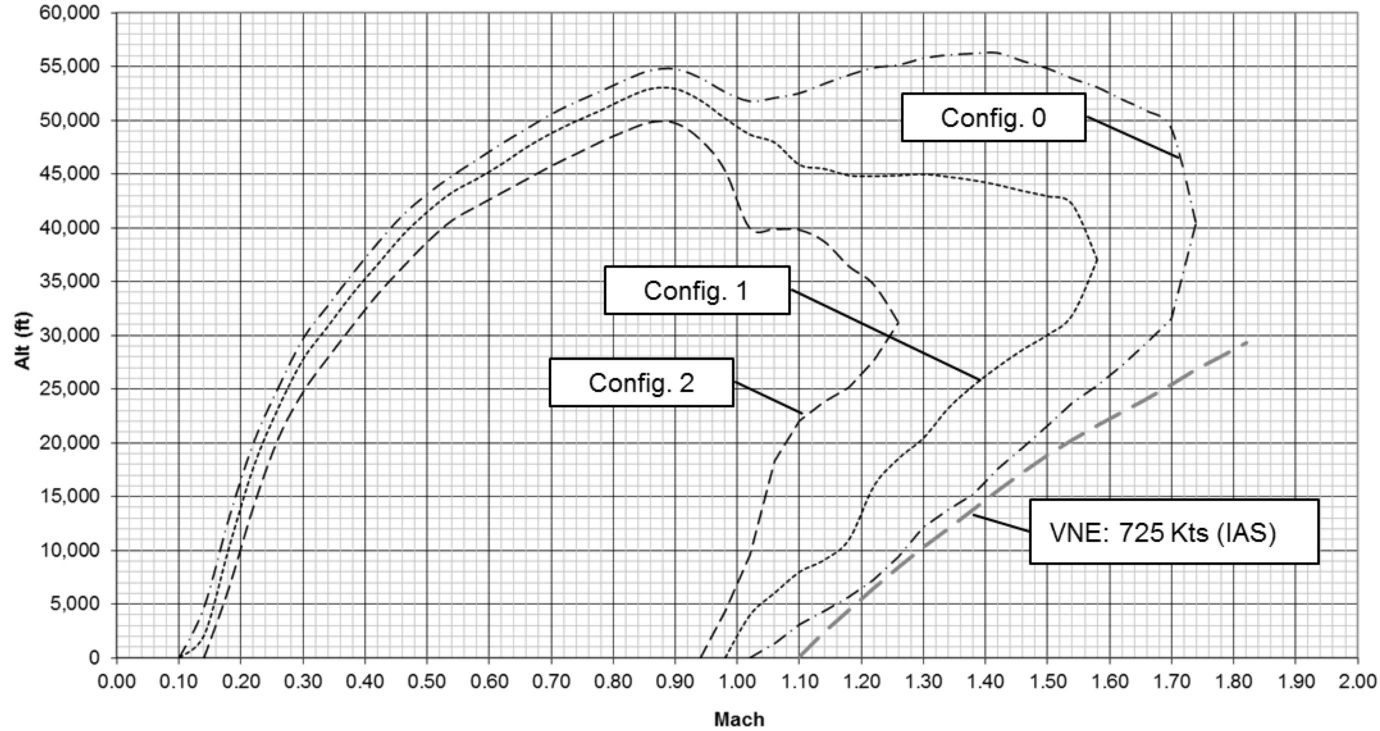
- GW : Current Gross Weight in lbs
- M : Mach number
- Paddle Switch : ON or OFF

```
If (GW < 32357) Then
    NgZMax = 7.5
Else
    If (GW > 44000) Then
        NgZMax = 5.5
    Else
        NgZMax = 7.5 - 2*(GW-32357)/(44000-32357)
    End If
End If
If (M > 0.9 And M < 1.1) Then
    NgZMax = NgZMax - 1
    If (NgZMax < 5) Then
        NgZMax = 5
    End If
End If
If (Paddle_Switch=ON) Then
    NgZMax = NgZMax * 4 / 3
End If
```

# *Level Flight Envelope*

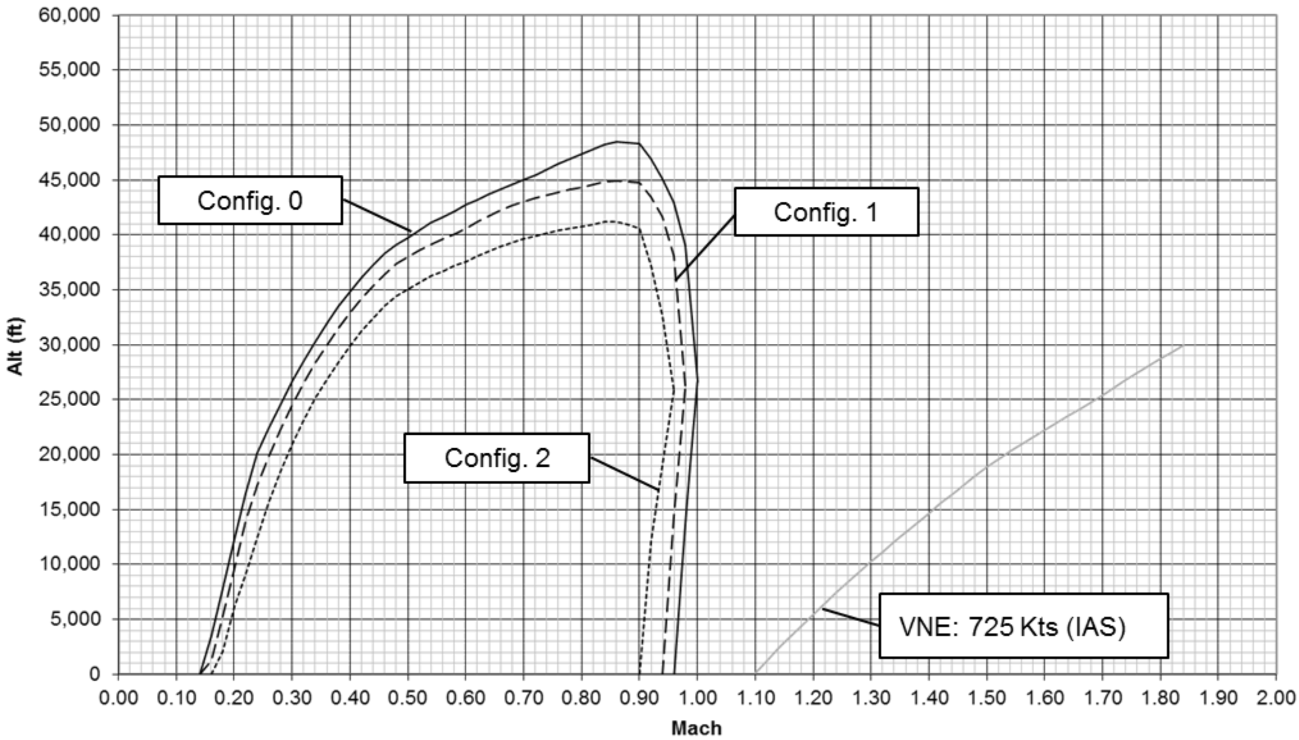
**DATA BASIS : COMPUTED**
**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**




**DATA BASIS : COMPUTED**
**CONDITIONS:**
**Standard Day - ISA**
**MILL Power**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**



# PART 2: CLIMB

## INTRODUCTION

This section defines the climb performances of the F/A-18A & C airplane.

## CONSTANT TRUE AIR SPEED CLIMB

For each identified configuration, two main climb performances are detailed: Constant true air speed climb rate, and climb angle.

The first one is the vertical velocity (in ft/s), of the aircraft when load factor is 1G and true air speed (TAS) is constant, values are given with Maximum After Burner (Max A/B) and Military Power (MIL).

The second one is the climb angle under the same conditions (angle between the flight path, or velocity vector, and the horizontal), it is materialized in the Head Up Display by the position of the Flight Path Marker (FPM) along the vertical scale.

Note that these values are lower than Constant Mach Number Climb rate and angle below 36,000ft, as sound speed decrease with altitude, a constant Mach number climb means True air speed decreasing, and consequently allow higher climb rates and angles.

On the opposite, a constant Indicated Air Speed (IAS) climb provide a much lower climb rate as it request a True Air Speed increase when climb.

In addition, for each configuration, you will find a Climb Schedule Table giving the best climb speed (Mach number, Indicated Air Speed and True Air Speed) along altitude.

## SUBSONIC ISO-MACH CLIMB SCHEDULE

This kind of diagram describe time, distance and fuel required to climb to a given altitude, using maximum A/B thrust and an Iso-Mach flight profile.

This flight profile assumes the climb angle of the flight path is continuously adapted to keep the Mach number constant along the time.

The values displayed in these diagram do not take into account time, distance and fuel required to accelerate to the desired Mach number, nor to rotate from level flight to climb attitude.

These diagrams contain performances for various aircraft configurations, assumed to be effective at the start of the climb.

## SUBSONIC ISO-CAS CLIMB SCHEDULE

This kind of diagram describe time, distance and fuel required to climb to a given altitude, using maximum Military Thrust and an Iso-CAS flight profile until a given Mach number is reached, then an iso-Mach flight profile.

This flight profile assumes the climb angle of the flight path is continuously adapted to keep the Corrected Air Speed (CAS) constant along the time, and then Mach number.

The values displayed in these diagram do not take into account time, distance and fuel required to accelerate to the desired Mach number, nor to rotate from level flight to climb attitude.

These diagrams contain performances for various aircraft configurations, assumed to be effective at the start of the climb.

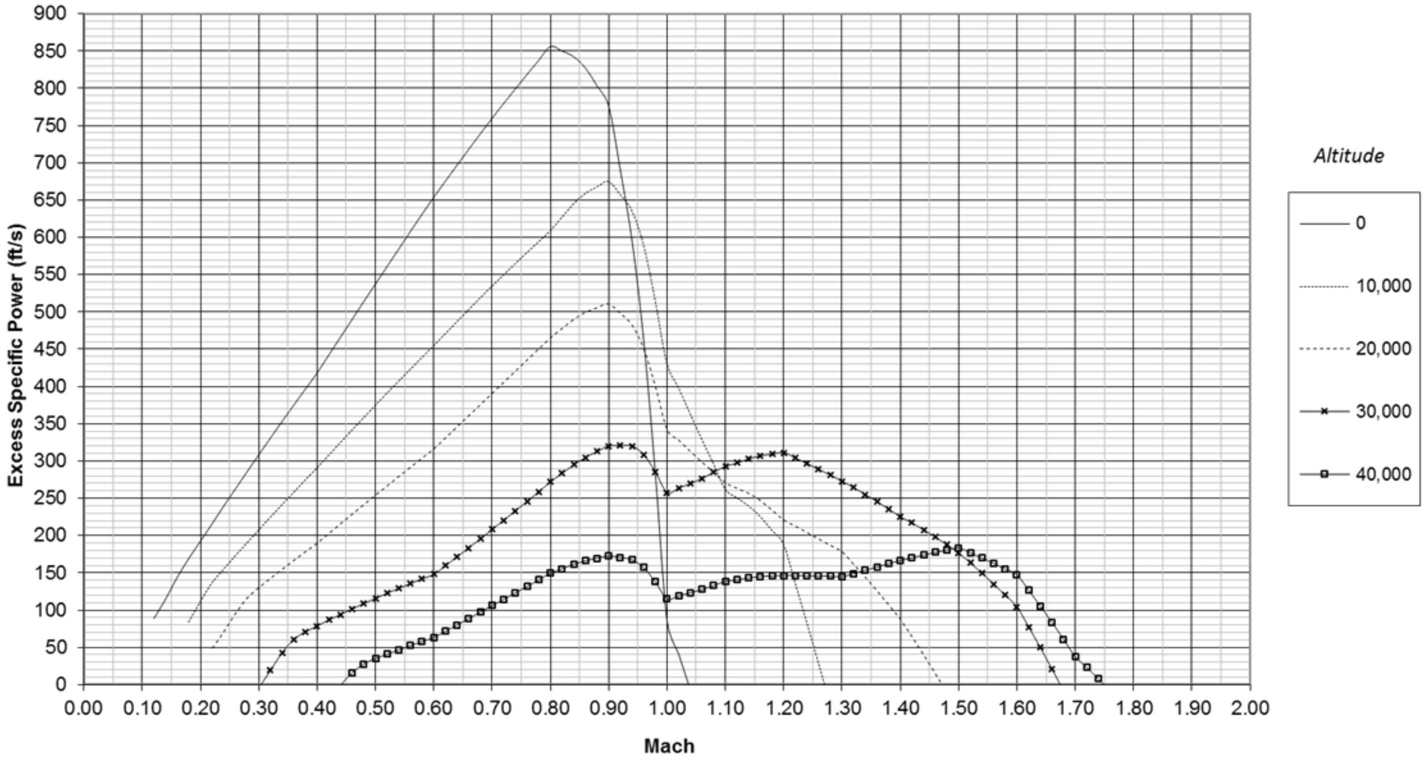
**DATA BASIS : COMPUTED**
**26-Jan-16**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

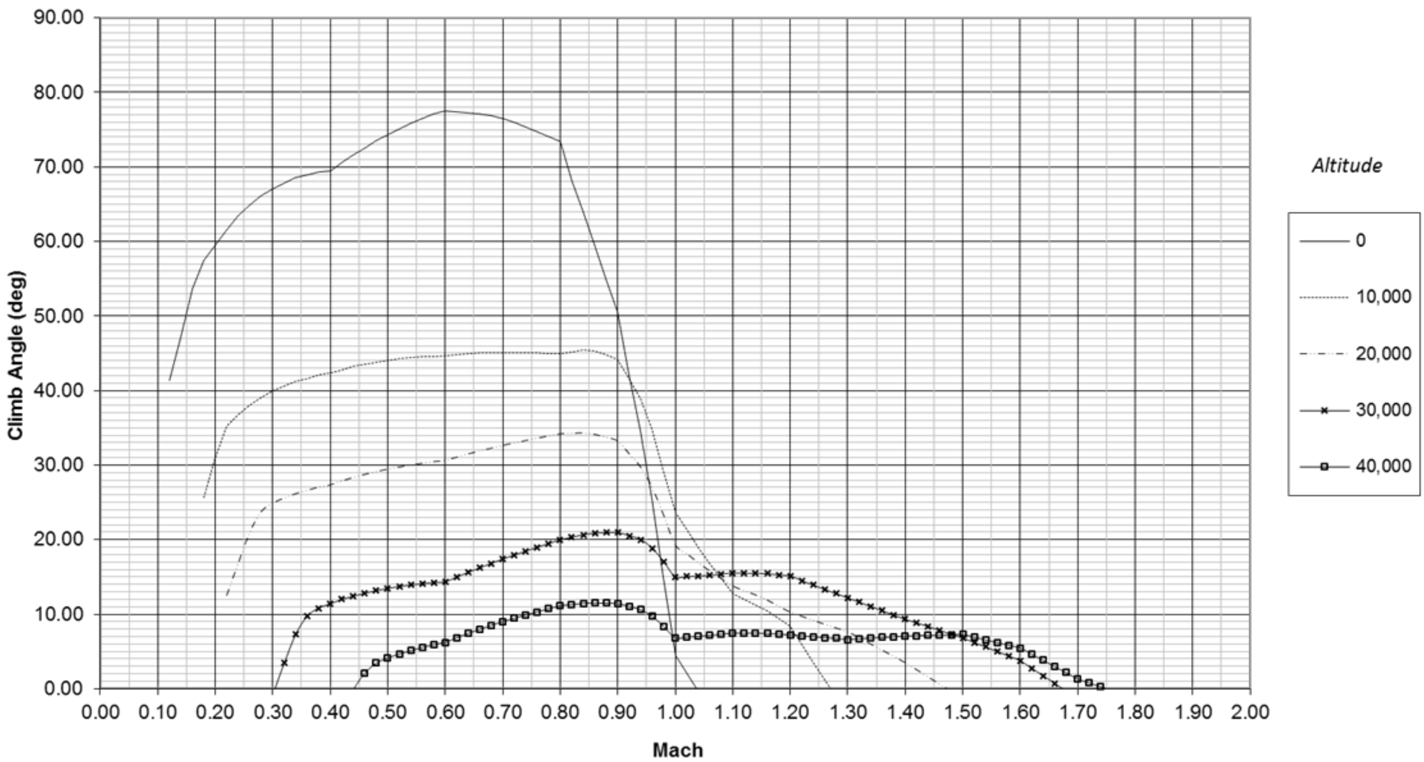
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**

**Climb Rate at Constant True Air Speed**




**Climb Angle at Constant True Air Speed**

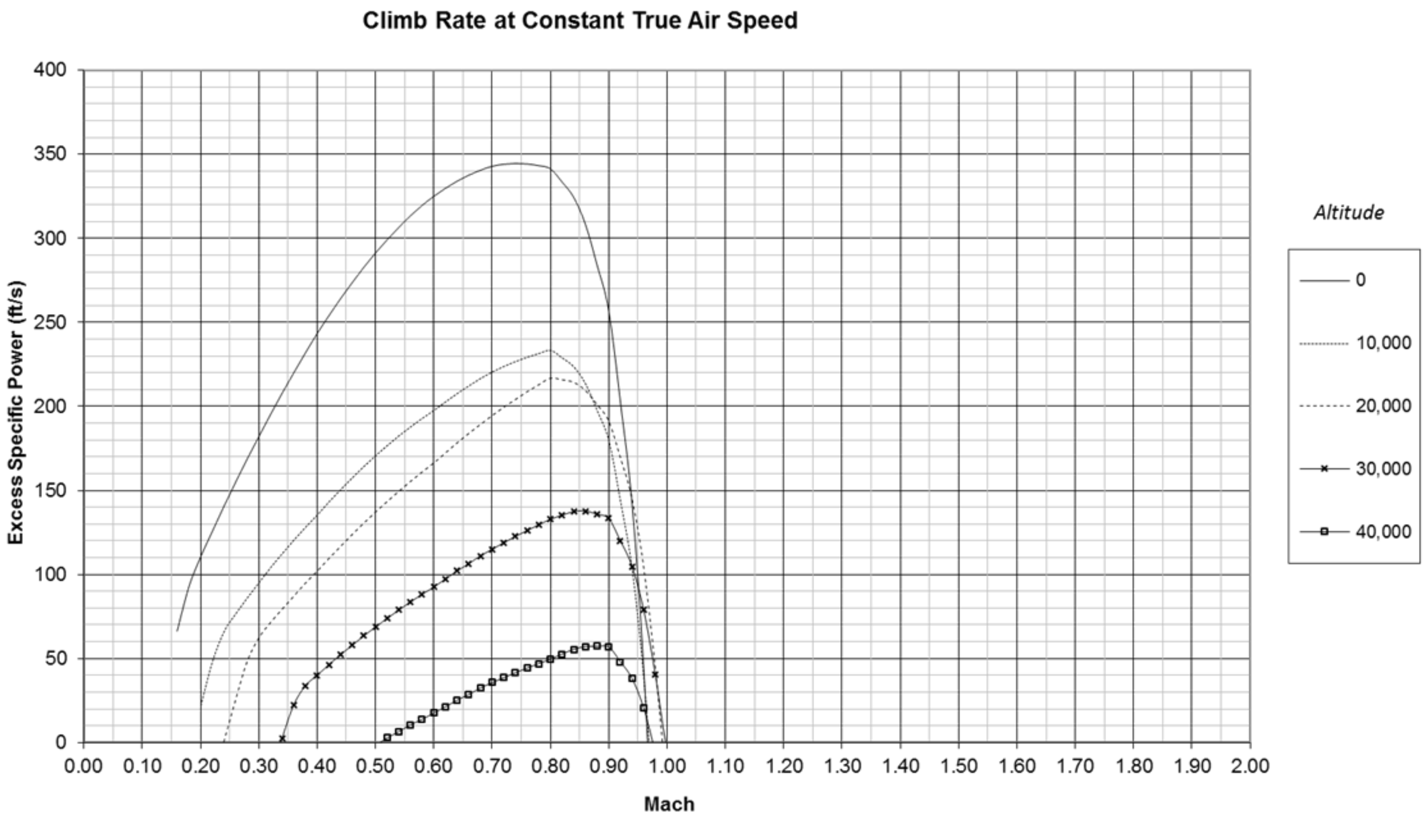


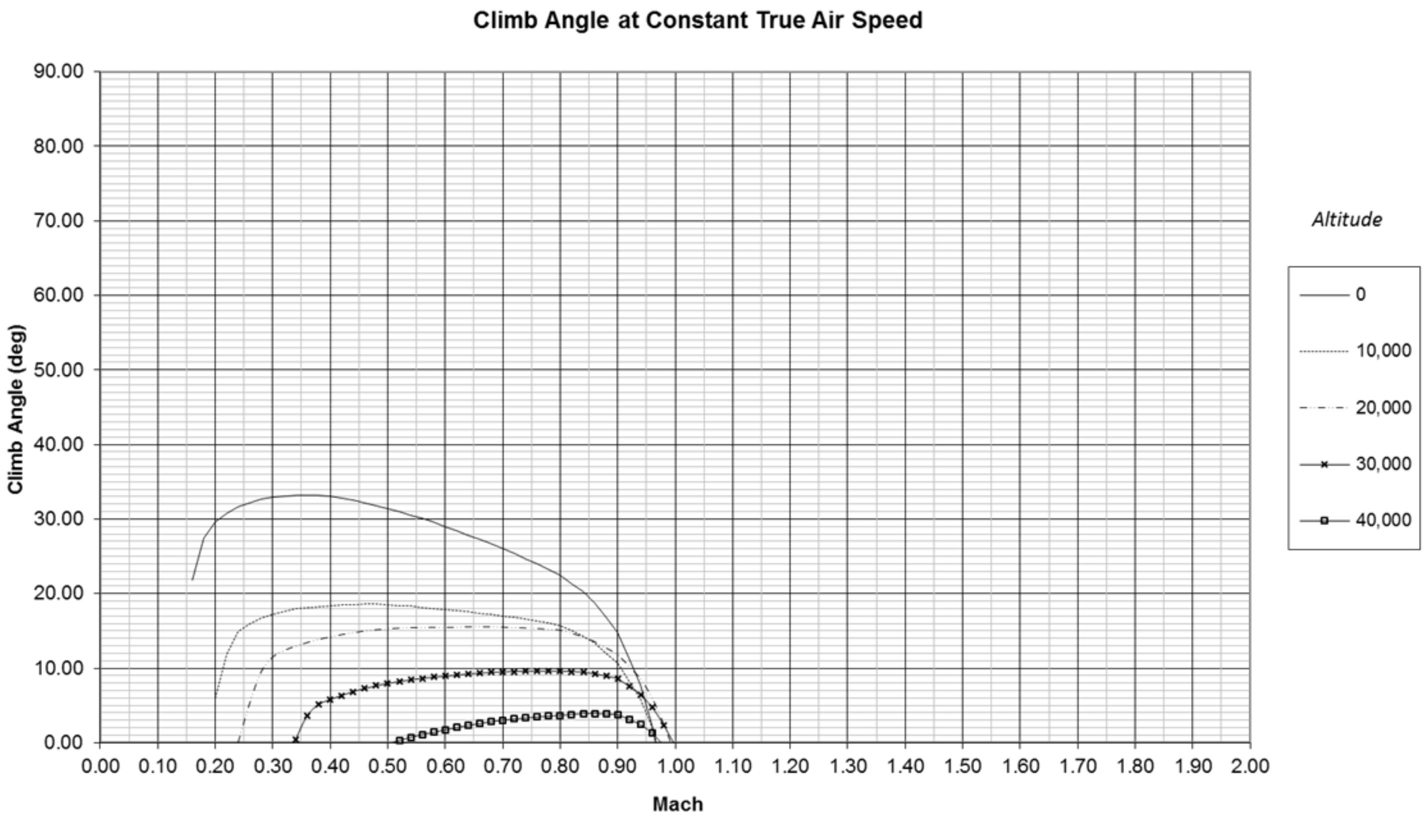
**DATA BASIS : COMPUTED**
**26-Jan-16**

**CONDITIONS:**
**Standard Day - ISA**
**MIL Power**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



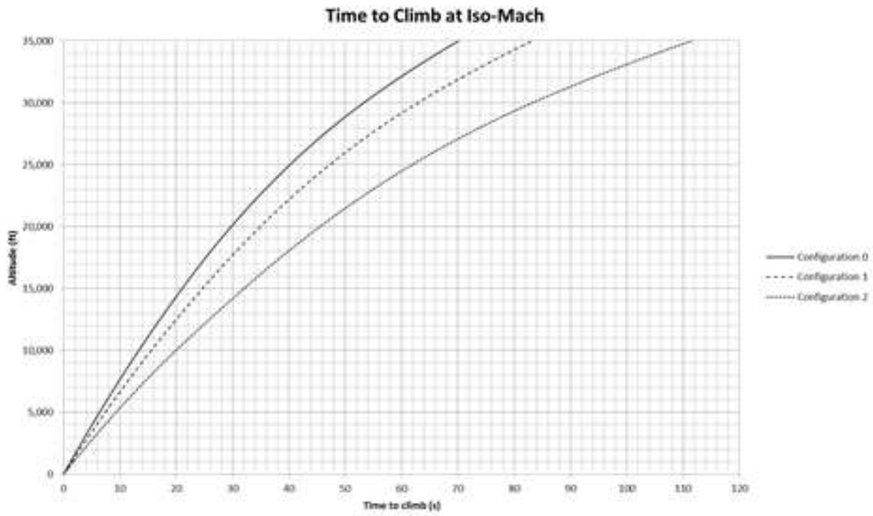
# *Iso-Mach Climb Schedule*

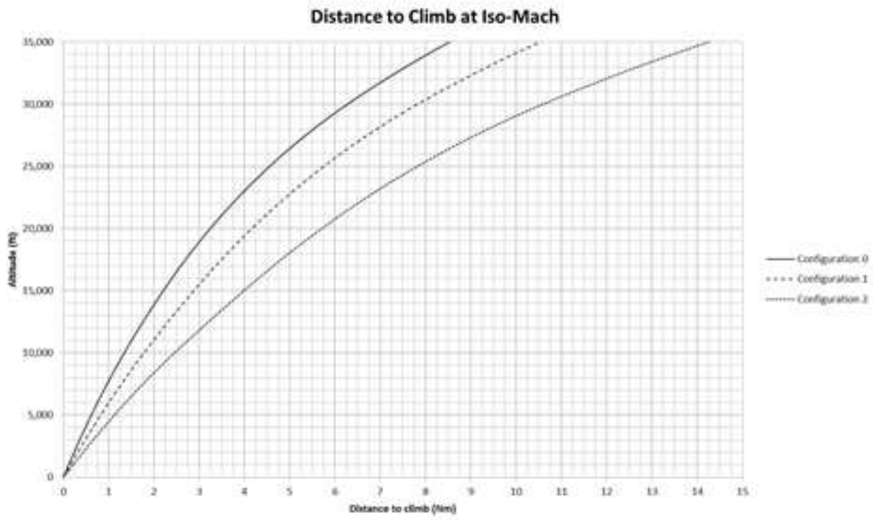
**DATA BASIS : COMPUTED**
**9-Feb-16**

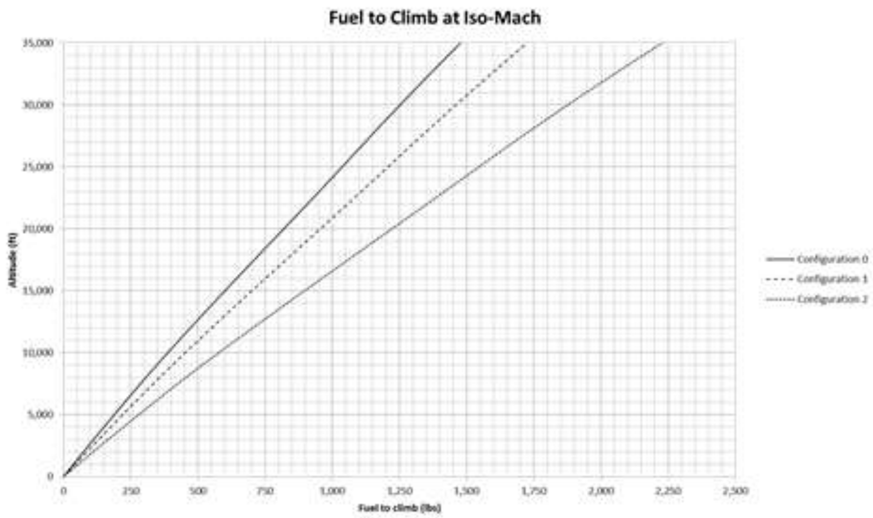
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0 : M 0.88**
**CONFIGURATION 1 : M 0.86**
**CONFIGURATION 2 : M 0.82**



# *Iso-CAS Climb Schedule*

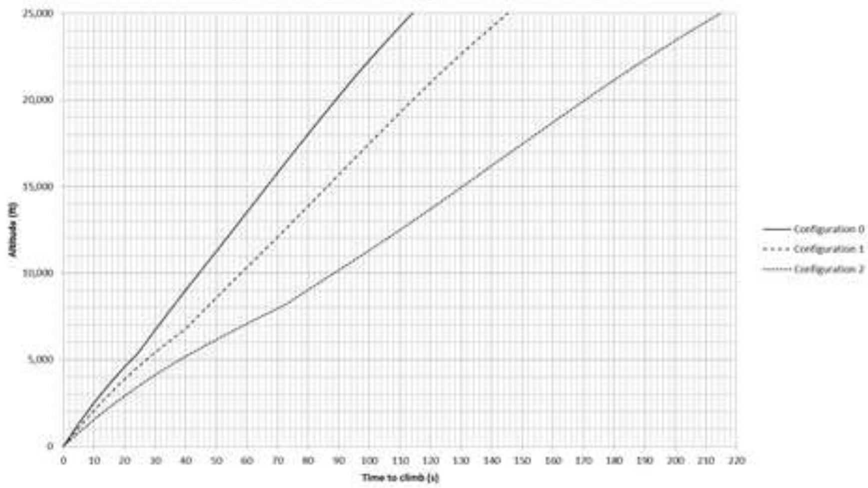
**DATA BASIS : COMPUTED**
**9-Feb-16**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**

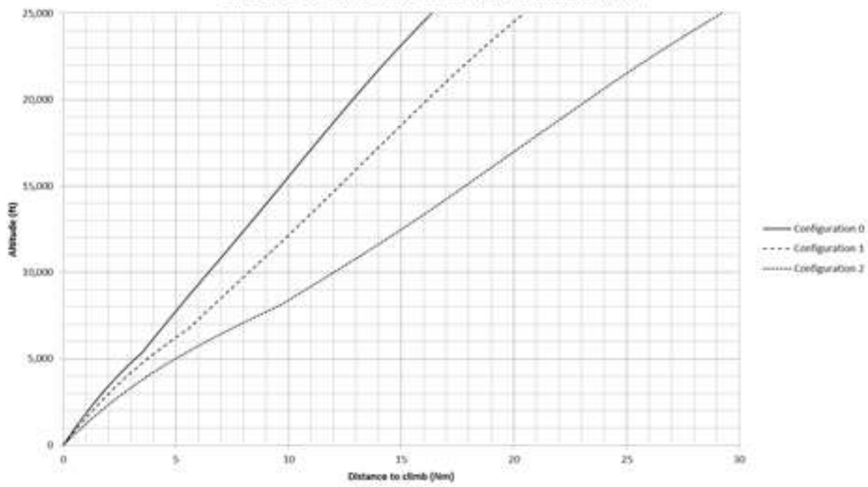
**CONDITIONS:**
**Standard Day - ISA**
**MIL Power**

**CONFIGURATION 0 : 515Kts / M 0.85**
**CONFIGURATION 1 : 490Kts / M 0.83**
**CONFIGURATION 2 : 460Kts / M 0.80**

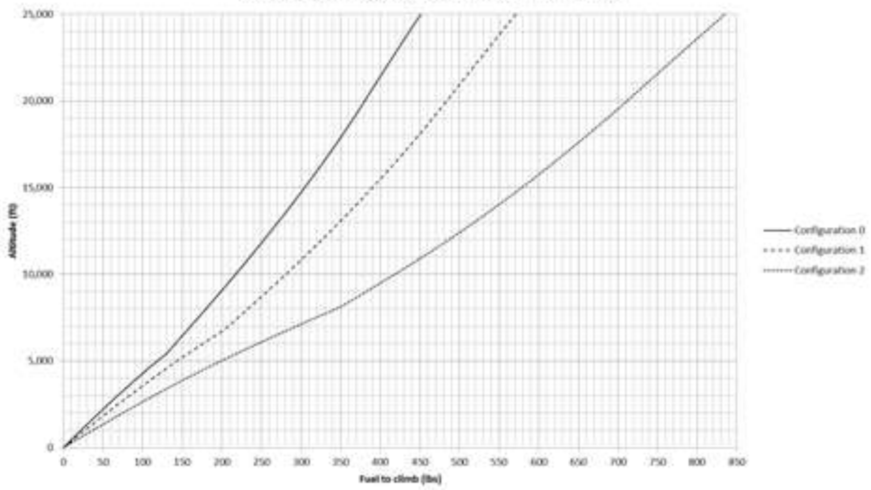
**Time to Climb at Iso-CAS until maximum Mach**




**Distance to Climb at Iso-CAS until maximum Mach**




**Fuel to Climb at Iso-CAS until maximum Mach**



# PART 3: CRUISE, RANGE and ENDURANCE

## INTRODUCTION

This section presents the fuel management data during cruise flight (constant speed and altitude in Military Thrust). For each aircraft configuration, you will find the instantaneous fuel flow (in lbs/h) required to sustain a given Mach number at a given altitude, the autonomy at a given Mach number and altitude (distance, in Nm that can be covered with a unit amount of fuel: 1,000lbs), and the endurance at a given Mach number and altitude (time in minutes that can be flew with a unit amount of fuel: 1,000lbs).

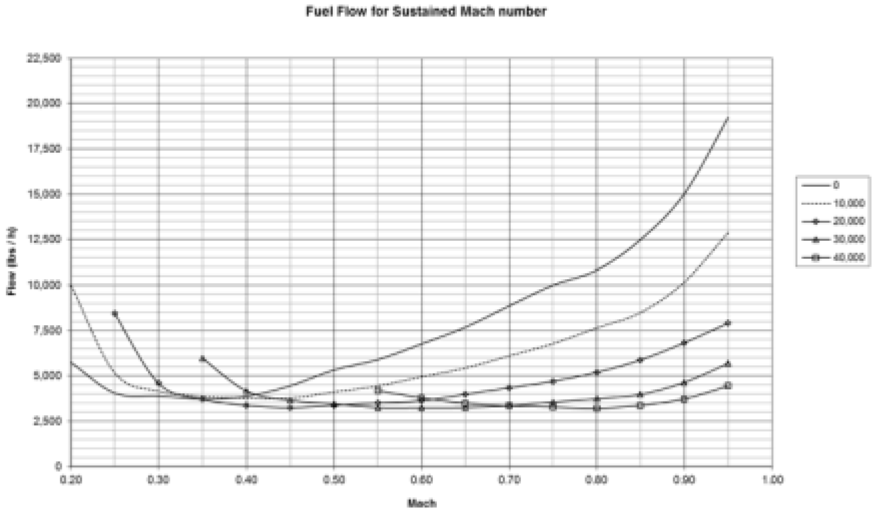
# *Fuel Flow – Endurance - Autonomy*

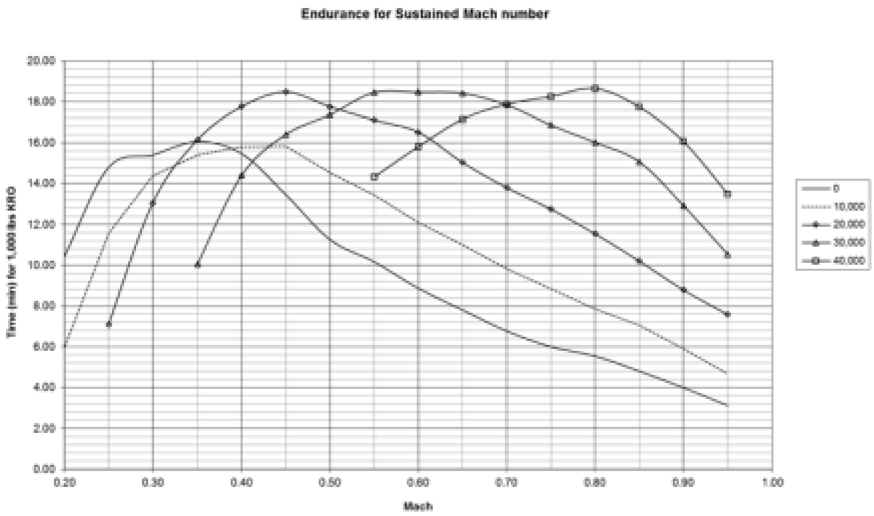
**DATA BASIS : COMPUTED**
**26-Jan-16**

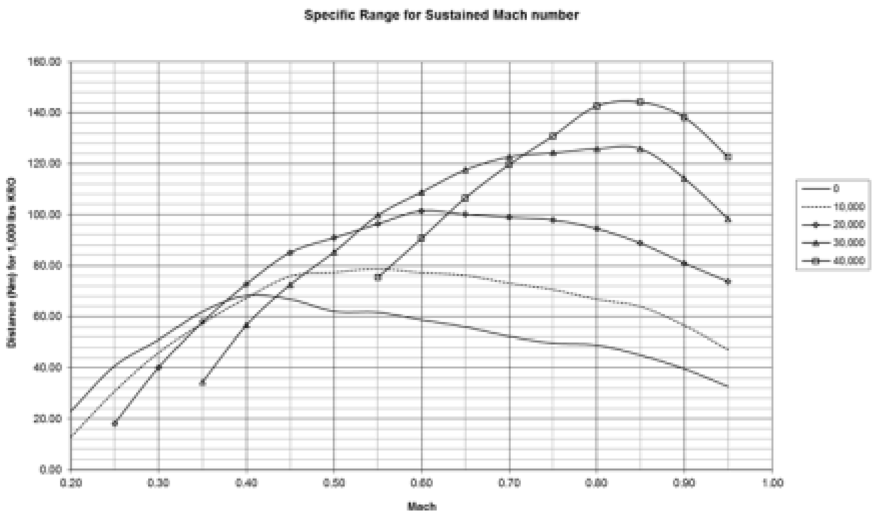
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**MIL Power**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



# *Fuel Flow – Endurance - Autonomy*

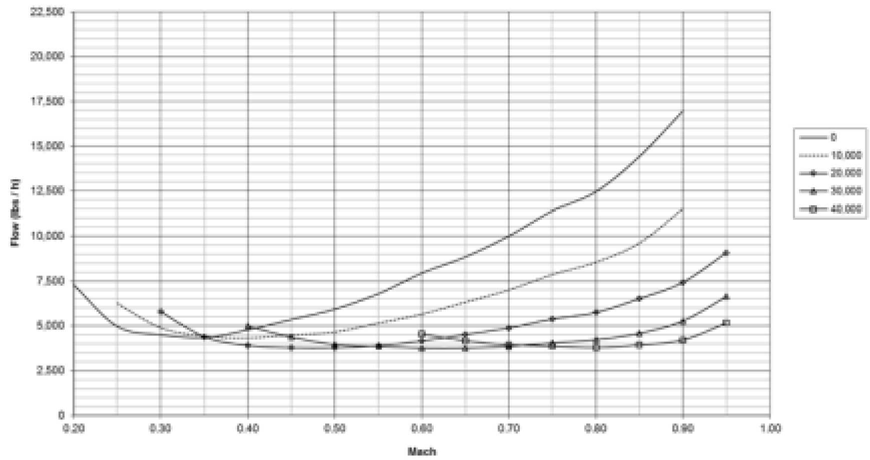
**DATA BASIS : COMPUTED**
**26-Jan-16**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**

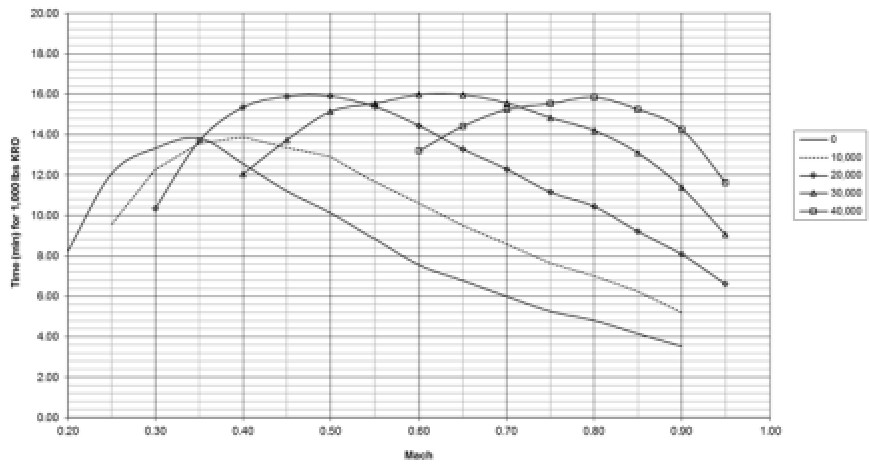
**CONDITIONS:**
**Standard Day - ISA**
**MIL Power**

**CONFIGURATION 1**
**2xAIM-9 + 4xAIM-120 + 1xCL Tank**
**GW=35,000 lbs**

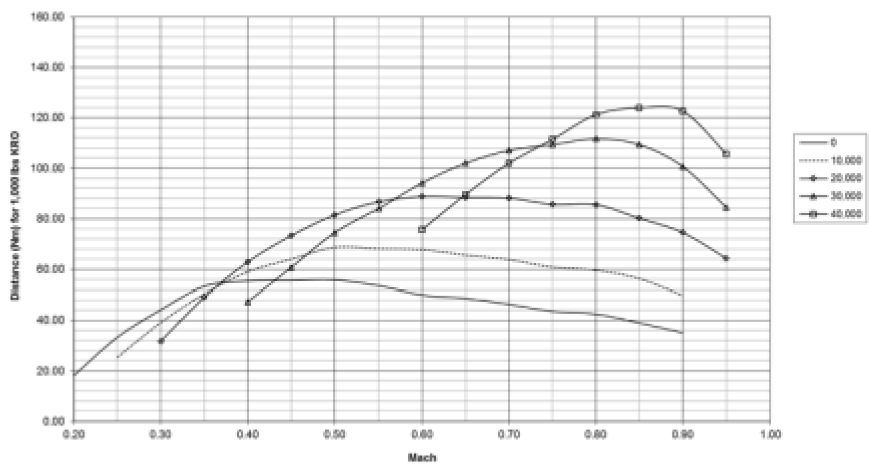
**Fuel Flow for Sustained Mach number**




**Endurance for Sustained Mach number**




**Specific Range for Sustained Mach number**



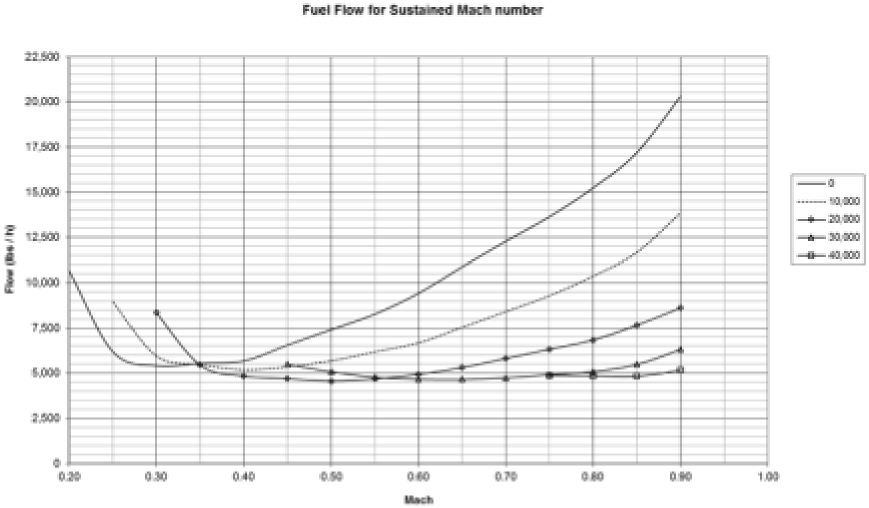
# Fuel Flow – Endurance - Autonomy

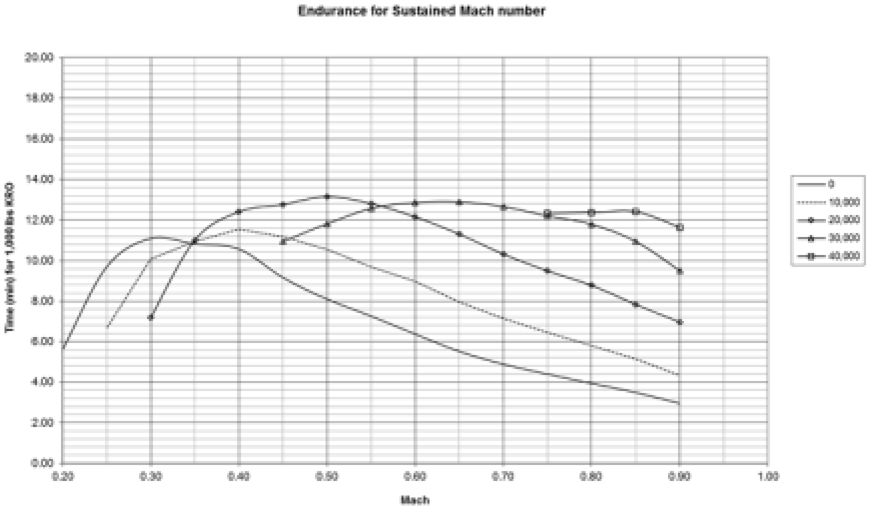
**DATA BASIS : COMPUTED**
**26-Jan-16**

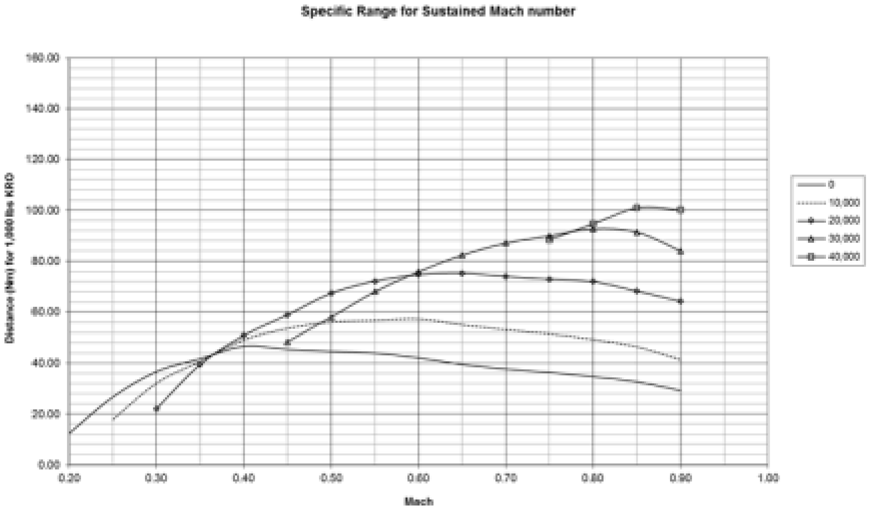
**CONDITIONS:**
**Standard Day - ISA**
**MIL Power**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONFIGURATION 2**
**2xAIM-9 + 1xCL Tank 2xWing Tank +**
**1x AAS/38B + 4xGBU-12**
**GW=40,000 lbs**



# PART 4: ACCELERATION

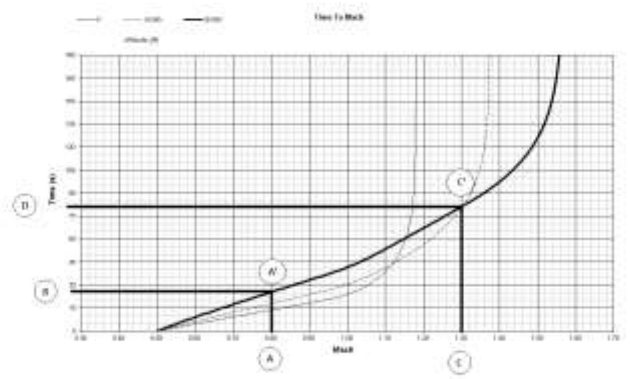
**INTRODUCTION**

Performances described in this section are related to level flight (1G) acceleration. It's organized by configuration (all data presented on one figures are related to the same configuration). The aircraft configuration is assumed to be the one at the beginning of the acceleration run (specifically the remaining fuel).

Figures present the time, horizontal distance and fuel quantity required to accelerate from a give Mach number to a greater at constant altitude.

**SAMPLE PROBLEM**

Use case is to accelerate from M0.8 to M1.3 at 20,000ft.




Find initial Mach number (0.8) on horizontal axis (A), go vertical up to the curve related to the desired altitude: 20,000ft (A'), then go horizontal to find the start time (B) : 25s

Find final Mach number (1.3) on horizontal axis (C), go vertical up to the curve related to the desired altitude: 20,000ft (C'), then go horizontal to find the start time (D): 80s.

Compute difference between final and initial values: the time required to accelerate from M0.8 to M1.3 at 20,000 in this configuration is 80 – 25 = 55s.

Same method is to be used to find the horizontal distance (in Nm) and the fuel quantity (in lbs) required to perform the same acceleration.

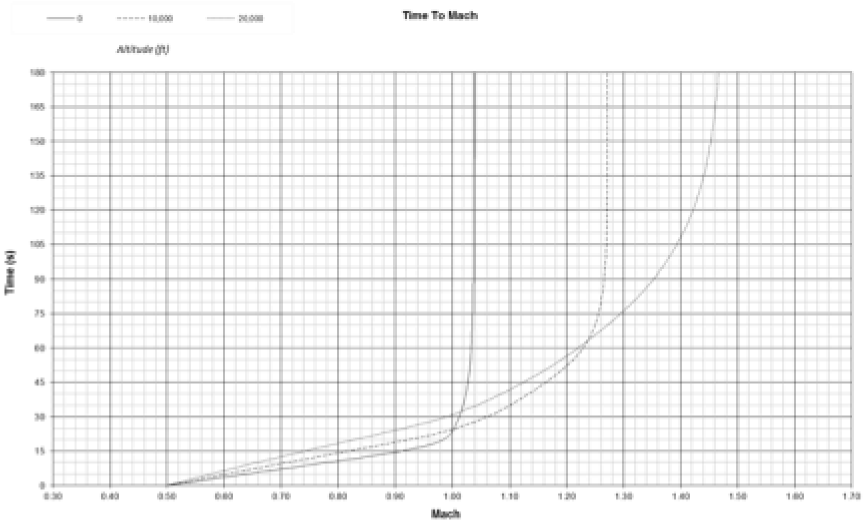
# Acceleration Schedule

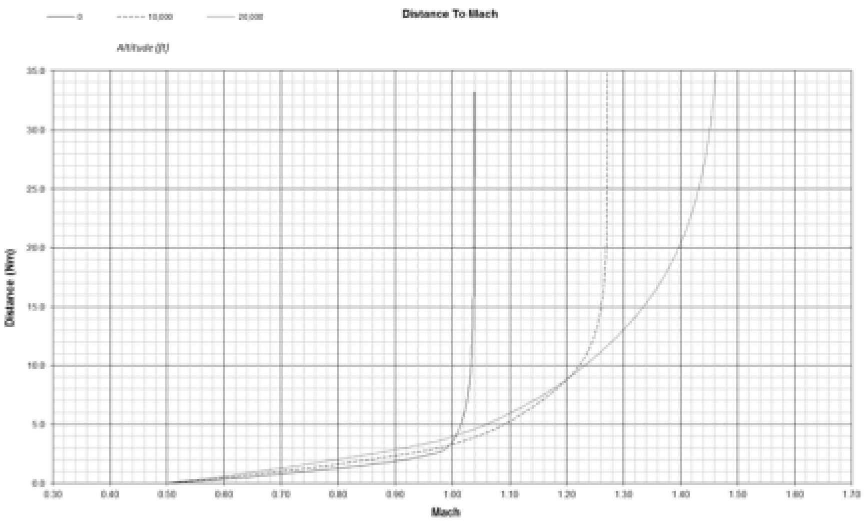
**DATA BASIS : COMPUTED**
**26-Jan-16**

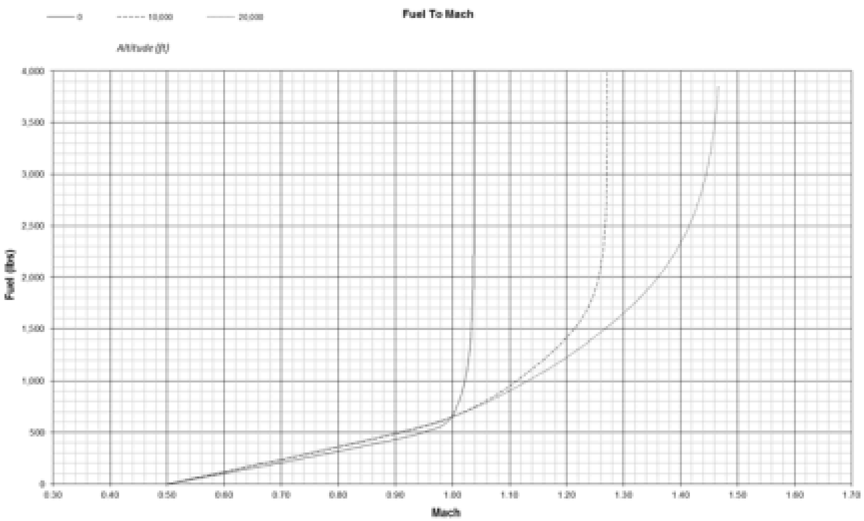
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



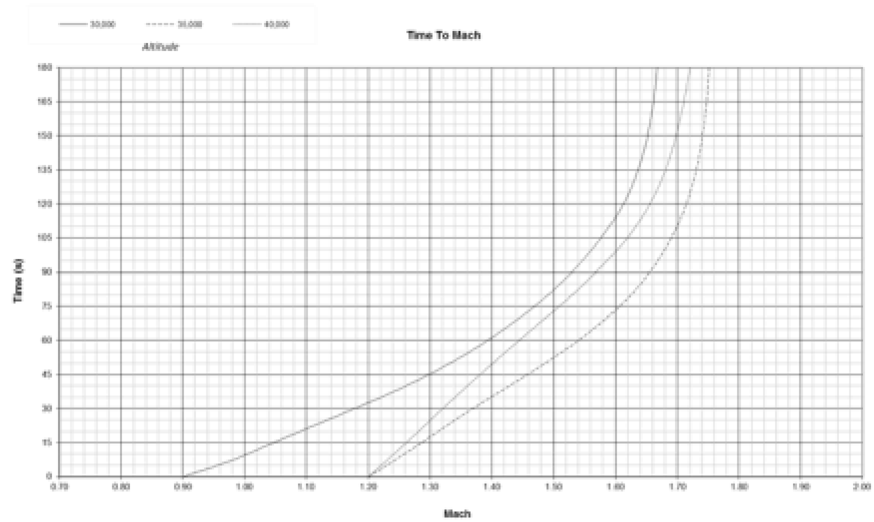
# Acceleration Schedule

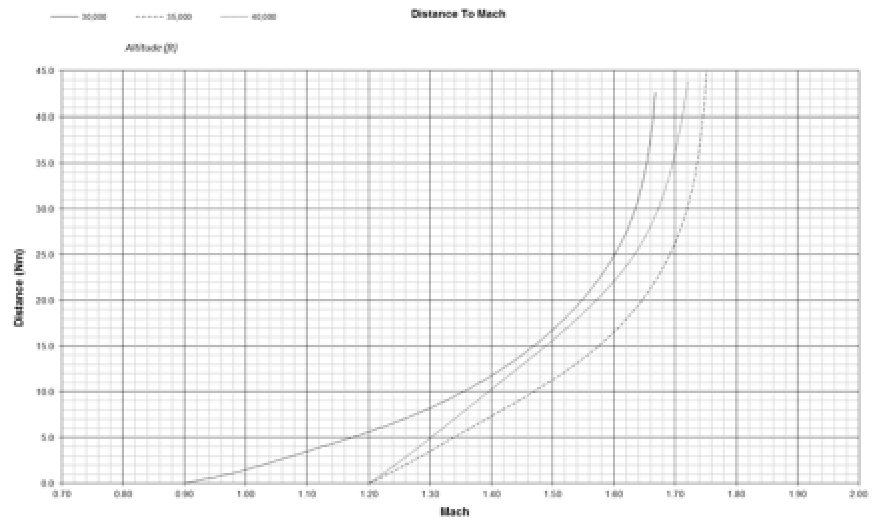
**DATA BASIS : COMPUTED**
**26-Jan-16**

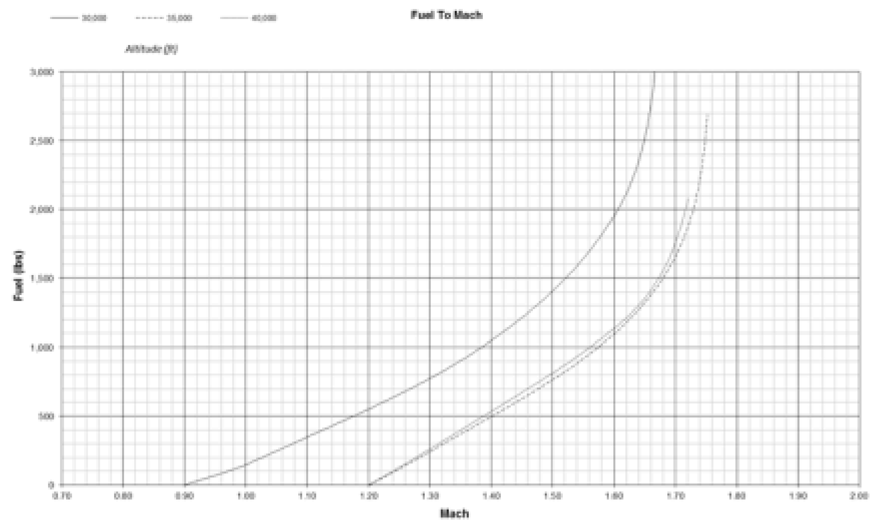
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



# PART 5: TURNING

### INTRODUCTION

This section is organized by aircraft configurations. For each of them, you will find the following set of figures:

### TURN PERFORMANCE SUMMARY

Sustained Turn Rate summary: three figures giving for different altitudes, the maximum sustainable (constant true air speed and altitude) turn rate (d/s), normal load factor (Ng) and minimum turn radius.

Maximum Turn Rate summary: three figures giving for different altitudes, the maximum reachable (at maximum possible lift) turn rate (d/s), normal load factor (Ng) and minimum turn radius.

### ENERGY MACH DIAGRAM

An Energy Mach Diagram is given per altitude (Turn Rate vs Calibrated Air Speed), with Iso-Ps (Extra Specific Power) curves set, and graphical indication of specific performances: maximum reachable (maximum lift and load factor) turn rate, maximum sustainable (Ps=0) turn rate, minimum instantaneous and sustainable (Ps=0) turn radius.

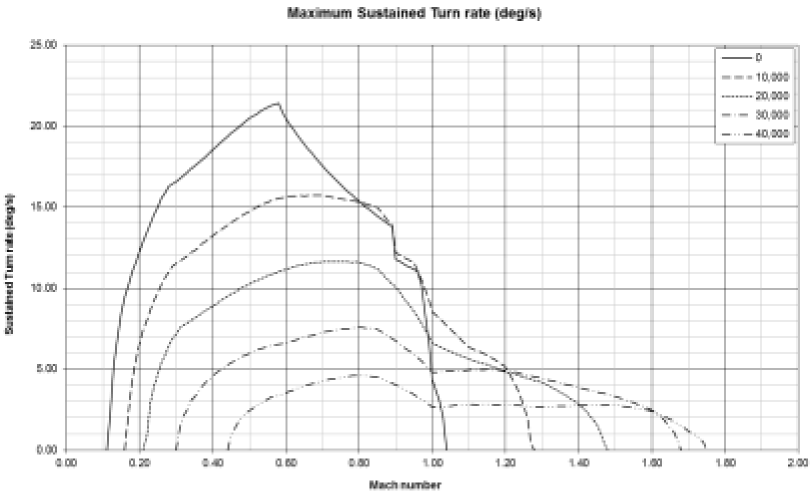
# *Sustained Turn Summary*

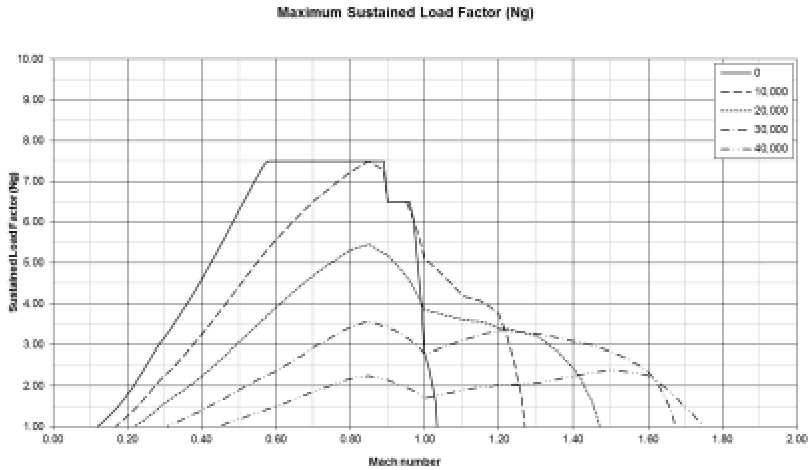
**DATA BASIS : COMPUTED**
**25-Jan-16**

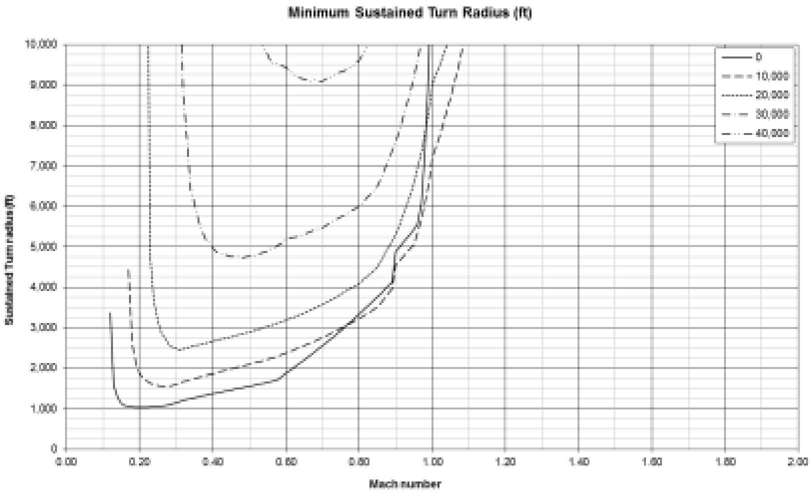
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



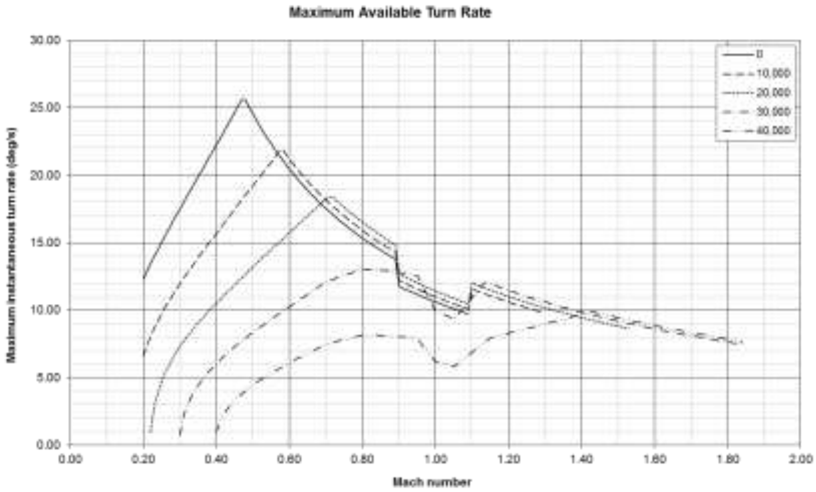
# *Instantaneous Turn Summary*

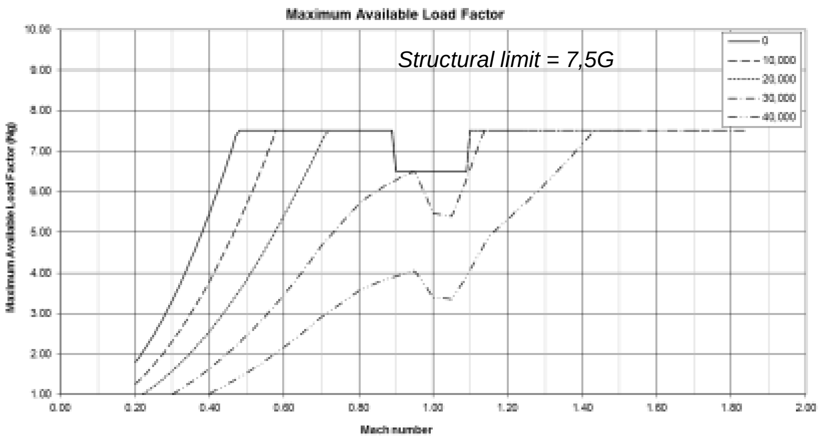
**DATA BASIS : COMPUTED**
**25-Jan-16**

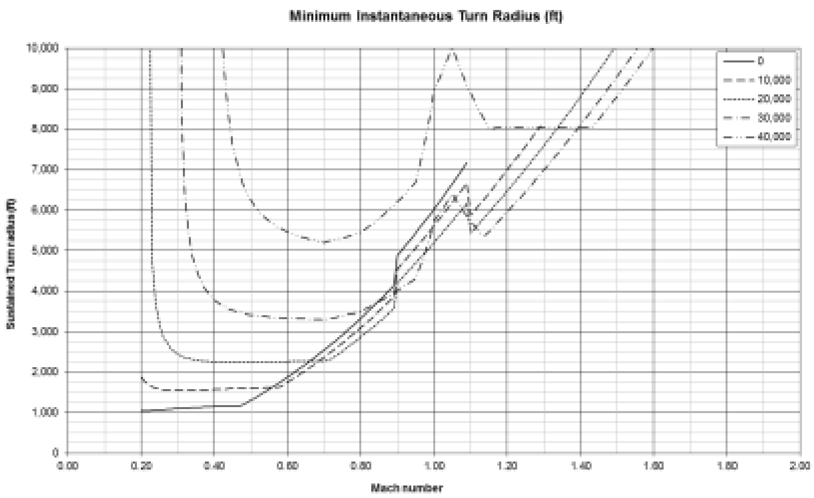
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

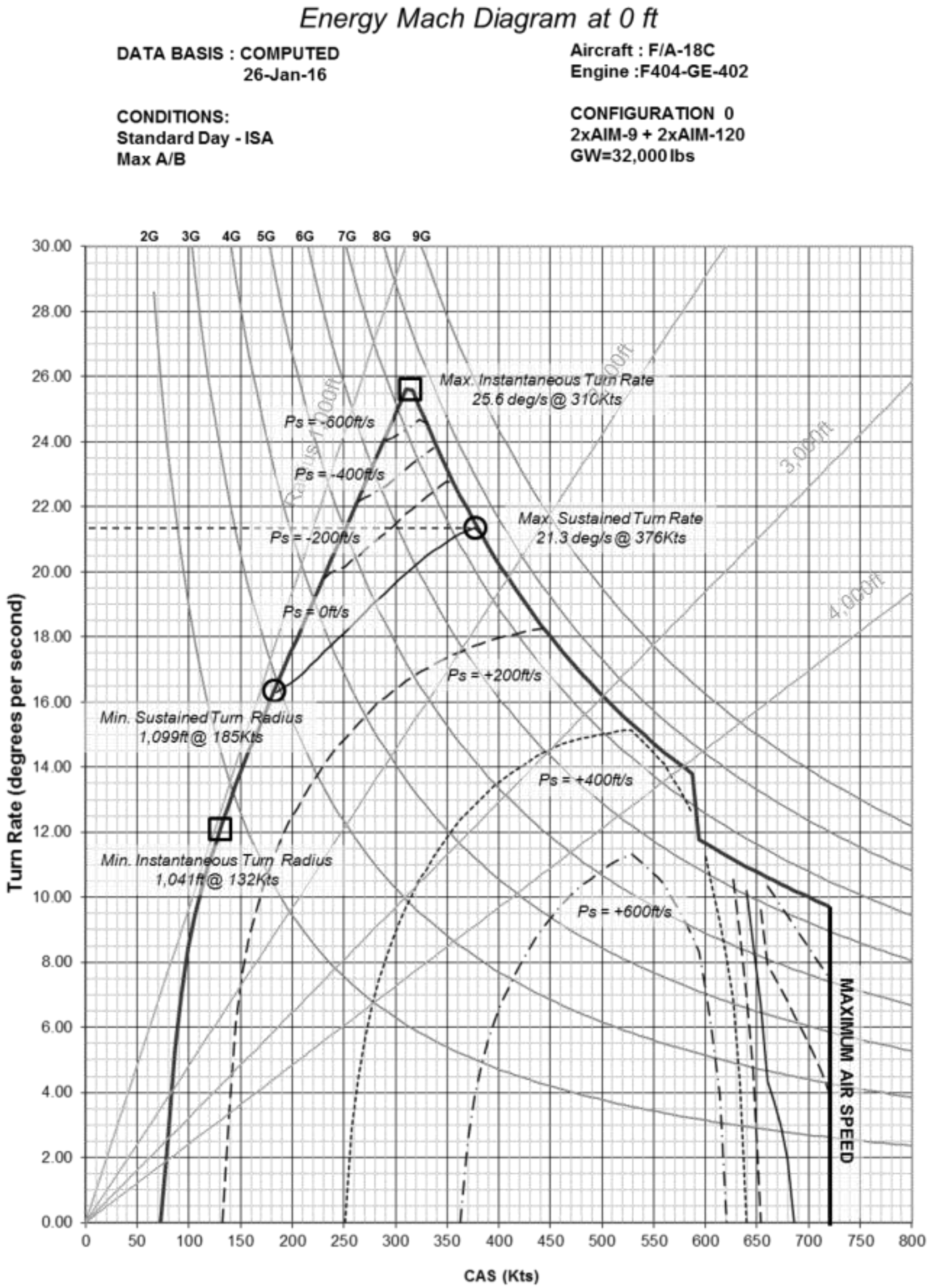
**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**




Energy Mach Diagram at 0 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Max. Instantaneous Turn Rate
25.6 deg/s @ 310Kts
Max. Sustained Turn Rate
21.3 deg/s @ 376Kts
Min. Sustained Turn Radius
1,099ft @ 185Kts
Min. Instantaneous Turn Radius
1,041ft @ 132Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Ps = 0ft/s
Ps = +200ft/s
Ps = +400ft/s
Ps = +600ft/s
3,000ft
4,000ft
MAXIMUM AIR SPEED
Turn Rate (degrees per second)
CAS (Kts)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
30.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800

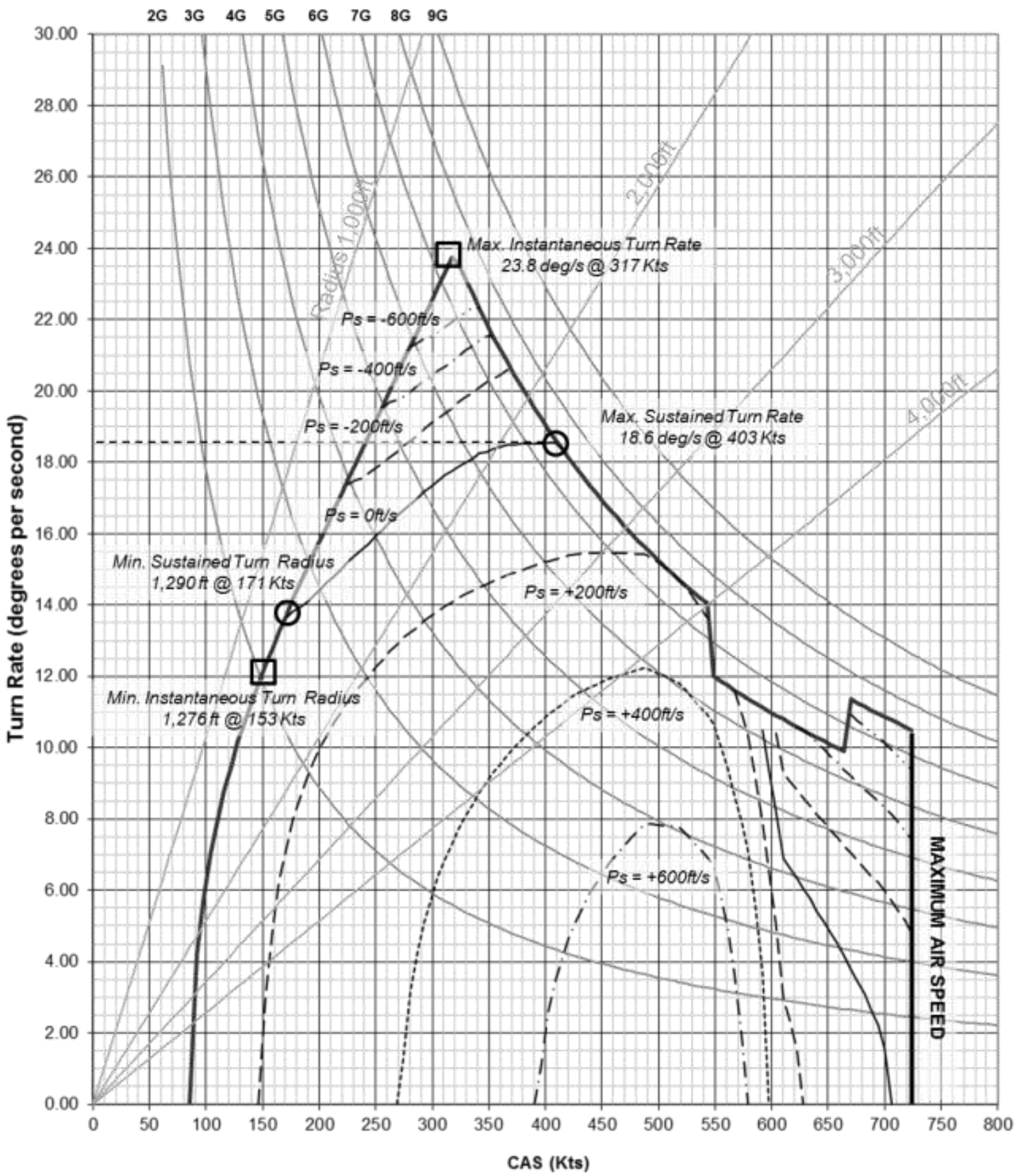
## Energy Mach Diagram at 5,000 ft

**DATA BASIS : COMPUTED**
**26-Jan-16**

**Aircraft : F/A-18C**
**Engine :F404-GE-402**

**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



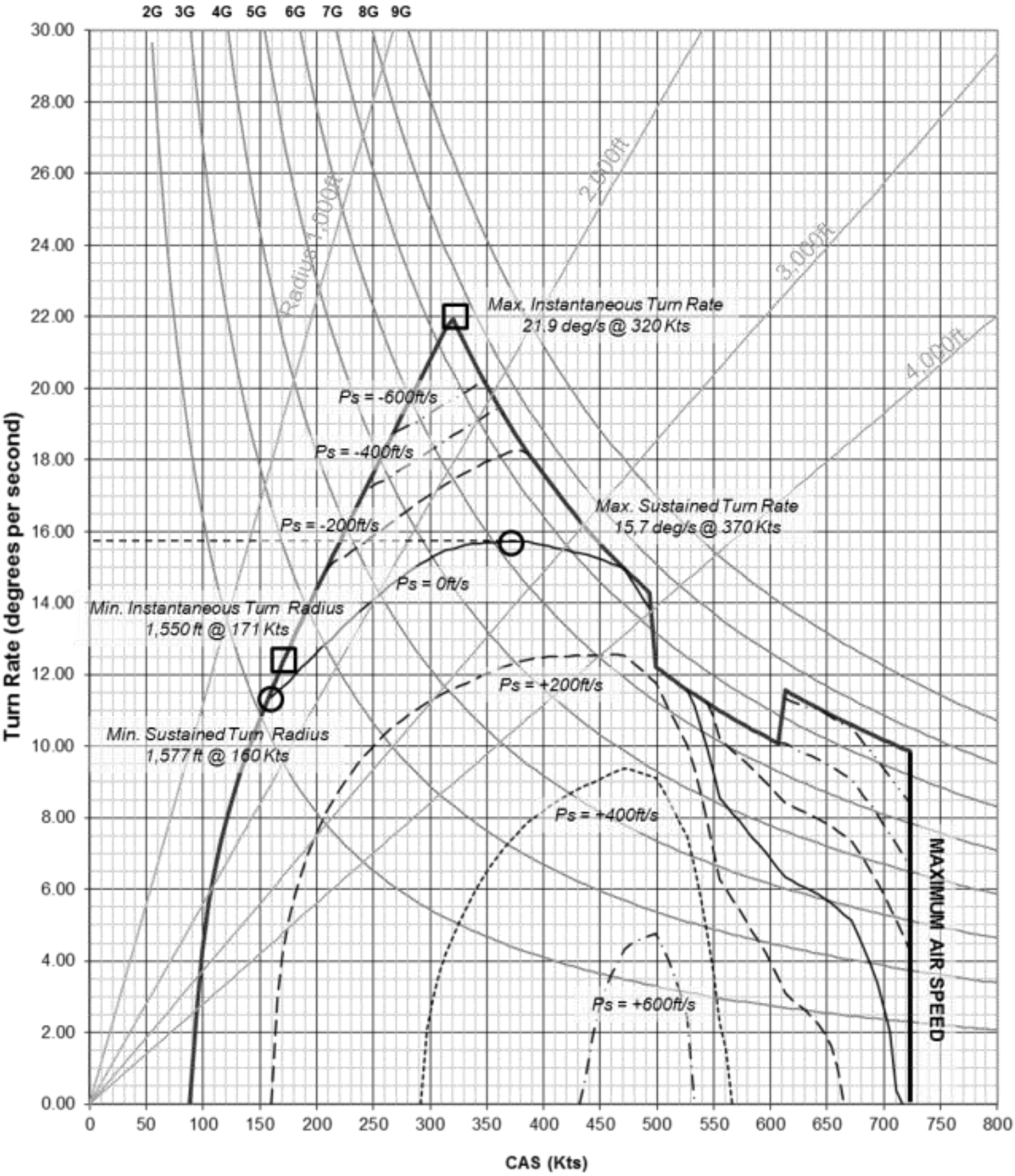
Energy Mach Diagram at 10,000 ft

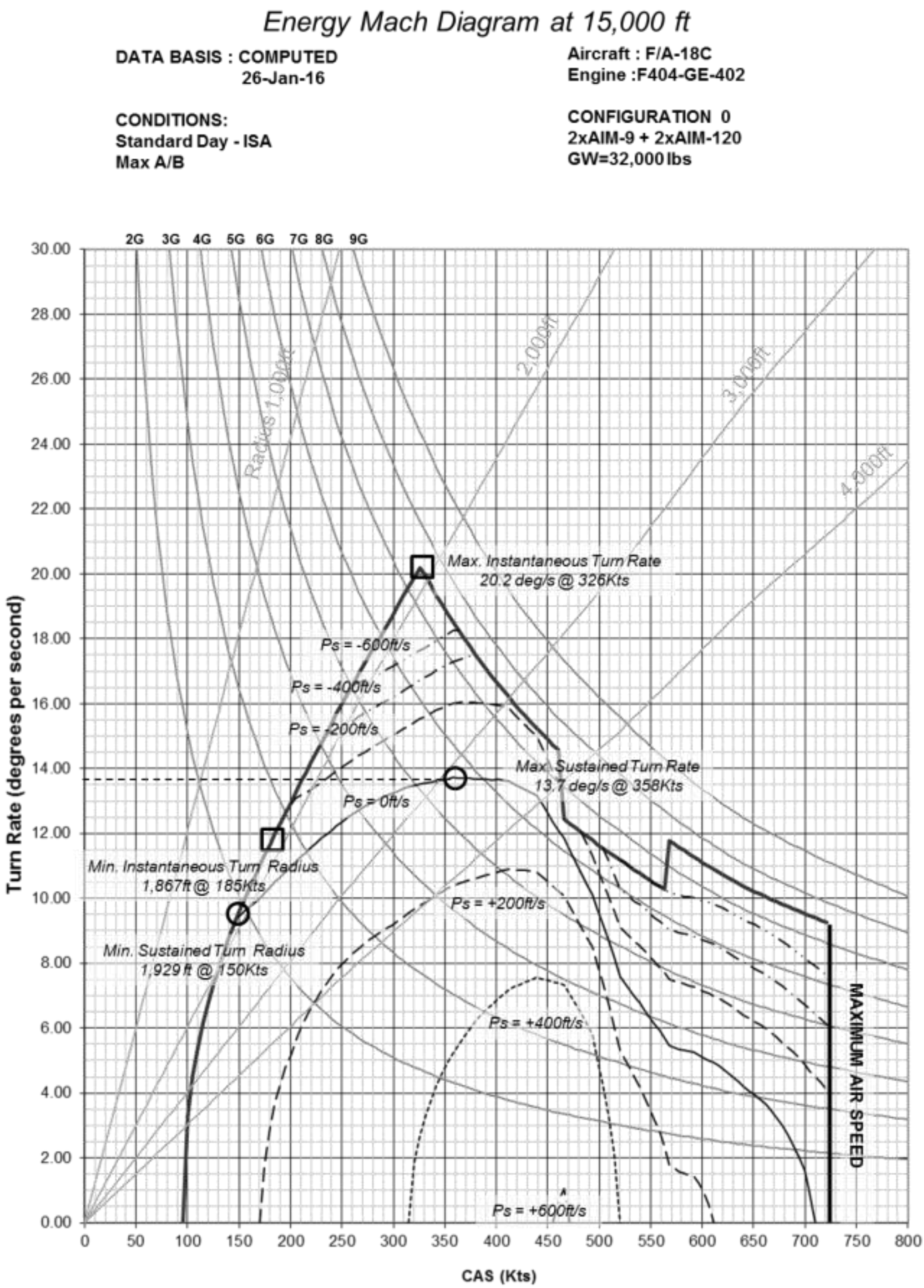
**DATA BASIS : COMPUTED**
**26-Jan-16**

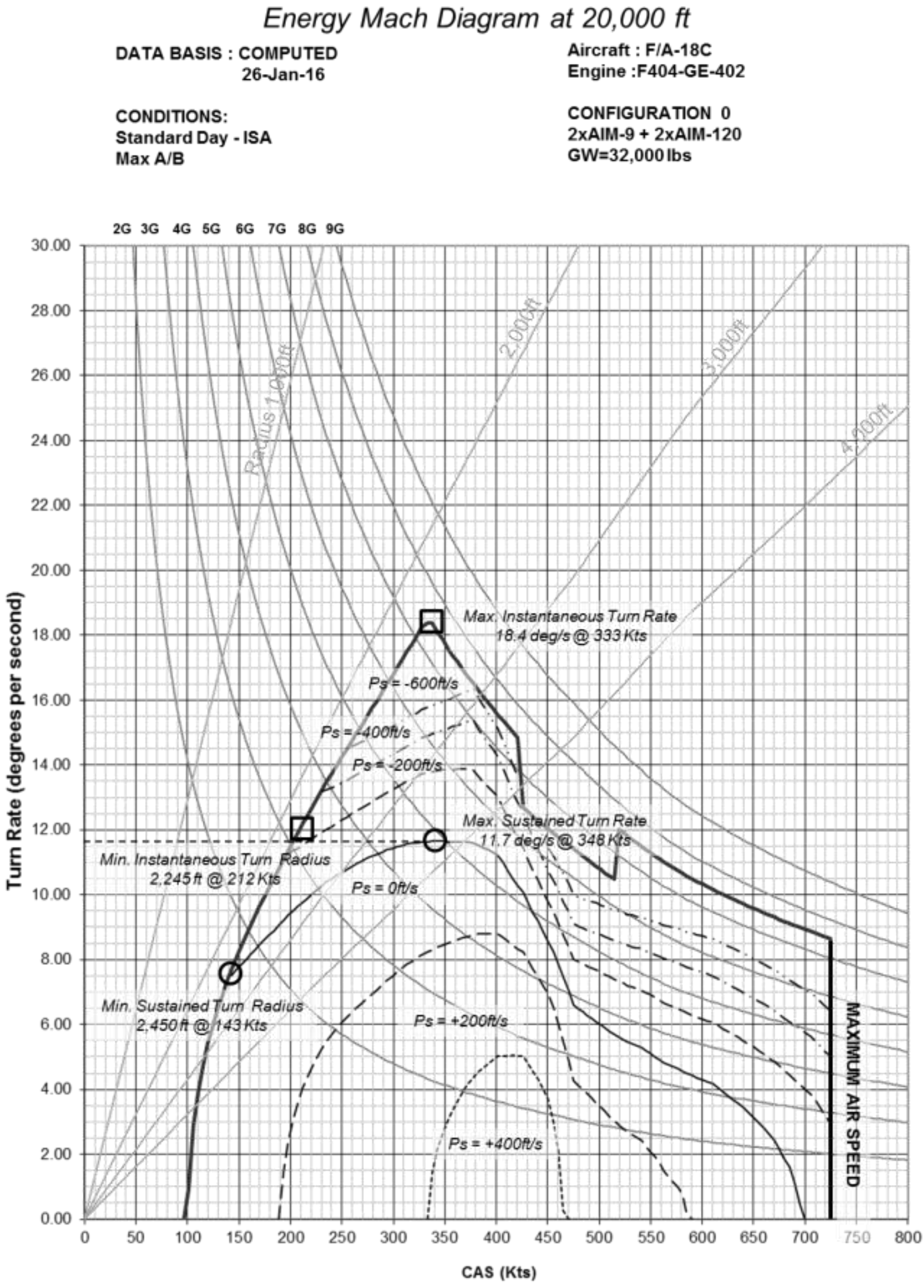
**Aircraft : F/A-18C**
**Engine :F404-GE-402**

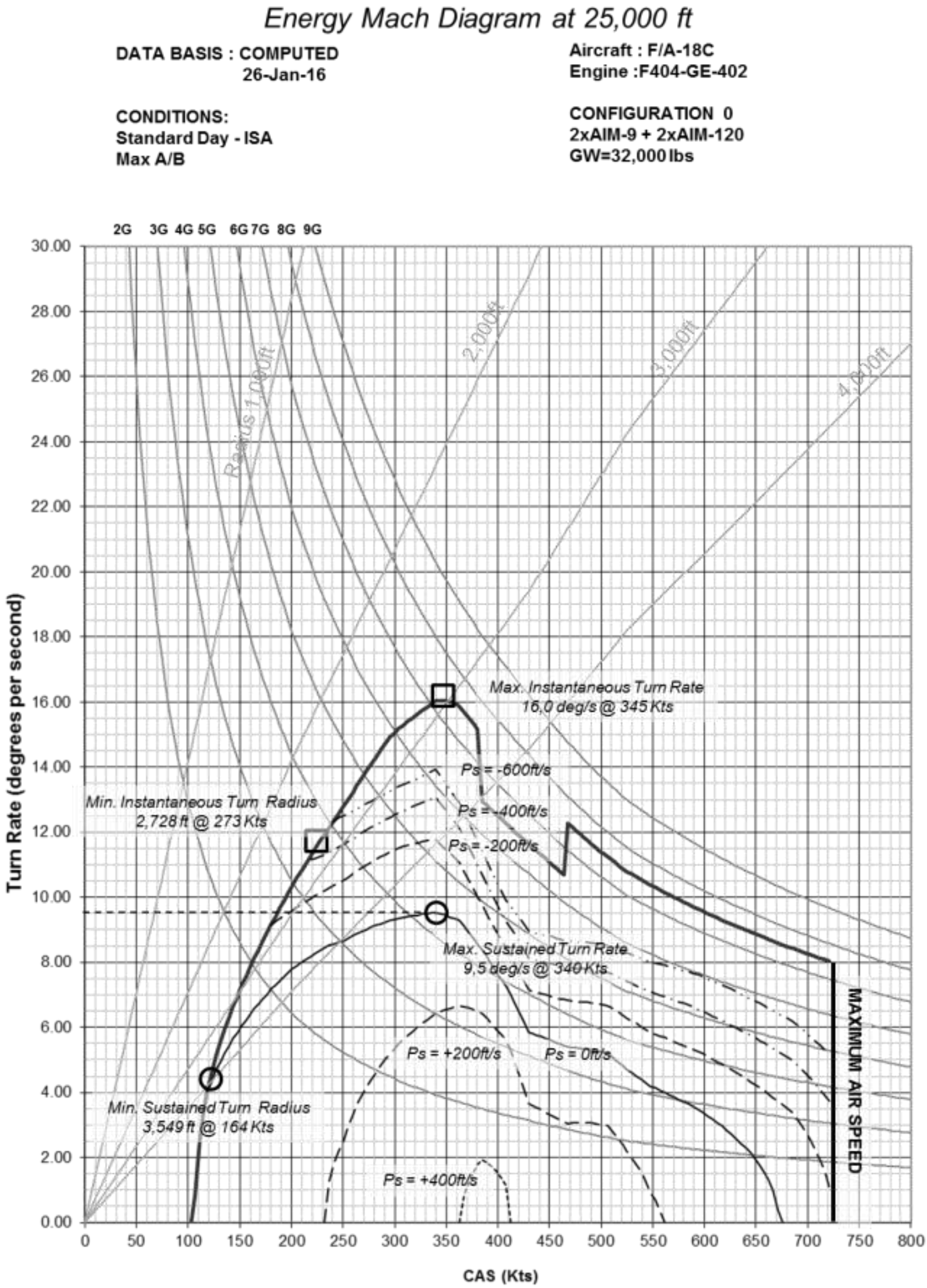
**CONDITIONS:**
**Standard Day - ISA**
**Max A/B**

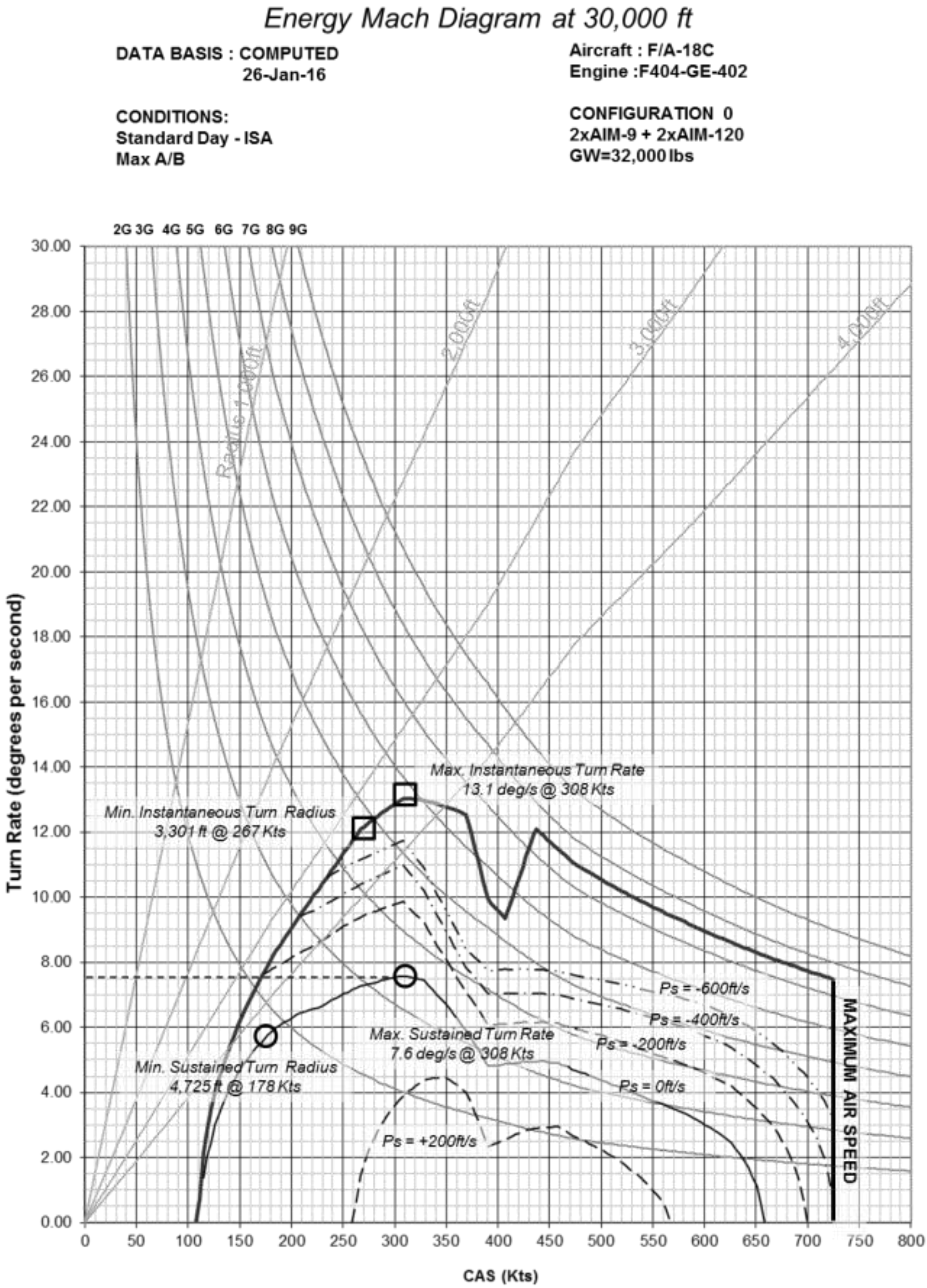
**CONFIGURATION 0**
**2xAIM-9 + 2xAIM-120**
**GW=32,000 lbs**



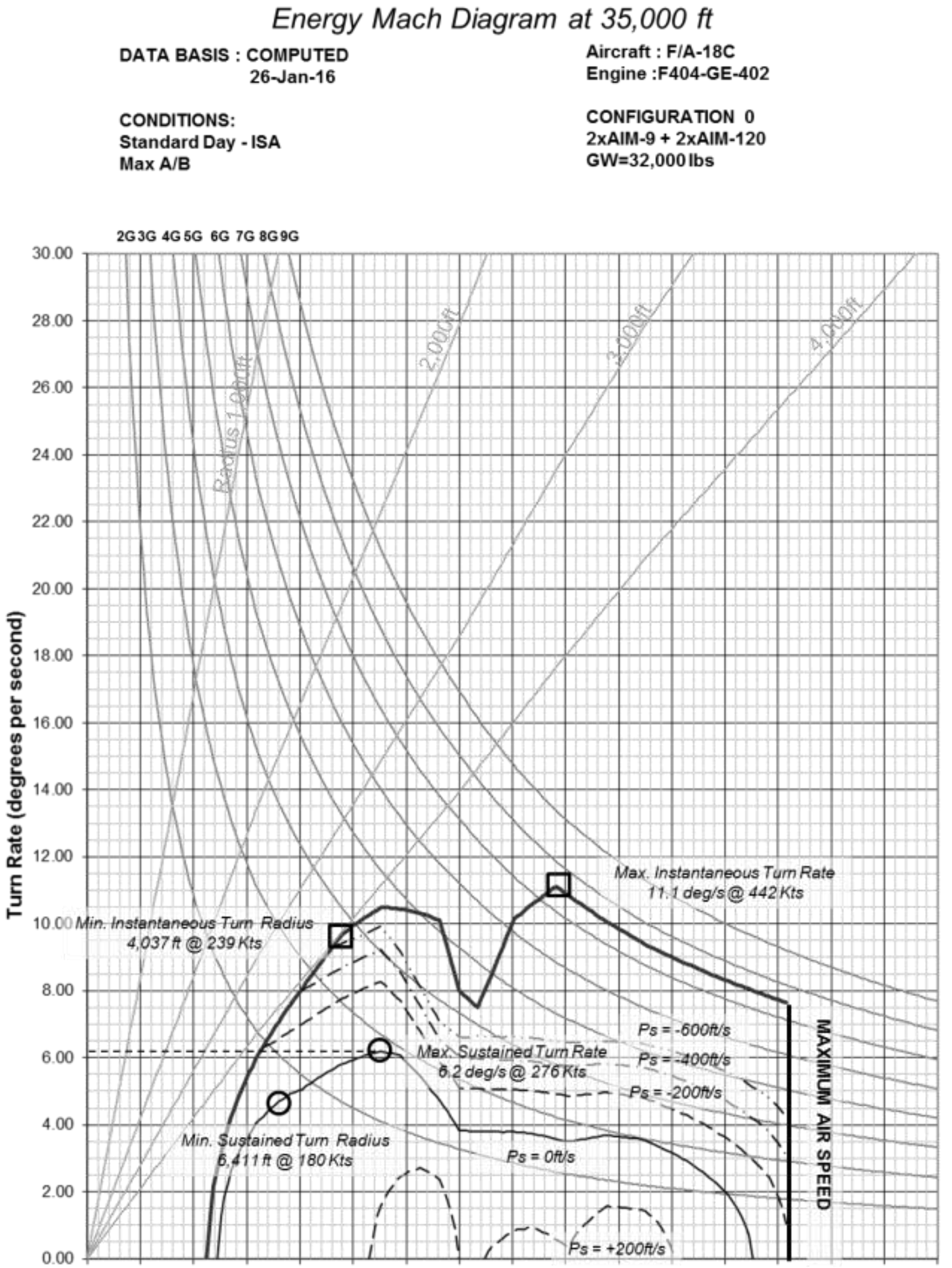

Energy Mach Diagram at 15,000 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Radius 1,000ft
2,000ft
3,000ft
4,000ft
Max. Instantaneous Turn Rate
20.2 deg/s @ 326Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Max. Sustained Turn Rate
13.7 deg/s @ 358Kts
Ps = 0ft/s
Min. Instantaneous Turn Radius
1,867ft @ 185Kts
Min. Sustained Turn Radius
1,929 ft @ 150Kts
Ps = +200ft/s
Ps = +400ft/s
Ps = +600ft/s
MAXIMUM AIR SPEED
Turn Rate (degrees per second)
CAS (Kts)
30.00 28.00 26.00 24.00 22.00 20.00 18.00 16.00 14.00 12.00 10.00 8.00 6.00 4.00 2.00 0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800


Energy Mach Diagram at 20,000 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Radius 1,000ft
2,000ft
3,000ft
4,000ft
Max. Instantaneous Turn Rate
18.4 deg/s @ 333 Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Max. Sustained Turn Rate
11.7 deg/s @ 348 Kts
Min. Instantaneous Turn Radius
2,245 ft @ 212 Kts
Ps = 0ft/s
Min. Sustained Turn Radius
2,450 ft @ 143 Kts
Ps = +200ft/s
Ps = +400ft/s
MAXIMUM AIR SPEED
Turn Rate (degrees per second)
CAS (Kts)
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800


Energy Mach Diagram at 25,000 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Radius 1,000ft
2,000ft
3,000ft
4,000ft
Max. Instantaneous Turn Rate
16,0 deg/s @ 345 Kts
Min. Instantaneous Turn Radius
2,728 ft @ 273 Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Max. Sustained Turn Rate
9,5 deg/s @ 340 Kts
Ps = +200ft/s
Ps = 0ft/s
Min. Sustained Turn Radius
3,549 ft @ 164 Kts
Ps = +400ft/s
MAXIMUM AIR SPEED
Turn Rate (degrees per second)
CAS (Kts)
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800



Energy Mach Diagram at 30,000 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Radius 1,000ft
2,000ft
3,000ft
4,000ft
Max. Instantaneous Turn Rate
13.1 deg/s @ 308 Kts
Min. Instantaneous Turn Radius
3,301 ft @ 267 Kts
Max. Sustained Turn Rate
7.6 deg/s @ 308 Kts
Min. Sustained Turn Radius
4,725 ft @ 178 Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Ps = 0ft/s
Ps = +200ft/s
MAXIMUM AIR SPEED
Turn Rate (degrees per second)
CAS (Kts)


Energy Mach Diagram at 35,000 ft
DATA BASIS : COMPUTED
26-Jan-16
Aircraft : F/A-18C
Engine :F404-GE-402
CONDITIONS:
Standard Day - ISA
Max A/B
CONFIGURATION 0
2xAIM-9 + 2xAIM-120
GW=32,000 lbs
2G 3G 4G 5G 6G 7G 8G 9G
Radius 1,000ft
2,000ft
3,000ft
4,000ft
Turn Rate (degrees per second)
CAS (Kts)
Max. Instantaneous Turn Rate
11.1 deg/s @ 442 Kts
Min. Instantaneous Turn Radius
4,037 ft @ 239 Kts
Max. Sustained Turn Rate
6.2 deg/s @ 276 Kts
Min. Sustained Turn Radius
6,411 ft @ 180 Kts
Ps = -600ft/s
Ps = -400ft/s
Ps = -200ft/s
Ps = 0ft/s
Ps = +200ft/s
MAXIMUM AIR SPEED