ADAPTATION OF DIGITAL DATCOM INTO A CONCEPTUAL DESIGN PROCESS

by

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ABSTRACT

ADAPTATION OF DIGITAL DATCOM INTO A CONCEPTUAL DESIGN PROCESS

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As implied with open-ended 'design decision-making' there are multiple prospective conventional and unconventional aircraft solution concepts available to satisfy a given mission specification. The task of defining, assessing and selecting prospective options for the mission at hand is the primary purpose of the aircraft conceptual design (CD) phase. In addition, conceptual design tends to be fast paced and requires an iterative and multidisciplinary process structure delivering fast turnaround design-responses. The lack of design information available during the early conceptual design phase requires the aircraft designer to utilize lower fidelity analysis techniques that focus on overall correctness of prospective solution concepts (trends and sensitivities) of a new technology on the design. However, correctly predicting the impact of gross design decisions on mission performance drivers is a non-trivial undertaking. Furthermore, if the parametric design trends and sensitivities are correctly predicted there will not be a single solution to a given mission. Consequently, the open-ended conceptual design (CD) process tends to be the most abstract design phase throughout the product development cycle. The Aerospace Vehicle Design Laboratory (AVD Lab) is continuously developing the Aerospace Vehicle Design Synthesis (AVDS) process aimed at supporting early fact-based decision making. The AVDS methodology contains a data-base, knowledge-base, methods library and process library that are utilized in conjunction with each other to arrive at a design solution best satisfying the mission objectives. The focus of this thesis is on augmenting aerodynamic configuration prediction capability within the AVDS process.

The consistent aerodynamic evaluation of conventional and unconventional aircraft configurations throughout the flight regime poses a significant challenge to the designer. This problem is attributed to the fact that no single aerodynamic prediction tool does exist with the ability to model flight vehicle configuration choices throughout the flight envelope Given the non-existence of this ideal ‘unified aerodynamic prediction tool’, the designer has to organize a methods library instead, thereby dealing with constant method-switching and resulting inconsistency issues. There are many aerodynamic methods to choose from with different capabilities and requirements. Digital DATCOM is aerodynamic prediction software with a vast self-contained methods library for the required methods-switching, but it is restricted to a defined set of aircraft configuration concept. The methods available in the original handbook ‘paper-version’ of DATCOM can be applied to a wider range of aircraft configuration concepts compared to its digital implementation called Digital DATCOM. Given these restrictions, this thesis documents further development of the Digital DATCOM implementation into DATCOM MAX. Development aim of the ‘MAX’ implementation has been to expand the existing capability towards the ability to predict key aerodynamic contributions of aircraft components and control surfaces during the conceptual design phase for a more diverse set of geometric configuration concepts. The B747-200F verification and validation case study has been chosen because of the richness of the information available about this aircraft. First DATCOM MAX is cross-verified to match Digital DATCOM output plus the new prediction capability, using the B747-200F model. Then the correctness of DATCOM MAX methods is verified against published experimental aerodynamic data for the B747-200F. A user’s manual and programmer’s guide have been prepared to accompany the source code, thereby allowing informed further-development of the software in the future.

The research presented is a step taken to expand the capability of the AVDS methods library in the area of aerodynamics by removing selected process restrictions inherent in the original Digital DATCOM. The objective is to create a tool capable of producing a static and dynamic derivative database for a given aircraft design. This thesis identifies the research problem, the selection of aerodynamic tool for adaption, the modification of Digital DATCOM FORTRAN 90 source code. A tail aft configuration (TAC) transport aircraft, B747-200F, example verifies and validates the new DATCOM MAX program.

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NOTATIONS

Abbreviations

ADP = Advanced Development Programs

AMHT = All Moving Horizontal Tail

AMHT+e = All Moving Horizontal Tail with an Elevator

AVD Lab = Aerospace Vehicle Design Laboratory

AVDS = Aerospace Vehicle Design Synthesis

CD = Conceptual Design

DATCOM = Data Compendium

DD = Detail Design

DiCE = Directional Control Effector

DOF = Degrees of Freedom

ECS = Environment Control System

ESDU = Engineering Sciences Data Unit

FT/C/M = Flight Test/Certification/Manufacturing

FWC = Flying Wing Configuration

I/AI = Incident/Accident Investigation

LaCE = Lateral Control Effector

LE = Leading Edge

LG = Landing Gear

LoCE = Longitudinal Control Effector

M = Mach number

MDS = Main Data Sheet

O = Operations

p = pitch rate

PD = Preliminary Design

PDAS = Public Domain Aeronautical Software

PrADO = Preliminary Aerospace Design and Optimization

TAC = Tail Aft Configuration

TE = Trailing Edge

TFC = Tail First Configuration

TSC = Three Surface Configuration

UFD = Understanding Fluid Dynamics

USAF = United States Air force

UTA-MAE = University of Texas at Arlington Mechanical and Aerospace Engineering

VATES = Virtual Test and Evaluation Simulator

VLM = Vortex Lattice Method

V = Velocity

VT = Vertical Tail

W = Wing

WBHV = Wing-Body-Horizontal-Vertical configuration

WBS = Work Breakdown Structure

Symbols

α = Angle-of-attack

β = Side-slip angle

δ = Control surface or high lift device deflection angle

$\frac{d\epsilon}{d\alpha}$ = Downwash angle with respect to angle of attack derivative

ϵ = Downwash angle at horizontal tail

$\frac{q}{q_\infty}$ = Ratio of dynamic pressures at the horizontal tall to the free stream

C_A = Axial-force coefficient

C_D = Drag coefficient

C_{D_0} = Drag coefficient for zero angle of attack

C_{h_α} = Control-surface hinge-moment derivative due to angle of attack

C_{h_δ} = Control-surface hinge-moment derivative due to control surface deflection

C_l = Rolling moment coefficient of lift

C_{l_β} = Variation of rolling moment coefficient of lift with sideslip

C_{l_p} = Variation of rolling moment coefficient of lift with roll rate

C_{l_r} = Variation of rolling moment coefficient of lift with yaw rate

C_L = Lift coefficient

C_{L_q} = Variation of lift coefficient with pitch rate

$C_{L_{\dot{\alpha}}}$ = Variation of lift coefficient with rate of change of angle of attack

$(C_{L_\alpha})\delta$ = Lift-curve slope of the deflected, translated surface

C_m = Pitching moment coefficient

C_{m_q} = Variation of pitching moment coefficient with pitch rate

$C_{m_{\dot{\alpha}}}$ = Variation of pitching moment coefficient with rate of change of angle of attack

C_n = Yawing moment coefficient

C_N = Normal-force coefficient

C_{n_β} = Variation of yawing moment coefficient with sideslip

C_{n_p} = Variation of yawing moment coefficient with roll rate

C_{n_q} = Variation in yawing moment coefficient with pitch rate

C_{n_r} = Variation of yawing moment coefficient with yaw rate

C_Y = Side-force coefficient

C_{Y_β} = Variation of side-force coefficient with angle of sideslip

C_{Y_p} = Variation of side-force coefficient with change in roll rate

ΔC_D = Coefficient of drag increment due to control surface deflection

ΔC_{D_i} = Coefficient of induced drag increment due to control surface deflection

$\Delta C_{D_{min}}$ = Coefficient of minimum drag increment due to control surface deflection

ΔC_l = Rolling moment coefficient of lift increment due to control surface deflection

ΔC_L = Coefficient of lift increment due to control surface deflection

$\Delta C_{L_{max}}$ = Coefficient of maximum-lift increment due to control surface deflection

ΔC_m = Pitching moment coefficient increment due to control surface deflection

ΔC_n = Yawing moment coefficient increment due to control surface deflection

ΔC_Y = Side-force coefficient increment due to control surface deflection

Subscripts

a = Aileron

e = Elevator

f = Flaps

GE = Ground effect

HT = Horizontal Tai

r = Rudder

s = Spoiler

sb = Speed brake

CHAPTER 1

INTRODUCTION AND OBJECTIVES

1.1 Introduction and Background

Determining the best solution to an open-ended problem in aerospace is the primary purpose of aerospace vehicle design. The ‘best’ solution is defined by a mission to accomplish and can be cost or politically driven. The future of a company or organization tends to depend on the quality of the solution. This pressure pushes design environments to pursue new aircraft configurations and concepts aimed at a performance advantage as shown in Figure 1.1. In doing so, the designer must also manage risk when selecting aircraft configurations and concepts for a particular business case by balancing capability required with capability available.

Figure 1.1 Aircraft Configuration Concepts (1)

To clarify, ‘aircraft configuration’ and ‘aircraft concept’ are defined below by (2).

“The ***Aircraft Configuration*** *specifies the arrangement of the lift generating surfaces relative to the positioning, and/or number, and/or integration of the longitudinal control effector(s) (e.g., Tail-Aft Configuration [TAC], Three-Surface Configuration [TSC], Flying-Wing Configuration [FWC]).*

The ***Aircraft Concept*** specifies, for a given aircraft configuration, possible permutations of either lift-, volume-, control-, and propulsion-generating contributors (i.e., possible wing concepts for specific TAC are: high aspect-ratio wing, delta wing, variable sweep wing, etc.)

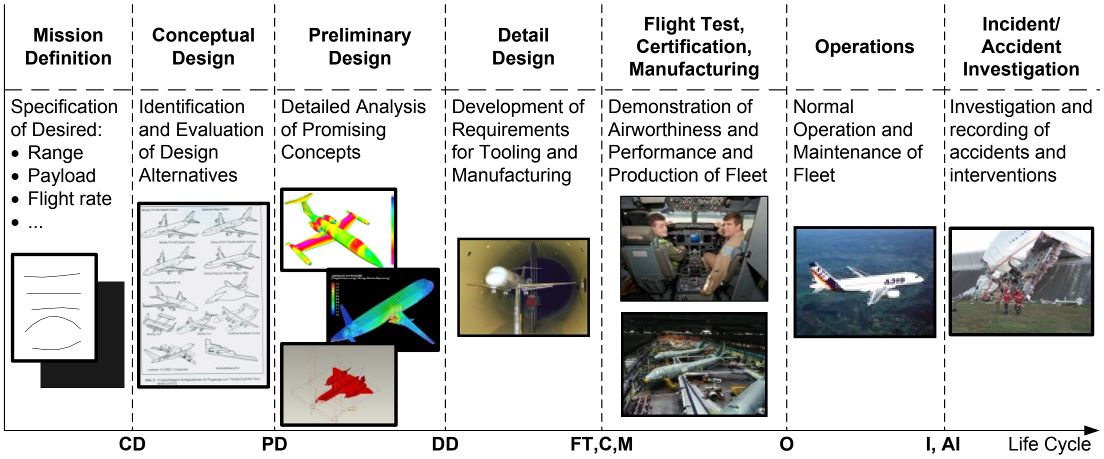
The Aerospace Vehicle Design (AVD) Laboratory at the University of Texas at Arlington Mechanical and Aerospace Engineering (UTA-MAE) approaches aircraft design with the aim of improving the overall aircraft product development lifecycle from conceptual design to simulated accident/incident investigation (3). The Aerospace Vehicle Design Synthesis (AVDS) methodology and software underdevelopment at the AVD Lab is a multi-disciplinary parametric approach to aircraft design which employs carefully crafted tools to simulate the entire lifecycle of an aircraft starting from the conceptual design phase (partial reference Amen?). To establish a basis for this thesis, background information on the aircraft design lifecycle, *AVDS*, *AVD Sizing*, *AerоMech*, and *VATES* are given in the following sections.

1.1.1 Aircraft Design Lifecycle

The term “design lifecycle” is used in the AVD Lab to describe the development and operational life-span of a flight vehicle defined by its overall mission objectives. The life-cycle is divided into six continuous parts (3), Figure 1.2.

1. Conceptual Design (CD)
2. Preliminary Design (PD)
3. Detail Design (DD)
4. Flight Test / Certification / Manufacturing (FT/C/M)
5. Operations (O)
6. Incident / Accident Investigation (I/AI)

It is important to mention that during the conceptual design, the AVD Lab process simulates all these phases except Detail Design (4).



Mission Definition	Conceptual Design	Preliminary Design	Detail Design	Flight Test, Certification, Manufacturing	Operations	Incident/ Accident Investigation
Specification of Desired: • Range • Payload • Flight rate • ...	Identification and Evaluation of Design Alternatives	Detailed Analysis of Promising Concepts	Development of Requirements for Tooling and Manufacturing	Demonstration of Airworthiness and Performance and Production of Fleet	Normal Operation and Maintenance of Fleet	Investigation and recording of accidents and interventions

Figure 1.2 Aircraft Life-Cycle as Described in The AVD Lab (4)

Conceptual Design (CD)

The conceptual design phase determines the feasibility of meeting the requirements with a credible aircraft design (5). The requirements are outlined by the mission definition. Using the underlying mission definition principal design-decisions are made that define the aircraft design in terms of aircraft configuration choice, -shape, and –size. The tasks in this phase include the creation of measureable design objectives from the mission definition, exploration of the design solution space where feasible design concepts are located, evaluation of these design alternatives with respect to objectives, and the selection of the most viable concept(s) (6). The objective in producing credible aircraft designs during the early design phase is essential for identifying the primary business case, thus this design phase is required to capture the trends and sensitivities of each aircraft configuration concept choice.

Preliminary Design (PD)

In the preliminary design phase the preferred configuration(s) from the conceptual study is subjected to a more rigorous technical analysis (7). The purpose of this phase is to refine the assumptions made during the CD phase to determine if the concept truly meets design objectives (6). The objective changes from capturing trends and sensitivities (correctness of the solution concepts) to accuracy. Here, high-fidelity tools and wind tunnel testing is used to refine and optimize the aircraft configuration concept. Consideration is also given to manufacturing with plans for jigs, tooling, and production breaks (5). Detailed parametric studies are often performed around the baseline aircraft configuration concept until the design is ‘frozen’ (7). Once frozen major changes to the aircraft are no longer feasible. The end result is a complete aircraft design including systems and subsystems (4).

Detail Design (DD)

The detail design phase engineers and constructs the hardware to the airframe and systems, overall leading to form a complete aircraft prototype for flight testing and certification (6). A more detailed description is provided below by Nicolai (5).

> *"…The drawings for the jigs, tooling, and other production fixtures are done at this time. A detailed cost estimate based upon work breakdown structure (WBS) is made. All equipment and hardware items are specified. Often, system mock-ups (such as fuel system, landing gear, ECS, engine-inlet, and a hardware-in-the-loop flight control system called an iron bird) will be designed, built, and testing during this phase."*

Design changes can still accord but are limited to a minimum since the cost of making a change is significant once the drawing hits the shop floor (5).

Flight Test / Certification / Manufacturing (FT/C/M)

During this phase a test vehicle is manufactured and flight tested to demonstrate airworthiness. Performance is checked against customer requirements minor design modifications are made if necessary. Once approved, mass manufacturing begins and aircraft shipments to the customers are made.

Operations (O)

The operational phase is the flying of the delivered aircraft by the customer. The customer can be military, commercial, or private. New customers as well as previous customers often request a performance modification be made to the aircraft. Changes during this design phase come in the form of modifications, upgrades, and/or system integrations.

Incident / Accident Investigation (I/AI)

Lastly, incident and accident investigation takes place when an incident or accident involving the aircraft occurs. Information gathered from incidents or accidents may influence any of the earlier design phases.

1.1.2 Aerospace Vehicle Design Synthesis (AVDS)

The principal idea is to integrate conceptual design synthesis up to flight test emulation into an integrated work environment. A consistent tool-set simulates the product life-cycle (3).

The integrated software AVDS is an iterative multidisciplinary process, see Figure 1.3. Its objective is to simulate all relevant design phases up to incident and accident investigation starting from the CD phase to accelerate design response time; increase design freedom; and improve correctness and reliability of design decisions (3). For more information on the AVDS process, see (3).

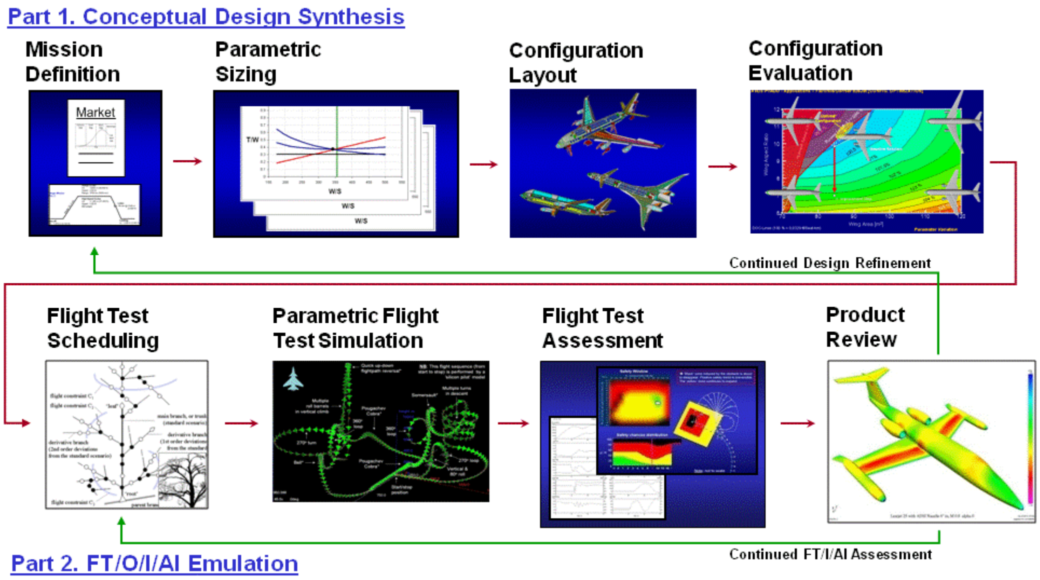


Figure 1.3 Overview of Product Lifecycle Methodology at CD (3)

AVDS consists of the following multi-disciplinary and disciplinary software modules AVD Sizing, AeroMech, PrADO, and VATES. A brief description of each tool is described below. This research is focused on adding aerodynamic prediction capability to this toolset.

1.1.3 AVD Sizing

AVD Sizing has been developed by Gary Coleman and is a parametric sizing tool for visualizing the solution space (2) (8). The sizing process is based on the constant mission sizing logic documented in Hypersonic Convergence by Paul Czysz (9). The AVD sizing logic is shown as a Nassi Shneiderman diagram in Figure 1.4.

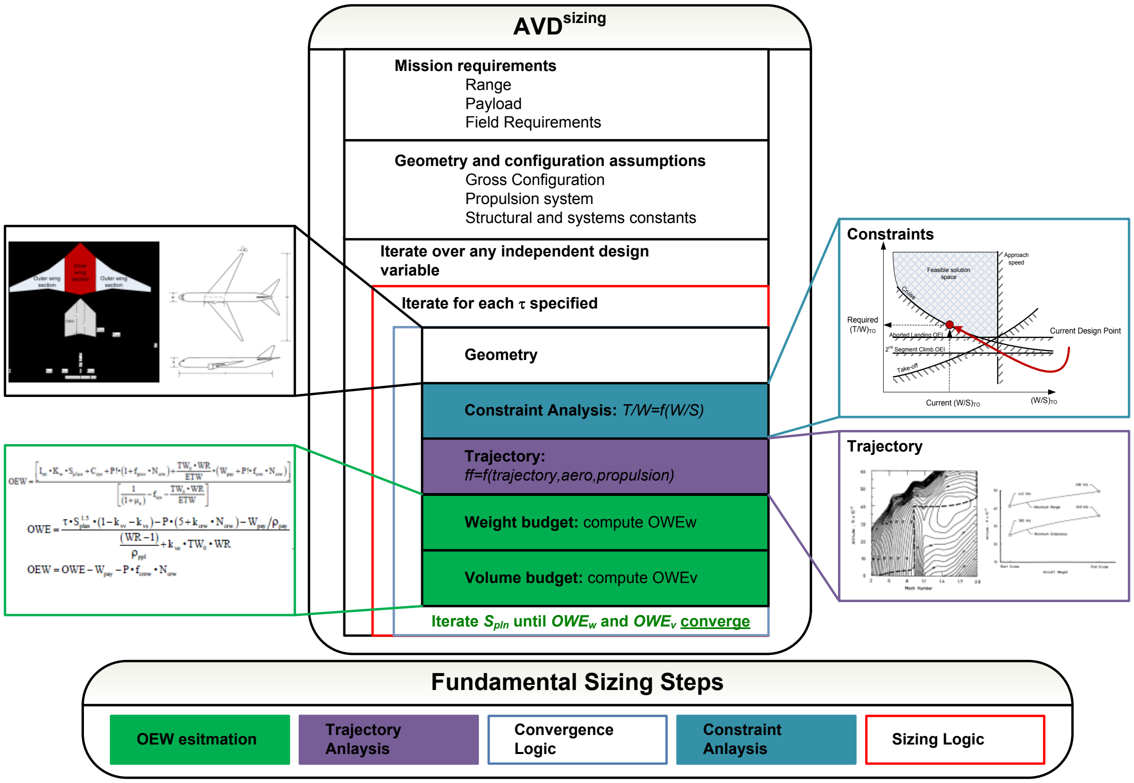


Figure 1.4 Fundamental AVD Sizing Logic (10)

For a complete description of AVD Sizing, see (10)

1.1.4 AeroMech

AeroMech is a generic stability and control tool (2). As expressed by G. Coleman (8), AeroMech analyzes an aircraft configuration concept for the assessment of

1. Control power leading to the sizing of primary control effectors
2. Static and dynamic stability (open and closed loop) for flight safety
3. 6-DOF trimmed aerodynamics for aircraft performance estimates

For a complete description of AeroMech, see (2) (8) (4). One objective of this thesis is to provide the aerodynamic input for AeroMech.

1.1.5 Preliminary Analysis, Design and Optimization (PrADO)

PrADO is a state-of-the-art multidisciplinary preliminary aircraft design tool. It is built on a modular architecture and is a collection of approximately 500 FORTRAN programs, which reflect the major disciplines involved in design (11). The attributes that make this system an exceptionally robust configuration evaluation tool, defined by Gary Coleman (10), are as follows:

1. Modular Design
2. Disciplinary Method Robustness
3. Data Visualization
4. Configuration Robustness

Examples of various applications PrADO has been used for are shown in Figure 1.5. For a complete description of PrADO, see (11).

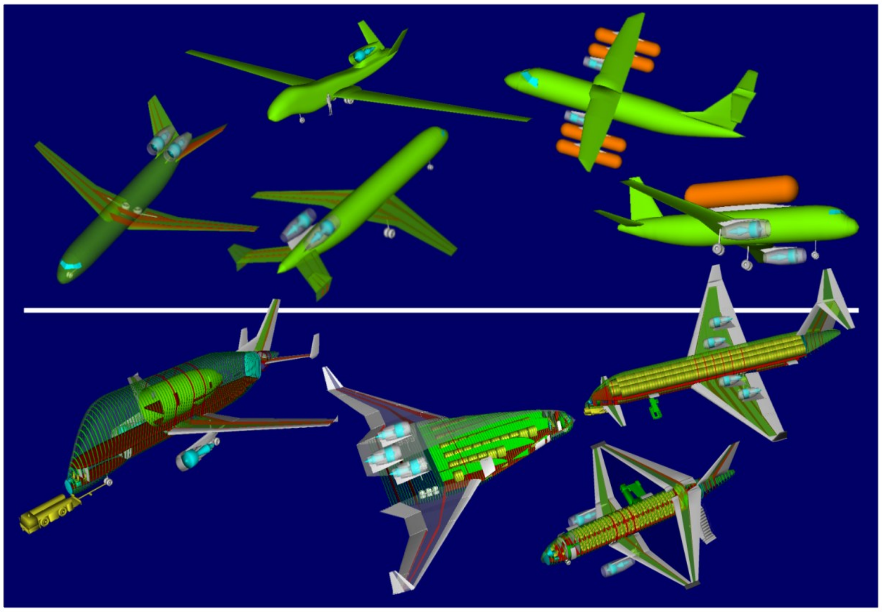


Figure 1.5 Examples of Various Applications of PrADO (11)

The original objective of this thesis has been initially to integrate DATCOM MAX into PrADO. Having reviewed the state of the DATCOM MAX itself, it was determined that this goal is beyond the scope of this M.S. thesis.

1.1.6 Virtual Test and Evaluation Simulator (VATES)

VATES performs autonomous (non-piloted) simulation by modeling the "*pilot-vehicle-operational environment*" system behavior in a complex (multi-factor) flight situation, for which the vehicle performance is to be tested and evaluated (12). The tool has a library of over 500 flight scenarios and has been applied to 18 aircraft, 3 helicopters, and 2 hypersonic vehicles. An example of a few flight scenarios is shown in Figure 1.6.

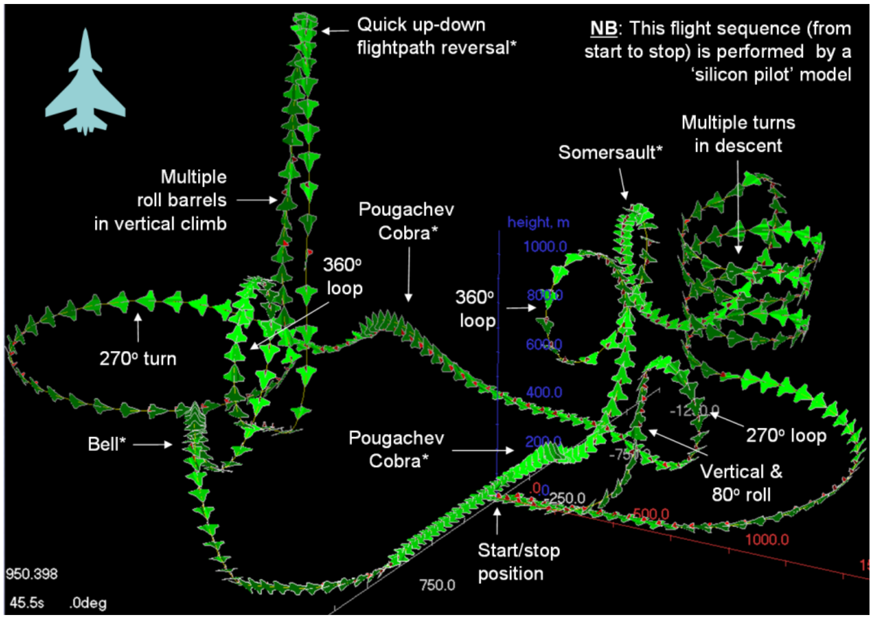


Figure 1.6 Examples of VATES Flight Scenarios (13)

A complete aerodynamic database is required for VATES and is the other tool this thesis focuses providing aerodynamic data for. For a complete description of VATES see (12).

1.2 Problem Description

AeroMech and VATES play a critical role in the AVDS process. Before those tools can be executed a complete aerodynamic database for a given aircraft configuration concept must be generated. The aircraft configuration concept can come from one of two places. One is from AVD Sizing and another is from an existing aircraft used as a case study. The AVDS tool set is capable of addressing conventional and unconventional aircraft configuration concepts. Consequently, the tool aerodynamic prediction toolbox must also be adaptable to conventional and unconventional aircraft configuration concepts. Method applicability, fast turnaround times, and tool robustness are criteria that need to be addressed when trying to generate an aerodynamic database in the context of the AVDS process.

1.3 Research Objectives & Tasks

The goal of this research undertaking is to provide a tool that can generate an aerodynamic database for a wide range of aircraft configuration concepts to be used in AeroMech and VATES. An aircraft main data sheet (MDS) must also be compiled to facilitate the building of an aircraft model to be used as a case study. Lastly, a user’s manual must be written for the aerodynamic tool. The research objectives and tasks required can be summarized in the following points:

1. Select case study aircraft and build MDS.
2. Survey existing aerodynamic tools applicable to this problem and select one.
3. Modify and adapt the selected tool to generate an aerodynamic database compatible with AeroMech and VATES.
4. Verify the tools functionality using the case study aircraft (B747-200F).

1.4 Chapter Summary

This chapter gives an introduction to the research incentive. It provides background information, problem description, Master of Science (M.S.) objectives and immediate research tasks. The background information provides a description of the aircraft design lifecycle, the AVD Lab's AVDS process and synthesis tools. This research aims at producing an aerodynamic database for the fixed-wing aircraft conceptual design phase. Lastly, the research objectives and overall research tasks are introduced.

CHAPTER 2

AERODYNAMICS IN CONCEPTUAL DESIGN

2.1 Configuration Aerodynamics

Configuration Aerodynamics considers overall flow phenomena present for the integral flight vehicle of a particular configuration and concept (2). This aerodynamic understanding, classified by Anderson (14), has ‘three dimensions’, (a) pure experiment, (b) pure theory, and (c) computational fluid dynamics (CFD). He concludes that CFD “… nicely and synergistically complements the other two approaches of pure theory and pure experiment, but it will never replace either of these approaches.”

The objectives of configuration aerodynamics according to Mason (15), is as follows:

- Develop the flow physics insight to form a “mental model” of each flow field or concept against which to gauge computational/experimental “reality”.
- Understand the computational/experimental tools must be used together, it’s not either/or. Both have strengths and weaknesses.
- Value analytical theory: airplanes were built before CFD ([using] UFD! [Understanding Fluid Dynamics]). Analytical formulas provide insight into the role of key flow and configuration shape parameters.
- Answer the question based on physics: “What configuration do I want to do this job?”

Lastly, Mason (16) states: “…Since the conceptual and preliminary design phases determine the basic configuration architecture, this is the area where improved design methods can make the biggest impact.”

2.2 Aerodynamic Tools in Conceptual Design

The definition of an aerodynamic database for use during the conceptual design of an aerospace vehicle is a task which must yield credible results in a timely manner (2). The 'three dimensions', stated by Anderson, directly correctly to three types of aerodynamic calculation techniques: (a) analytical, (b) semi-empirical and empirical, and (c) numerical. An overview of these techniques and example corresponding tools are shown in, Table 2.1

Table 2.1 Engineering Techniques for Configuration Aerodynamics Analysis (2)

Analytical		**Semi-Empirical/Empirical**		**Numerical**	
Method	***Year***	***Method***	***Year***	***Method***	***Year***
Lifting Line Theory (17)	1921	RAE Standard Method (18)	1940	Vortex Lattice Method (19)	1943
Swept-Wing Theory (20)	1935	Hoerner (21) (22) (23)	1951	Panel Method (24)	1962
Swept Wing Lin Theory (25)	1942	DATCOM (26)	1960	Finite Difference Method (CFD) (27)	1975
Low Aspect Ratio Wing Theory (28)	1946	ESDU (29)	1963	Finite Element Method (CFD) (30)	1978
Loading Function Method (31)	1950	Schemenski (32)	1973	Finite Volume Method (CFD) (33)	1973
Modified Lifting Line Method (34)	1952	Missile DATCOM (35)	1981	Spectral Method (CFD) (36)	1977
(…)	(…)	(…)	(…)	(…)	(…)

2.2.1 Analytical

Shevell states (37):

> *"…analytical methods plus wind tunnel studies allow many airplanes to be developed and to meet the predicted performance with acceptable accuracy. Since the 1950's it has been correct to say that the experienced aerodynamicist could predict the drag and lift of a high sub-sonic speed transport airplane with analytical tools over almost all of the possible speed and angle-of-attack conditions. … When flow separation was involved, as at the stall, or shock waves were present on the wing surface, the theories broke down. … Unfortunately, for most aircraft designs these limited regions were the most important."*

These tools provide a first order estimate of aerodynamic forces and moments and they are valuable during the conceptual design phase because of their fast turnaround times. These methods are aircraft configuration and operationally dependent, which reduces the model flexibility (2). Because of the limited capability of these methods they are determined not applicable to the aerodynamic database generating tool development.

2.2.2 Semi-Empirical and Empirical

Sinclair defines empirical as knowledge or study that is based on practical experience and observation rather than theories (38).

Snyder defines semi-empirical as (39):

> *"the 'semi' in semi-empirical methods means that the parameters used in the correlations were reasonable parameters based on the physics of the situations… In the development of semi-empirical methods, basic aerodynamic theory is used to make first order estimates of lift and drag and to define reasonable aerodynamic parameters to be used in the correclations. Then empirical corrections are made to the theory to produce good agreement with wind tunnel and flight test data."*

When these methods are used within their applicability, such as Digital DATCOM (Data Compendium), remarkable levels of accuracy and short turnaround times are achieved, ideal for conceptual design work (40). The problem with these methods is described by Snyder (39):

> *"… when the geometric parameters used in an airplane design are significantly different than those in the database that was used to develop the semi-empirical aerodynamic methodology, the methodology results are subject to question."*

Chudoba concludes (2):

> *"the non-generic character of semi-empirical and in particular empirical estimation techniques disqualifies those methods from being the 'work horse' for the generic stability and control methodology AeroMech"*

Although these methods are not generic they do apply to TAC aircraft and a wide range of aircraft components. Because of this these tools are considered to be implemented into the AVDS system.

2.2.3 Numerical

Lastly, numerical methods are linear and non-linear and are commonly referred to as CFD techniques.

Non-Linear

The non-linear Navier-Stokes, Euler, and Full Potential equations require extensive computer resources. This is because grids must be constructed to fill the flow field around a volume of interest. Other tasked required to use non-linear numerical methods are flow field discretization, solving systems of equations, data storage and transmission, and flow visualization. Runtimes can vary depending on the model but in general CFD has slow turnaround times and is high maintenance. The attributes disqualify CFD estimation methods for aerodynamic estimation during the conceptual design phase.

Linear

The linear Prandtl-Glauert equation requires much less computing power to solve. Methods such as the Vortex Lattice Method (VLM) and panel method analyze the geometric surface eliminated the need to model a geometric volume. However, linear estimation techniques do not estimate effects like boundary layer, wake roll up, transonic flow, or strong shocks instead (2). Synder adds (39).

"… they do provide reasonable estimates of the inviscid aerodynamics, including drag, for a large class of airplane geometries in both subsonic and supersonic flow"

The linear CFD techniques are favorable because they apply to a large class of airplane geometries but lack the ability to provide aerodynamic estimations for control effectors that are predominantly sized to comply with critical flight conditions at the boundary of the flight envelope, which is highly non-linear (2).

2.2.4 Tool Selection

From the arguments above, analytical methods are disqualified for the purpose of this thesis. Empirical methods are highly database dependent and not applicable to addressing new aircraft configuration concepts. Non-linear numerical methods are also disqualified for reasons mentioned earlier. That leaves linear numerical methods and semi-empirical methods.

The most applicable tools that are represented by these two categories are Digital DATCOM, VORLAX, VORSTAB summarized below by Gary Coleman (8):

- VORSTAB (41), a non-linear vortex lattice method;
- Digital DATCOM (42), a digital semi-empirical handbook method;
- VORLAX (43), a linear vortex lattice method

All these tools provide the capability to generate an aerodynamic database with fast turnaround times. VORLAX can handle a wide variety of aircraft configuration concepts but cannot handle flight envelopes involving stall. VORSTAB attempts to overcome this but still falls short unable to model unsteady aerodynamics neglecting $C_{m_{\dot{\alpha}}}$ and $C_{L_{\dot{\alpha}}}$, which play a significant role in longitudinal damping and is needed for accessing dynamic stability. Digital DATCOM shortfall is the inability to handle a wide variety of aircraft configuration concepts. As detailed in (2) VORSTAB, Digital DATCOM, and VORLAX were selected in support of each other to generate the aerodynamic database for AeroMech and VATES. The required input summarized by Gary Coleman (8) is shown in Table 2.2.

Table 2.2 AeroMech and VATES Input

Static Derivatives	Dynamic Derivatives	LOCE Increments	LaCE Increments	DiCE Increments
C_L	$C_{L_{\dot{\alpha}}}$	ΔC_L	ΔC_L	ΔC_L
C_D	$C_{m_{\dot{\alpha}}}$	ΔC_D	ΔC_D	ΔC_D
C_m	C_{L_q}	ΔC_m	ΔC_m	ΔC_m
C_{Y_β}	C_{m_q}	ΔC_Y	ΔC_Y	ΔC_Y
C_{l_β}	C_{Y_p}	ΔC_l	ΔC_l	ΔC_l
C_{n_β}	C_{l_p}	ΔC_n	ΔC_n	ΔC_n
	C_{n_q}			
	C_{n_r}			
	C_{l_r}			
	C_{n_r}			

Out of these tools Digital DATCOM was selected to be adapted into the AVDS process to produce the required aerodynamic database. Eventually, all three tools will be incorporated in support of each other into the AVDS process. Digital DATCOM has been selected because it can produce the entire aerodynamic database needed for AeroMech and VATES. The set of aircraft configuration concepts available in Digital DATCOM can also be expanded, within the context off the configuration buildup process of Digital DATCOM described later.

2.3 Digital DATCOM

Digital DATCOM is a 357+ subroutine code program that was produced by a team of engineers at McDonnell Douglas over 22 years. It is capable of calculating static and dynamic derivatives as well as a wide variety of high lift and control device contributions through subsonic, transonic, supersonic, and hypersonic speed regimes. Its purpose is to provide a rapid and economical estimation of aerodynamic stability and control characteristics (42). For a complete description of Digital DATCOM, see (42) (44) (45).

2.4 Chapter Summary

This chapter discusses configuration aerodynamics and its role during the conceptual design phase. All aerodynamic tools available, comprising of analytical, semi-empirical and empirical, and numerical techniques, for conceptual design are presented. The tools are then narrowed down to ones applicable to this thesis and Digital DATCOM is selected to be adapted into the AVDS process. Lastly, the selected tool is briefly summarized as an introduction into the DATCOM MAX debugging and capability expansion activity.

CHAPTER 3

DATCOM MAX PROTOTYPE SYSTEM DEVELOPMENT

3.1 DATCOM MAX Development History

Work on DATCOM MAX originally began in 2005 by research students Gary Coleman and Amit Oza in the AVD Laboratory, UTA MAE. The last known modification was noted in 2009. The source code they started from was purchased from Public Domain Aeronautical Software (PDAS) (46) noted as '1' in Table 3.1. From there they produced eight versions ending with version 10, version 1 being the acquisition of the PDAS source code, also shown in Table 3.1. The 10th version of DATCOM MAX was the version the author started with. All work up until version 11 was done by research students Gary Coleman and Amit Oza. The software development environment utilized is Compaq Visual Fortran 6.6.a on a 32-bit Windows XP Professional computer.

The order in which the programs are listed in Table 3.1 indicates the order in which the modifications have been made to the original source code culminating in DATCOM MAX. The 'Last Modification Date' column shows the last date each DATCOM MAX version or original source code has been modified. Each version is summarized below. One should note that no external documentation of versions 2 through 10 has been produced beyond the source code documentation. The researcher initiated a source code familiarization phase resulting in the brief summary statements below.

Version 2

The first version's sole purpose is to call and run the provided Digital DATCOM executable from PDAS. No modifications were made to the PDAS source code.

Table 3.1 DATCOM MAX Versions

	Version	Last Modification Date	Comments
1	**DATCOM (PDAS)**	01/05/1999	Official version of Digital DATCOM from PDAS
2	**RunDATCOM**	11/11/2005	Runs DATCOM.EXE through Fortran File
3	**Source Codev1**	11/14/2005	PDAS source code modified to run in Fortran 90
4	**Digital DATCOM Source Codev2**	11/15/2005	Modified Source Codev1
5	**DATCOMvInput_filename**	11/15/2005	Prompts for input file name
6	**DATCOMvAuto_file**	07/10/2006	Doesn't ask for name of input file
7	**DATCOMvAUTO_FILE2**	07/11/2006	Working version of DATCOMvAuto_file
8	**DATCOMv2**	07/31/2008	Start of DATCOM MAX
9	**DATCOM MAX (10-28-08)**	10/28/2008	Unknown version properties of DATCOM MAX
10	**DATCOM MAX (5-1-09)**	05/01/2009	Unknown version properties of DATCOM MAX
11	**DATCOM MAX V3**	09/01/2011	Last version of DATCOM MAX compatible with AeroMech (vA2)
12	**Digital-Datcom-Package (USAF)**	11/22/2002	Official version of Digital DATCOM from William Blake (USAF)
13	**DATCOM MAX V4**	09/29/2011	Latest released version of DATCOM MAX
14	**DATCOM MAX V5**	11/05/2011	Created for further development

Version 3

The purpose of version 3 is to convert the source code from Fortran 77 to Fortran 90 to be able to use it in the Compaq Visual Fortran environment. This was done by modifying the syntax of the PDAS source code.

Version 4 through 7

These versions are testing programs to familiarize the programmer with the Fortran environment and the PDAS Digital DATCOM source code. Little is known about these versions due to the developmental structure of the code. The information that can be drawn from these versions is summarized in Table 3.1.

Version 8 through 10

These are the first versions of DATCOM MAX that are modifications of the PDAS source code that try to address the problems outlined in chapter 1.3 . The version produced by that research effort was version 10, ‘DATCOM MAX (5-1-09)’. Version 10 produced an aerodynamic database used in AeroMech and VATES.

3.2 DATCOM MAX Prototype Software Development

The development of DATCOM MAX follows: (a) review of previous work done by Gary Coleman and A. Oza, (b) establishment of prototype system requirements, (c) verification of DATCOM MAX against Digital DATCOM executable using the B747-200F case study, and (d) DATCOM MAX V4 User's Manual.

3.2.1 Review of Previous DATCOM MAX Work

Review of previous work done started with the most recent version of DATCOM MAX available, which was DATCOM MAX (5-1-2009). The only documentation for DATCOM MAX produced by Gary Coleman and Amit Oza was the source code. The modifications made to Digital DATCOM by Gary Coleman and Amit Oza is to a select set of subroutines. These modifications have been identified necessary through 3 means: (a) following the Digital DATCOM routine using the B747-200F case study, (b) comparing the DATOCM MAX B747-200F model output against the provided Digital DATCOM executable executing the B747-200F model, and (c) using WinMerge (47) to make a direct comparison of the original Digital DATCOM source code files. Results of this review have been presented in the previous subchapter, see DATCOM MAX Development History.

3.2.2 Prototype System Requirements

The DATCOM MAX requirements are derived from the problem statement and research objectives and are shown in Table 3.2.

Table 3.2 DATCOM MAX Prototype System Requirements

Priority	Prototype System Requirements
1	Produce static and dynamic stability derivatives database for a given aircraft configuration to be used for AeroMech and VATES
2	Versatile configuration modeling capability
3	Documentation: (a) software development, (b) software verification, validation, calibration, (c) users guide

Priority 1 is to be able to produce a complete conceptual aerodynamic database that can be used in AeroMech and VATES for a given aircraft configuration concept. Accuracy is desired but capturing an aircraft concept trends and sensitivities (correctness) is more important. DATCOM provides the legacy methods for calculating the trends and sensitivities of aircraft concepts while Digital DATCOM provides the platform which can be modified to calculate the trends and sensitivities for a model.

Priority 2 requires expanding Digital DATCOM to provide a versatile configuration modeling capability. Addressing novel aircraft configuration concepts at the conceptual level is extremely difficult because of method limitations. The methods contained in DATCOM can be applied to a wide range of aircraft configuration concepts. This provides the versatile configuration modeling capability to address different aircraft configuration concepts. The problem with DATCOM is twofold. One, the paper document DATCOM is not in a medium that can provide fast turnaround times during the conceptual design phase. Two, although Digital DATCOM provides the medium for fast turnaround times the digital implementation is restricted in aircraft configuration versatility compared to the original paper version.

Lastly, Priority 3 is to produce documentation to go along with the source code and executable so the tool can be used for future project and expanded as needed. The documentation includes a recorded history of DATCOM MAX, source code modifications list with comments, and a user’s manual. The recorded history provides a platform for future students to springboard off of to begin working on DATCOM MAX. The source code modifications and comments are required for future development of DATCOM MAX. The user’s manual is critical in allowing anyone to use the tool correctly.

3.2.3 Verification of DATCOM MAX

Verification is the process of checking the DATCOM MAX output against the Digital DATCOM output. The purpose of verification is to make sure DATCOM MAX can reproduce the same information from Digital DATCOM. The process to verify DATCOM MAX output is configuration dependent due to Digital DATCOM's operational limitations and is further described in the DATCOM MAX User's Manual in the appendix on page 91.

During the development of DATCOM MAX V3 errors related to the Digital DATCOM source code have been found and continue to be found. This is reinforced by the note in Digital DATCOM manual, "differences between DATCOM and Digital DATCOM do exist" (42). It is the author's experience that these errors are more often than not due to bookkeeping in the code than the methods but that is not always the case. A list of the discovered errors is shown in the DATCOM MAX V4 User's Manual (in the appendix on page 91) but more are assumed to exist. This leads to questioning the correctness of the results provided by the purchased PDAS Digital DATCOM source code and provided executable. William Blake at the USAF has been contacted, who is one of the original developers of Digital DATCOM. He notes himself and Jim Simon as "the last 'keepers' of the code until it became public domain" in 1996 (48). He provided the author with the original Digital DATCOM source code cleared for public release in 1996. After reviewing the source codes, differences between the original PDAS and USAF Digital DATCOM were found in the USAF Digital DATCOM code, shown in Table 3.3. Those differences can mainly attributed to, debugging lines of code added, thus they do not affect the core of Digital DATCOM.

Since the original FORTRAN 77 source codes cannot be compiled into an executable without modification; the provided executable from PDAS and the USAF have been used simultaneously to compare results utilizing the B747-200F case study. Rounding differences in the data as well as differences in declaring unused variables are the only differences found and do not affect the results. Even though the results appear be nearly identical both executables are used to verify DATCOM MAX output since it is not known at this point if the PDAS and the USAF versions output will always match. The strategy of using both executables to verify DATCOM MAX does add another layer of checking.

Table 3.3 USAF and PDAS Digital DATCOM Subroutine Differences

Subroutine	Purpose
ALDLPR	Logic to Print Blacks
AUXOUT	Write Auxiliary and Partial Outputs
AXPRNT	Print Auxiliary Panel Outputs
FLTCL	Trim Related
HEADR	Write Page Headings and Calls INTERM
INTERM	Intermediate Logic for Output
M42O52	Exec for Overlay 42, Hypersonic Flap Aero
OUTPT2	Writes High Lift and Control Data

Lastly, for the two added methods for the rudder and landing gear it is not possible to verify the operation of DATCOM MAX against Digital DATCOM because these methods are not present in Digital DATCOM or Paper DATCOM. Both methods were implemented by Gary Coleman and Amit Oza and cannot be verified.

3.2.4 Validation of DATCOM MAX

Validation is the process of checking DATCOM MAX output against experimental aerodynamic data, if available. The purpose is to validate the correctness of the DATCOM methods and the modeling assumptions. As stated previously, “differences between DATCOM and Digital DATCOM do exist” (42). Although the DATCOM methods are proven legacy material it is clear the output needs to be checked against actual data. To check every DATCOM method using a design case study like B747-200F is extremely time consuming beyond the scope of the current effort to verify functionality of DATCOM MAX. Instead, it is the author’s experience that simple comparisons prove to be very effective in finding errors. The currently known errors and corrections found in Digital DATCOM are described in the DATCOM MAX V4 User’s Manual in the appendix on page 91.

3.2.5 DATCOM MAX User’s Manual

The DATCOM MAX V4 User’s Manual provides descriptions of required input, configuration concepts versatility and limitations, available output, and operational information of the latest software release called DATCOM MAX V4. The purpose of the manual is to allow user

DATCOM MAX familiarization for future development. The DATCOM MAX V4 User's Manual is given in the appendix on page 91.

The DATCOM MAX V4 User's Manual contains the following information.

Release Note

The release notes give a brief summary of DATCOM MAX development history, a list and description of modifications made between versions 'DATCOM MAX (10-28-08)' and 'DATCOM MAX V4', and a list describing known problems in Digital DATCOM and DATCOM MAX V4.

Program Guidelines

The program guidelines describe the DATCOM MAX V4's routine, capabilities, and limitations.

Output Formats

This section lists and describes the available output from DATCOM MAX V4.

Input Files

This section lists and describes the required input for DATCOM MAX V4.

Validation Process

The Validation process contains two parts; Verification of the DATCOM MAX results and validation of the DATCOM MAX results. The description of verification and validation is described earlier in this chapter. The DATCOM MAX V4 User's Manual gives a step by step process of how to verify a DATCOM MAX model.

How to Build a New Version of DATCOM MAX

Lastly, a step by step example of how to create a new version of DATCOM MAX in the Compaq Visual Fortran environment is shown to allow for future development of DATCOM MAX.

3.2.6 DATCOM MAX Routine

The purpose of this section is to describe the DATCOM MAX V4 routine at the top level. The routine in which the code runs at the top level is shown in Figure 3.1 and is described below.

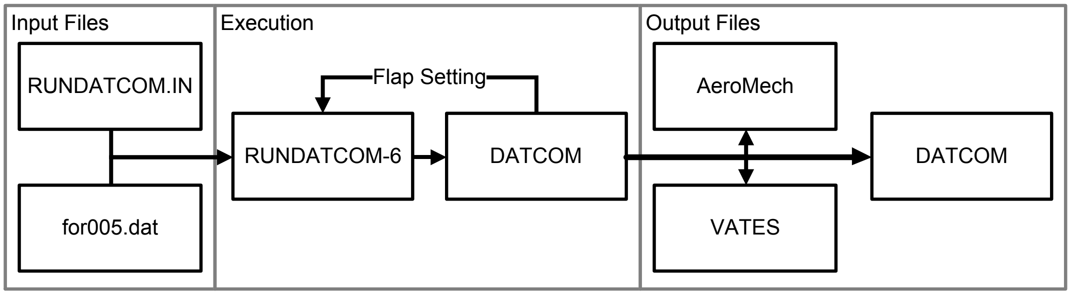


Figure 3.1 DATCOM MAX V4's Routine

3.2.7 Input Files

There are two files that handle the input for DATCOM MAX. As show in Figure 3.1 they are RUNDATCOM.IN and for005.dat.

for005.dat

The for005.dat file is built using the same syntax as described in the Digital DATCOM User's Manual (42). The differences are what cases and in what order they must be placed in the for005.dat file to properly model an aircraft configuration concept. The order and cases to be placed in the for005.dat is as follows:

1) Clean & LOCE cases
2) LACE 1 case (Ailerons, if applicable)
3) LACE 2 case (Spoilers, if applicable)
4) DICE case (Rudder, if applicable)
5) Speed Breaks case (if applicable)

Depending on the configuration and flight conditions executed, the cases required will vary. Required case selection is made using the Digital DATCOM User's Manual (42).

RUNDATCOM.IN

The RUNDATCOM.IN file is very different from the for005.dat file and does not contain the same syntax as the for005.dat does. For a complete description of the syntax and contents of the RUNDATCOM.IN input file please see the DATCOM MAX V4 User's Manual, given in the appendix on page 91. The purpose of this file is to provide the inputs for the landing gear and rudder methods added as well as execution information used by DATCOM MAX. Some of the information is redundant to the for005.dat file and is reminisce from the (5-1-09) version of DATCOM MAX structure.

3.2.8 Execution

The execution of DATCOM MAX is handled by the driver program, RUNDATCOM-6, and the DATCOM subroutine. The purpose of this section is to describe program execution logic.

RUNDATCOM-6

RUNDATCOM-6 is the driver program that reads the RUNDATCOM.in input file, writes all the output files except datcom.out, and builds the aircraft configuration concept using saved results from the DATCOM subroutine. RUNDATCOM-6 calls DATCOM for each flap setting declared in the RUNDATCOM.IN input file, shown in Figure 3.1.

DATCOM

The DATCOM subroutine is originally the driver program for Digital DATCOM. It has been modified and is now the subroutine called by RUNDATCOM-6. Each time the DATCOM subroutine is called the for005.dat input is read and all cases are executed. Depending on the flaps settings input to the RUNDATCOM.IN file the for005.dat information will be executed differently for each flap setting.

3.2.9 Output Files

There are three groups of output files that DATCOM MAX produces. Two groups are for AeroMech and VATES while the last group is reminisce of the Digital DATCOM code and is neglected. For a complete description of the output formats see the DATCOM MAX V4 User's Manual, given in the appendix on page 91.

3.3 DATCOM MAX V4

DATCOM MAX V4 is an adaptation of Digital DATCOM intended for use in the AVDS process. The purpose of DATCOM MAX V4 is to provide an aerodynamic database of static and dynamic stability derivatives for an aircraft configuration concept generated by AVD Sizing or provided by a case study. This chapter describes the modifications made to Digital DATCOM in order to arrive at DATCOM MAX V4, capabilities and limitations of DATCOM MAX, and a complete description of the aircraft configuration concept buildup equations implemented into DATCOM MAX V4.

3.3.1 DATCOM MAX Modifications to Arrive at V4

To create DATCOM MAX three subroutines have been added and nineteen Digital DATCOM subroutines have been modified, shown in Table 3.4. Each subroutine required extensive modification. For a complete list of modifications with comments please see the DATCOM MAX V4 User's Manual, given in the appendix on page 91.

Table 3.4 DATCOM MAX V4 Subroutines

	Subroutine	Purpose
Created		
1	**DIFLP****	Computes incremental wing lift due to flaps (Rudder)
2	**LNGR****	Computes incremental landing gear contributions (Torenbeek)
3	**RUNDATCOM-6***	Driver Program (wrapper for DATCOM subroutine)
Modified		
1	**BODOPT**	Computes asymmetrical body aerodynamics
2	**CMALPHA***	Computes lifting surface CMA
3	**DATCOM***	Driver subroutine for Digital DATCOM
4	**DECODE**	Read user input NACA designation and decode
5	**DRAGFP**	Calculates subsonic flap induced drag
6	**FLAPCM***	Computes wing CM due to flaps
7	**GRDEFF***	Computes ground effects
8	**IDEAL**	Calculates the section ideal aerodynamic parameters
9	**LATFLP**	Computes incremental wing lift due to control devices
10	**LIFTFP***	Computes incremental wing lift due to flaps
11	**M11O13***	Exec for overlay 11, ground effects
12	**MAIN00**	Top level executive
13	**MAIN01***	Digital DATCOM subsonic aero executive
14	**MAIN02***	Subsonic ground effects data executive
15	**MAIN05***	Subsonic high lift and control devices executive
16	**OUTPT2***	This subroutine writes the high lift and control data
17	**TRSONI**	Computes transonic wing lift slope, CLMAX, ALPHA CLMAX, AND CD0 body lift and moment slopes, drag at angle-of-attack
18	**WBAERO**	Compute wing body lift, pitching moments and drag
19	**WBCM**	Wing-Body moment calculations

Note: *Gary Coleman and/or Amit Oza contributed to subroutine
**Author did not contribute to subroutine

3.3.2 Capabilities and Limitations

DATCOM MAX V4 aircraft configuration concept modeling capability is defined in the same manner Digital DATCOM defines aircraft configuration concept modeling capability, as shown in the Digital DATCOM User's Manual (42). This is done through three charts: 'Aerodynamic Output', 'High Lift & Control Device Output', and 'Additional Analysis'.

Aerodynamic Output

The 'Aerodynamic Output' defines the static and dynamic stability derivatives estimation capability (output) available for the particular aircraft configuration for the specific flight speed regimes. Digital DATOM has 10 different configurations, while DATCOM MAX V4 has 2 configurations. Digital DATCOM has limited capability to calculate subsonic, transonic, supersonic, and hypersonic speed regimes, while DATCOM MAX V4 is currently only available for subsonic calculations. This is because DATCOM MAX requires debugging and validation for each aircraft configuration in each speed regime and is beyond the scope of the current work. For Digital DATCOM's available aerodynamic output please see the Digital DATCOM User's Manual (reference). DATCOM MAX V4's available aerodynamic output is shown in Table 3.5.

Table 3.5 DATCOM MAX V4 Aerodynamic Output

● Output Available
□ Output only for configurations with straight tapered surfaces

Configuration	Speed Regime	Static Aerodynamic Characteristic Output											
		C_{D0}	C_D	C_L	C_m	C_N	C_A	$C_{L\alpha}$	$C_{Y\beta}$	$C_{n\beta}$	q/q_∞	ε	$d\varepsilon/d\alpha$
Wing-Body	Subsonic	●	●	●	●	●	●	●	●	●			
	Transonic												
	Supersonic												
	Hypersonic												
	Speed Regime	**Dynamic Stability Output**											
		C_{Lq}	C_{mq}	$C_{L\dot{\alpha}}$	$C_{m\dot{\alpha}}$	C_{lP}	C_{YP}	C_{nP}	C_{nr}	C_{lr}			
	Subsonic	●	●	●	●	●	●	●	●	●			
	Transonic												
	Supersonic												
	Hypersonic												
Wing - Body - Horizontal Tail - Vertical Tail	**Speed Regime**	**Static Aerodynamic Characteristic Output**											
		C_{D0}	C_D	C_L	C_m	C_N	C_A	$C_{L\alpha}$	$C_{Y\beta}$	$C_{n\beta}$	q/q_∞	ε	$d\varepsilon/d\alpha$
	Subsonic	□	□	□	□	□	□	●	●	●	□	□	□
	Transonic												
	Supersonic												
	Hypersonic												
	Speed Regime	**Dynamic Stability Output**											
		C_{Lq}	C_{mq}	$C_{L\dot{\alpha}}$	$C_{m\dot{\alpha}}$	C_{lP}	C_{YP}	C_{nP}	C_{nr}	C_{lr}			
	Subsonic	□	□	□	□	□	□	□	□	□			
	Transonic												
	Supersonic												
	Hypersonic												

High Lift & Control Device Output and Additional Analysis

The ‘High Lift & Control Device Output’ shows what high lift and control devices can be modeled and the additional output available for each device, see Table 3.6. This information must be used in conjunction with the ‘Additional Analysis’ information, see Table 3.7. The ‘Additional Analysis’ table shows the individual concepts that can be used on what aircraft configuration and how many of each device.

Table 3.6 DATCOM MAX V4 High Lift & Control Device Output

Speed Remine Code **1 Subconic** **2 Supersonic** **3 Supersonic**

Control Device	ΔC_L*	ΔC_m	ΔC_D	ΔC_{Di}	ΔC_{Lmax}	$(C_{L\alpha})_\delta$	ΔC_{Dmin}*	C_{lW}	C_{nW}	C_{nVT}	C_{lHT}	C_{lVT}	C_{YVT}	$C_{h\alpha}$*	$C_{h\delta}$*
Jet Flaps															
Pure Jet Flap															
Jet Flap & Mech. Flap															
IBF															
EBF															
Flaps															
Plain	1	1		1	1		1							1	1
Single Slotted	1	1		1	1	1	1								
Fowler Slotted	1	1		1	1	1									
Double Slotted	1	1		1	1	1								1	1
Split	1	1		1											
Leading Edge	1	1		1											
Krueger	1	1													
Slats															
Leading Edge	1	1													
Spoilers															
Plug								1	1						
Flap								1	1						
Slotted								1	1						
Differential δ															
Horizontal Tails											1				
Wing Ailerons								1	1						
Rudder	1	1	1							1		1	1		
Landing Gear															
Nose Gear		1	1												
Main Gear		1	1												

Notes: *In addition to straight-tapered planforms, output also available on non-straight-tapered planforms (e.g., double delta).

Ailerons are identified as plan flaps in program.

IBF	Internally blown flap
EBF	Externally blown flap
W	Wing
HT	Horizontal tail
VT	Vertical tail

Table 3.7 DATCOM MAX V4 Additional Analysis

Additional Analysis	Applicable Configurations*	
	B+W	B+W+H+V
Properller Power		
Jet Power		
Ground Effects		
Twin Vertical Tail		
Symmetrical Flap on Wing[1]	●	●
Symmetrical Flap on Horizontal Tail[2]	●	●
Asymmetrical Flap on Wing[3]	●	●
Asymmetrical Flap on Horizontal Tail[4]	●	●
Jet Flap on Wing		
Symmetrical Flap and Asymmetrical Flap on Wing[5]	●	●
Landing Gear[4]	●	●

*Note Configuration Codes:		
	B+W	Wing-Body
	B+W+H+V	Wing-Body-Horizontal-Vertical

[1] Up to 20 at the same time

[2] One per a case

[3] Up to 2

[4] One per a case

[5] Up to 20 SYMFP and 2 ASYFLP at the same time

Operational Limitations

Many functions in Digital DATCOM have not been addressed or verified in DATCOM MAX V4. They were not included in this research due to applicability or time constraints. The un-addressable components and functions un-included in DATCOM MAX V4 are the following:

- CASE CONTROL
    - TRIM – Will not work, AeroMech used instead
- NAMELIST NAME
    - PROPWR – Untested
    - JETPWR – Untested
    - TVTPAN- Untested
    - LARWB – Untested
    - TRANJET – Untested
    - HYPEFF- Untested
    - CONTAB – Untested
- SYMFLP
    - PLAIN FLAPS – Will not work, RUNDATCOM.IN needs modification
    - JET FLAPS – Will not work, RUNDATCOM.IN needs modification
- ASYFLP
    - AMHT (STYPE = 5) – Do not use, Implemented through RUNDATCOM.IN instead
- Program Subroutines
    - DWASH – Incomplete, uses only clean configuration

In addition, the ‘Operational Limitations’ of DATCOM MAX V4 are different from that found in section 2.4.5 of the Digital DATCOM User’s Manual (insert reference). The ‘Operational Limitations’ applicable and tested in DATCOM MAX V4 are listed below.

- The forward lifting surface is always input as the wing and the aft lifting surface as the horizontal tail. This convention is used regardless of the nature of the configuration.
- Airfoil section characteristics are assumed to be constant across the airfoil, span, or an average of the panel. Inboard and outboard panels of cranked or double-delta planforms can have their individual panel leading edge radii and maximum thickness ratios specified separately.
- If airfoil sections are simultaneously specified for the same aerodynamic surface by a NACA card designation and by coordinates, the coordinate information will take precedence.
- The effect of high lift and control devices on downwash is not calculated.
- The program uses the input namelist names to define the configuration components to be synthesized. For example, the presence of namelist HTPLNF causes Digital DATCOM to assume that the configuration has a horizontal tail.

3.3.3 Configuration Buildup Equations

The two aircraft configurations available in DATCOM MAX V4, shown in Table 3.5, and are Wing-Body and Wing-Body-Horizontal Tail-Vertical Tail. The component buildup is the same for each configuration except for the simpler, Wing-Body, configuration the horizontal tail and vertical tail contributions are ignored. To build a configuration concept, simply add the component contribution(s) to the clean configuration. Please note ground effect is shown for future development implementation into DATCOM MAX and is not used in DATCOM MAX V4. Using the output from DATCOM MAX V4 the aircraft configuration concept aerodynamic coefficients can be calculated.

- Drag Coefficient
- Lift Coefficient
- Pitching Moment Coefficient
- Side-Force Coefficient
- Rolling Moment Coefficient
- Yawing Moment Coefficient

The equations are shown with two tables. The “Buildup” table defines each variable and shows what each variable is a function of. The “DATCOM MAX Buildup Definitions” table shows how the variables defined in the “Buildup” table are defined in DATCOM MAX. The purpose of this table is to provide transparency of how DATCOM MAX builds the aircraft configuration concept. DATCOM MAX provides the input to these equations, which allow the coefficients to be determined for various control device deflections, high lift device deflections, flight conditions, and aircraft configurations.

Drag Coefficient

$$\begin{aligned} C_D = C_{D_{WBHV}}(\alpha, M) + \Delta C_{D_{Flaps}}\left(\alpha, M, \delta_f\right) + \Delta C_{D_{HT+\delta_e}}\left(\alpha, \delta_f, \delta_{HT}, \delta_e\right) \\ * K_D^M\left(\alpha, M, \delta_f\right) + \Delta C_{D_{sb}}(\alpha, M, \delta_{sb}) + \Delta C_{D_s}(\alpha, M, \delta_s) \\ + \Delta C_{D_{LGmax}}(\alpha, M) * \delta_{LG} \\ + \Delta C_{D_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE}) \end{aligned} \tag{1.1}$$

Table 3.8 Drag Coefficient Buildup

Function-characteristic representation	Characteristic representation in aerodynamic buildup equation	Main affecting parameter/component	Other effecting parameters
$\Delta C_{D_{WBHV}}(\alpha, M)$	$\Delta C_{D_{WBHV}}(\alpha, M)$	Clean Wing-Body-Horizontal Tail-Vertical Tail	-
$\Delta C_{D_{Flaps}}(\alpha, M, \delta_f)$	$\Delta C_{D_{Flaps}}(\alpha, M, \delta_f)$	Flap Setting (δ_f)	α, M
$\Delta C_{D_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{D_{HT+\delta_e}}(\alpha, \delta_f, \delta_{HT}, \delta_e) * K_D^M(\alpha, M, \delta_f)$	Horizontal Tail (δ_{HT}) and Elevator (δ_e)	α, M, δ_f
$K_D^M(\alpha, M, \delta_f)$	$K_D^M(\alpha, M, \delta_f)$	Mach Number (M)	α, δ_f
$\Delta C_{D_{sb}}(\alpha, M, \delta_{sb})$	$\Delta C_{D_{sb}}(\alpha, M, \delta_{sb})$	Speed Brake (δ_{sb})	α, M
$\Delta C_{D_s}(\alpha, M, \delta_s) = 0$	$\Delta C_{D_s}(\alpha, M, \delta_s)$	Spoiler (δ_s)	α, M
$\Delta C_{D_{LGmax}}(\alpha, M)$	$\Delta C_{D_{LGmax}}(\alpha, M) * \delta_{LG}$	Landing Gear Position (δ_{LG})	α, M
$\Delta C_{D_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	$\Delta C_{D_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	Altitude (h_{GE})	$\alpha, M, \delta_f, \delta_{HT}, \delta_e$

Table 3.9 DATCOM MAX Drag Coefficient Buildup Definitions

Function-characteristic representation	Characteristic representation in DATCOM MAX aerodynamic buildup equation
$\Delta C_{D_{WBHV}}(\alpha, M)$	$\Delta C_{D_{WBHV}}(\alpha, M, CONFIGURATION\ )$
$\Delta C_{D_{Flaps}}(\alpha, M, \delta_f)$	$\Delta C_{D_{Flaps}}(\alpha, M, \delta_f)$
$\Delta C_{D_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{D_{WBHV}}(\alpha, M, \delta_{HT}\ CONFIGURATION) - \Delta C_{D_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION) + \Delta C_{D_{\delta_e}}(\alpha, M, \delta_{HT}, \delta_e) + \Delta C_{D_{Flaps}}(\alpha, M, \delta_f)$
$K_D^M(\alpha, M, \delta_f)$	$\dfrac{\Delta C_{D_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION\ )}{\Delta C_{D_{WBHV}}(\alpha, 1ST\ MACH\ NUMBER, CLEAN\ CONFIGURATION\ )}$
$\Delta C_{D_{sb}}(\alpha, M, \delta_{sb})$	$\Delta C_{D_{sb}}(\alpha, M, \delta_{sb})$
$\Delta C_{D_s}(\alpha, M, \delta_s) = 0$	0
$\Delta C_{D_{LGmax}}(\alpha, M)$	$\Delta C_{D_{LGmax}}(\alpha, M)$
$\Delta C_{D_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	$\Delta C_{D_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$

Lift Coefficient

$$\begin{aligned} C_L = C_{L_{WBHV}}(\alpha, M) + \Delta C_{L_{Flaps}}(\alpha, M, \delta_f) + \Delta C_{L_{HT+\delta_e}}(\alpha, \delta_f, \delta_{HT}, \delta_e) \\ * K_L^M(\alpha, M, \delta_f) + \Delta C_{L_{sb}}(\alpha, M, \delta_{sb}) + \Delta C_{L_s}(\alpha, M, \delta_s) \\ + \Delta C_{L_{LGmax}}(\alpha, M) * \delta_{LG} \\ + \Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE}) + C_L^q(\alpha, m, \delta_f) * q * \frac{b}{V} \end{aligned} \tag{1.2}$$

Table 3.10 Lift Coefficient Buildup

Function-characteristic representation	**Characteristic representation in aerodynamic buildup equation**	**Main affecting parameter/component**	**Other effecting parameters**
$\Delta C_{L_{WBHV}}(\alpha, M)$	$\Delta C_{\mathrm{L}_{WBHV}}(\alpha, M)$	Clean Wing-Body-Horizontal Tail-Vertical Tail	-
$\Delta C_{\mathrm{L}_{Flaps}}(\alpha, M, \delta_f)$	$\Delta C_{\mathrm{L}_{Flaps}}(\alpha, M, \delta_f)$	Flap Setting (δ_f)	α, M
$\Delta C_{\mathrm{L}_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{\mathrm{L}_{HT+\delta_e}}(\alpha, \delta_f, \delta_{HT}, \delta_e)$ $* K_L^M(\alpha, M, \delta_f)$	Horizontal Tail (δ_{HT}) and Elevator (δ_e)	α, M, δ_f
$K_{\mathrm{L}}^M(\alpha, M, \delta_f)$	$K_{\mathrm{L}}^M(\alpha, M, \delta_f)$	Mach Number (M)	α, δ_f
$\Delta C_{\mathrm{L}_{sb}}(\alpha, M, \delta_{sb})$	$\Delta C_{\mathrm{L}_{sb}}(\alpha, M, \delta_{sb})$	Speed Brake (δ_{sb})	α, M
$\Delta C_{\mathrm{L}_s}(\alpha, M, \delta_s) = 0$	$\Delta C_{\mathrm{L}_s}(\alpha, M, \delta_s)$	Spoiler (δ_s)	α, M
$\Delta C_{\mathrm{L}_{LGmax}}(\alpha, M) = 0$	$\Delta C_{\mathrm{L}_{LGmax}}(\alpha, M) * \delta_{LG}$	Landing Gear Position (δ_{LG})	α, M
$\Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	$\Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	Altitude (h_{GE})	$\alpha, M, \delta_f, \delta_{HT}, \delta_e$
$C_L^q(\alpha, M, \delta_f)$	$C_L^q(\alpha, M, \delta_f) * q * \frac{b}{V}$	Pitch Rate (q)	α, M, δ_f

Table 3.11 DATCOM MAX Lift Coefficient Buildup Definitions

Function-characteristic representation	**Characteristic representation in DATCOM MAX aerodynamic buildup equation**
$\Delta C_{L_{WBHV}}(\alpha, M)$	$\Delta C_{L_{WBHV}}(\alpha, M, CONFIGURATION\ )$
$\Delta C_{\mathrm{L}_{Flaps}}(\alpha, M, \delta_f)$	$\Delta \mathrm{C}_{\mathrm{L}_{\mathrm{Flaps}}}(\mathrm{\alpha}, \mathrm{M}, \mathrm{\delta_f})$
$\Delta C_{\mathrm{L}_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{L_{WBHV}}(\alpha, M, \delta_{HT}\ CONFIGURATION) - \Delta C_{L_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION) + \Delta C_{L_{\delta_e}}(\alpha, M, \delta_{HT}, \delta_e) + \Delta C_{L_{Flaps}}(\alpha, M, \delta_f)$
$K_{\mathrm{L}}^{M}(\alpha, M, \delta_f)$	$\dfrac{\Delta C_{L_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION\ )}{\Delta C_{L_{WBHV}}(\alpha, 1ST\ MACH\ NUMBER, CLEAN\ CONFIGURATION\ )}$
$\Delta \mathrm{C}_{\mathrm{L}_{\mathrm{sb}}}(\mathrm{\alpha}, \mathrm{M}, \mathrm{\delta_{sb}})$	$\Delta C_{L_{sb}}(\alpha, M, \delta_{sb})$
$\Delta \mathrm{C}_{\mathrm{L}_{\mathrm{s}}}(\mathrm{\alpha}, \mathrm{M}, \mathrm{\delta_{s}})$	0
$\Delta C_{\mathrm{L}_{LGmax}}(\alpha, M)$	0
$\Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	$\Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$
$C_L^q(\alpha, M)$	$C_L^q\left(\alpha, M, \delta_f\right) * q * \dfrac{b}{V}$

Pitching Moment Coefficient

$$\begin{aligned} C_m = {} & C_{m_{WBHV}}(\alpha, M) + \Delta C_{m_{Flaps}}(\alpha, M, \delta_f) + \Delta C_{m_{HT+\delta_e}}(\alpha, \delta_f, \delta_{HT}, \delta_e) \\ & * K_m^M(\alpha, M, \delta_f) + \Delta C_{m_{sb}}(\alpha, M, \delta_{sb}) + \Delta C_{m_s}(\alpha, M, \delta_s) \\ & + \Delta C_{m_{LGmax}}(\alpha, M) * \delta_{LG} \\ & + \Delta C_{m_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE}) \\ & + \left[C_m^{\dot{\alpha}}(\alpha, M) * C_m^q(\alpha, M) * q\right] * \frac{b}{V} + C_L * \Delta_{x_{cg}} + C_D \\ & * \Delta z_{cg} \end{aligned} \tag{1.3}$$

Table 3.12 Pitching Moment Coefficient Buildup

Function-characteristic representation	**Characteristic representation in aerodynamic buildup equation**	**Main affecting parameter/component**	**Other effecting parameters**
$\Delta C_{m_{WBHV}}(\alpha, M)$	$\Delta C_{\mathrm{m}_{WBHV}}(\alpha, M)$	Clean Wing-Body-Horizontal Tail-Vertical Tail	-
$\Delta C_{\mathrm{m}_{Flaps}}(\alpha, M, \delta_f)$	$\Delta C_{\mathrm{m}_{Flaps}}(\alpha, M, \delta_f)$	Flap Setting (δ_f)	α, M
$\Delta C_{\mathrm{m}_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{\mathrm{m}_{HT+\delta_e}}(\alpha, \delta_f, \delta_{HT}, \delta_e) * K_m^M(\alpha, M, \delta_f)$	Horizontal Tail (δ_{HT}) and Elevator (δ_e)	α, M, δ_f
$K_{\mathrm{m}}^M(\alpha, M, \delta_f)$	$K_{\mathrm{m}}^M(\alpha, M, \delta_f)$	Mach Number (M)	α, δ_f
$\Delta C_{\mathrm{m}_{sb}}(\alpha, M, \delta_{sb})$	$\Delta C_{\mathrm{m}_{sb}}(\alpha, M, \delta_{sb})$	Speed Brake (δ_{sb})	α, M
$\Delta C_{\mathrm{m}_s}(\alpha, M, \delta_s) = 0$	$\Delta C_{\mathrm{m}_s}(\alpha, M, \delta_s)$	Spoiler (δ_s)	α, M
$\Delta C_{\mathrm{m}_{LGmax}}(\alpha, M) = 0$	$\Delta C_{\mathrm{m}_{LGmax}}(\alpha, M) * \delta_{LG}$	Landing Gear Position (δ_{LG})	α, M
$\Delta \mathrm{C}_{\mathrm{m}_{\mathrm{GE}}}(\alpha, \mathrm{M}, \delta_{\mathrm{f}}, \delta_{\mathrm{HT}}, \delta_{\mathrm{e}}, \mathrm{h}_{\mathrm{GE}})$	$\Delta \mathrm{C}_{\mathrm{m}_{\mathrm{GE}}}(\alpha, \mathrm{M}, \delta_{\mathrm{f}}, \delta_{\mathrm{HT}}, \delta_{\mathrm{e}}, \mathrm{h}_{\mathrm{GE}})$	Altitude (h_{GE})	$\alpha, \mathrm{M}, \delta_{\mathrm{f}}, \delta_{\mathrm{HT}}, \delta_{\mathrm{e}}$
$C_m^q(\alpha, M)$	$\mathrm{C}_{\mathrm{m}}^{\mathrm{q}}(\alpha, \mathrm{M}, \delta_{\mathrm{f}}) * \mathrm{q} * \frac{\mathrm{b}}{\mathrm{V}}$	Pitch Rate (q)	$\alpha, \mathrm{M}, \delta_{\mathrm{f}}$
$C_m^{\dot{\alpha}}(\alpha, M)$	$C_m^{\dot{\alpha}}(\alpha, M, \delta_{\mathrm{f}}) * \dot{\alpha} * \frac{b}{V}$	Angle-of-Attack Derivative ($\dot{\alpha}$)	$\alpha, \mathrm{M}, \delta_{\mathrm{f}}$
-	$C_L * \Delta x_{cg}$	C.G. x-shift (Δx_{cg})	α, M
-	$C_D * \Delta z_{cg}$	C.G. z-shift (Δz_{cg})	α, M

Table 3.13 DATCOM MAX Pitching Moment Coefficient Buildup Definitions

Function-characteristic representation	**Characteristic representation in DATCOM MAX aerodynamic buildup equation**
$\Delta C_{m_{WBHV}}(\alpha, M)$	$\Delta C_{L_{WBHV}}(\alpha, M, CONFIGURATION\ )$
$\Delta C_{\mathrm{m}_{Flaps}}(\alpha, M, \delta_f)$	$\Delta \mathrm{C}_{\mathrm{L}_{\mathrm{Flaps}}}(\alpha, \mathrm{M}, \delta_\mathrm{f})$
$\Delta C_{\mathrm{m}_{HT+\delta_e}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e)$	$\Delta C_{L_{WBHV}}(\alpha, M, \delta_{HT}\ CONFIGURATION)$ $- \Delta C_{L_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION)$ $+ \Delta C_{L_{\delta_e}}(\alpha, M, \delta_{HT}, \delta_e) + \Delta C_{L_{Flaps}}(\alpha, M, \delta_f)$
$K_{\mathrm{m}}^{M}(\alpha, M, \delta_f)$	$\dfrac{\Delta C_{L_{WBHV}}(\alpha, M, CLEAN\ CONFIGURATION\ )}{\Delta C_{L_{WBHV}}(\alpha, 1ST\ MACH\ NUMBER, CLEAN\ CONFIGURATION\ )}$
$\Delta \mathrm{C}_{\mathrm{m}_{\mathrm{sb}}}(\alpha, \mathrm{M}, \delta_{\mathrm{sb}})$	$\Delta C_{L_{sb}}(\alpha, M, \delta_{sb})$
$\Delta C_{m_s}(\alpha, M, \delta_s)$	0
$\Delta C_{\mathrm{m}_{LGmax}}(\alpha, M)$	0
$\Delta C_{m_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$	$\Delta C_{L_{GE}}(\alpha, M, \delta_f, \delta_{HT}, \delta_e, h_{GE})$
$C_m^q(\alpha, M)$	$C_L^q(\alpha, M, \delta_f) * q * \dfrac{b}{V}$
$\mathrm{C}_{\mathrm{m}}^{\dot{\alpha}}(\alpha, \mathrm{M})$	$\mathrm{C}_{\mathrm{m}}^{\dot{\alpha}}(\alpha, \mathrm{M}, \delta_\mathrm{f})$

Side-Force Coefficient

$$C_Y = C_Y^{\beta}(\alpha, M) * \beta + \Delta C_{Y_r}(\alpha, M, \delta_r) + \Delta C_{Y_a}(\alpha, M, \delta_a) + \Delta C_{Y_s}(\alpha, M, \delta_s) \qquad (1.4)$$

Table 3.14 Side-force Moment Coefficient Buildup

Function-characteristic representation	**Characteristic representation in aerodynamic buildup equation**	**Main affecting parameter/component**	**Other effecting parameters**
$C_Y^{\beta}(\alpha, M)$	$C_Y^{\beta}(\alpha, M) * \beta$	Sideslip (β)	α, M
$\Delta C_{Y_r}(\alpha, M, \delta_r)$	$\Delta C_{Y_r}(\alpha, M, \delta_r)$	Rudder (δ_r)	α, M
$\Delta C_{Y_a}(\alpha, M, \delta_a)$	$\Delta C_{Y_a}(\alpha, M, \delta_a)$	Aileron (δ_a)	α, M
$\Delta C_{Y_s}(\alpha, M, \delta_s)$	$\Delta C_{Y_s}(\alpha, M, \delta_s)$	Spoiler (δ_s)	α, M

Table 3.15 DATCOM MAX Side-Force Coefficient Buildup Definitions

Function-characteristic representation	**Characteristic representation in DATCOM MAX aerodynamic buildup equation**
$C_Y^{\beta}(\alpha, M)$	$C_Y^{\beta}(\alpha, M, CLEAN\ CONFIGURATION)$
$\Delta C_{Y_r}(\alpha, M, \delta_r)$	$\Delta C_{Y_r}(\alpha, M, \delta_r)$
$\Delta C_{Y_a}(\alpha, M, \delta_a)$	$\Delta C_{Y_a}(\alpha, M, \delta_a)$
$\Delta C_{Y_s}(\alpha, M, \delta_s)$	$\Delta C_{Y_s}(\alpha, M, \delta_s)$

Rolling Moment Coefficient

$$
\begin{aligned}
C_l = C_l^{\beta}(\alpha, M) * \beta + \Delta C_{l_r}(\alpha, M, \delta_r) + \Delta C_{l_a}(\alpha, M, \delta_a) + \Delta C_{l_s}(\alpha, M, \delta_s) \\
+ \left[C_l^{p}(\alpha, M) + C_l^{\beta}(\alpha, M) * \Delta xcg * \frac{2b}{l}\right] * p * \frac{l}{2V} \\
+ C_l^{r}(\alpha, M) * r * \frac{l}{2V}
\end{aligned}
\tag{1.5}
$$

Table 3.16 Rolling Moment Coefficient Buildup

Function-characteristic representation	**Characteristic representation in aerodynamic buildup equation**	**Main affecting parameter/component**	**Other effecting parameters**
$C_l^{\beta}(\alpha, M)$	$C_l^{\beta}(\alpha, M) * \beta$	Sideslip (β)	α, M
$\Delta C_{l_r}(\alpha, M, \delta_r)$	$\Delta C_{l_r}(\alpha, M, \delta_r)$	Rudder (δ_r)	α, M
$\Delta C_{l_a}(\alpha, M, \delta_a)$	$\Delta C_{l_a}(\alpha, M, \delta_a)$	Aileron (δ_a)	α, M
$\Delta C_{l_s}(\alpha, M, \delta_s)$	$\Delta C_{l_s}(\alpha, M, \delta_s)$	Spoiler (δ_s)	α, M
$C_l^{p}(\alpha, M)$	$C_l^{p}(\alpha, M) * p * \frac{l}{2V}$	Roll Rate (p)	α, M
$C_l^{\beta}(\alpha, M)$	$C_l^{\beta}(\alpha, M) * \Delta xcg * \frac{b}{V} * p$	Roll Rate (β)	α, M
$C_l^{r}(\alpha, M)$	$C_l^{r}(\alpha, M) * r * \frac{l}{2V}$	Yaw Rate (r)	α, M

Table 3.17 DATCOM MAX Rolling Moment Coefficient Buildup Definitions

Function-characteristic representation	**Characteristic representation in DATCOM MAX aerodynamic buildup equation**
$C_l^{\beta}(\alpha, M)$	$C_l^{\beta}(\alpha, M) * \beta$
$\Delta C_{l_r}(\alpha, M, \delta_r)$	$\Delta C_{l_r}(\alpha, M, \delta_r)$
$\Delta C_{l_a}(\alpha, M, \delta_a)$	$\Delta C_{l_a}(\alpha, M, \delta_a)$
$\Delta C_{l_s}(\alpha, M, \delta_s)$	$\Delta C_{l_s}(\alpha, M, \delta_s)$
$C_l^{p}(\alpha, M)$	$C_l^{p}(\alpha, M) * p * \frac{l}{2V}$
$C_l^{\beta}(\alpha, M)$	$C_l^{\beta}(\alpha, M, \delta_f) * \Delta xcg * \frac{b}{V} * p$
$C_l^{r}(\alpha, M)$	$C_l^{r}(\alpha, M, \delta_f) * r * \frac{l}{2V}$

Yawing Moment Coefficient

$$\begin{aligned} C_n = {} & \left[C_n^{\beta}(\alpha,M) + C_l^{\beta}(\alpha,M) * \Delta x_{cg} * \frac{b}{l}\right] * \beta + \Delta C_{n_r}(\alpha,M,\delta_r) \\ & + \Delta C_{n_r}(\alpha,M,\delta_r) * \Delta x_{cg} * \frac{b}{l} + \Delta C_{n_a}(\alpha,M,\delta_a) \\ & + \Delta C_{n_s}(\alpha,M,\delta_s) \\ & + \left[C_n^{r}(\alpha,M) + 2 * C_n^{\beta}(\alpha,M) * \Delta x_{cg} * \frac{2b}{l} + 2 \right. \\ & \left. * C_Y^{\beta}(\alpha,M) * \left(\Delta x_{cg} * \frac{b}{l}\right)^2\right] * r * \frac{l}{2V} + C_n^{p}(\alpha,M) * p \\ & * \frac{l}{2V} \end{aligned} \tag{1.6}$$

Table 3.18 Yawing Moment Coefficient Buildup

Function-characteristic representation	**Characteristic representation in aerodynamic buildup equation**	**Main affecting parameter/component**	**Other effecting parameters**
$C_n^{\beta}(\alpha,M)$	$C_n^{\beta}(\alpha,M) * \beta$	Sideslip (β)	α, M
$C_l^{\beta}(\alpha,M)$	$C_l^{\beta}(\alpha,M) * \Delta x_{cg} * \frac{b}{l} * \beta$	Sideslip (β)	α, M
$\Delta C_{n_r}(\alpha,M,\delta_r)$	$\Delta C_{n_r}(\alpha,M,\delta_r)$	Rudder (δ_r)	α, M
$\Delta C_{n_r}(\alpha,M,\delta_r)$	$\Delta C_{n_r}(\alpha,M,\delta_r) * \Delta x_{cg} * \frac{b}{l}$	C.G. x-shift (Δx_{cg})	α, M
$\Delta C_{n_a}(\alpha,M,\delta_a)$	$\Delta C_{n_a}(\alpha,M,\delta_a)$	Aileron (δ_a)	α, M
$\Delta C_{n_s}(\alpha,M,\delta_s)$	$\Delta C_{n_s}(\alpha,M,\delta_s)$	Spoiler (δ_s)	α, M
$C_n^{r}(\alpha,M)$	$C_n^{r}(\alpha,M) * r * \frac{l}{2V}$	Yaw Rate (r)	α, M
$C_n^{\beta}(\alpha,M)$	$C_n^{\beta}(\alpha,M) * \Delta x_{cg} * \frac{b}{V} * r$	Yaw Rate (r)	α, M
$C_Y^{\beta}(\alpha,M)$	$C_Y^{\beta}(\alpha,M) * \left(\Delta x_{cg} * \frac{b}{l}\right)^2 * 2 * r * \frac{l}{2V}$	Yaw Rate (r)	α, M
$C_n^{p}(\alpha,M)$	$C_n^{p}(\alpha,M) * p * \frac{l}{2V}$	Roll Rate (p)	α, M

Table 3.19 DATCOM MAX Yawing Moment Coefficient Buildup Definitions

Function-characteristic representation	**Characteristic representation in DATCOM MAX aerodynamic buildup equation**
$C_n^{\beta}(\alpha, M)$	$C_n^{\beta}(\alpha, M) * \beta$
$C_l^{\beta}(\alpha, M)$	$C_l^{\beta}(\alpha, M) * \Delta x_{cg} * \frac{b}{l} * \beta$
$\Delta C_{n_r}(\alpha, M, \delta_r)$	$\Delta C_{n_r}(\alpha, M, \delta_r)$
$\Delta C_{n_r}(\alpha, M, \delta_r)$	$\Delta C_{n_r}(\alpha, M, \delta_r) * \Delta x_{cg} * \frac{b}{l}$
$\Delta C_{n_a}(\alpha, M, \delta_a)$	$\Delta C_{n_a}(\alpha, M, \delta_a)$
$\Delta C_{n_s}(\alpha, M, \delta_s)$	$\Delta C_{n_s}(\alpha, M, \delta_s)$
$C_n^{r}(\alpha, M)$	$C_n^{r}(\alpha, M) * r * \frac{l}{2V}$
$C_n^{\beta}(\alpha, M)$	$C_n^{\beta}(\alpha, M) * \Delta x_{cg} * \frac{b}{V} * r$
$C_Y^{\beta}(\alpha, M)$	$C_Y^{\beta}(\alpha, M) * \left(\Delta x_{cg} * \frac{b}{l}\right)^2 * 2 * r * \frac{l}{2V}$
$C_n^{p}(\alpha, M)$	$C_n^{p}(\alpha, M) * p * \frac{l}{2V}$

3.4 Chapter Summary

In conclusion, this chapter describes DATCOM MAX's history, development process, and attributes. The modification of Digital DATCOM into DATCOM MAX V4 required review of previous work, defining the prototype system requirements, and verification. A DATCOM MAX V4 User's Manual was produced allowing user familiarization for future development. The capabilities and limitations of DATCOM MAX V4 are defined in the context of Digital DATCOM. Lastly, a description of DATCOM MAX V4's output and aircraft configuration concept building equations are shown.

CHAPTER 4

CASE STUDY: B747-200F

4.1 Introduction

The AVD Laboratory selected the B747-200F aircraft to calibrate the AVDS process because of the richness of data available for this aircraft, which includes geometry, weights, aerodynamic, structure layout, propulsion, and performance data (5) and (49) through (50).

To give an idea of the capabilities of the B747-200F the payload range diagram is shown in Figure 4.1. It should be noted the engines selected to be used for this aircraft are the GE CF6-50E2. This was selected because it is the newest and most common engine used on this aircraft. The importance engine selection plays in the Digital DATCOM case study is center of gravity definition. The center of gravity in Digital DATCOM is the moment reference center.

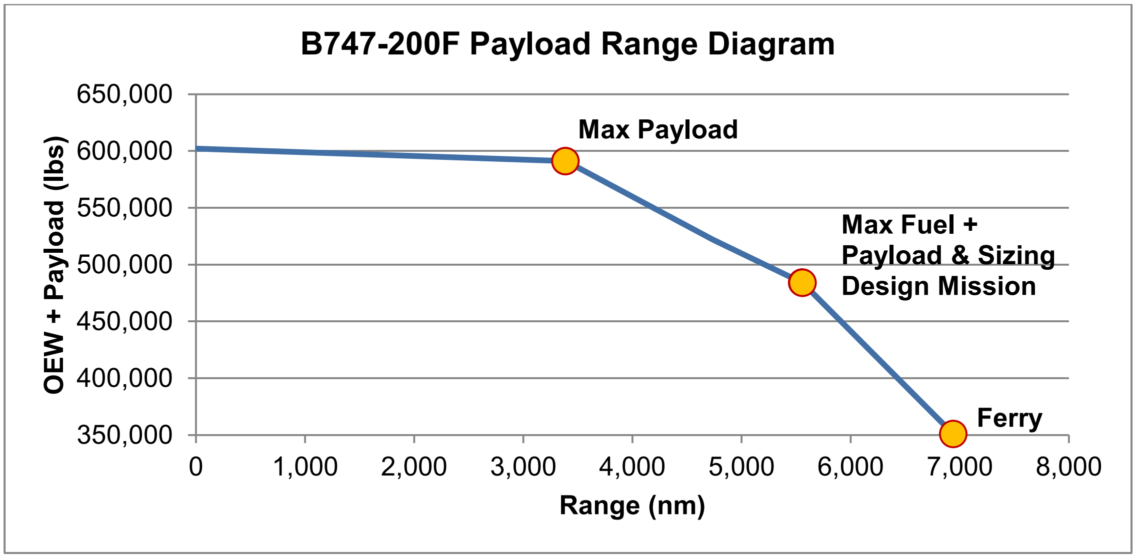


Figure 4.1 B747-200F with CF6-50E2 Engines Payload Range Diagram (51)

Based on the current capabilities of DATCOM MAX, described in ‘Capabilities and Limitations’, low speed flight at sea level without ground effect is chosen to model the B747-200F. According to experimental data available low speed flight is defined as Mach 0.075 to 0.377 or 50 to 250 knots at sea level (52). This Mach range is what the B747-200F is modeled for The aircraft is also modeled at the angles of attack experimental data is available for, which is -5 to 25 degrees (52). The mission for the B747-200F case study models is shown in Table 4.1.

Table 4.1 B747-200F Case Study Model Mission

Mission (Sea Level)							
Mach Numbers	**Angle-of-Attack**						
0.075	-5^0	0^0	5^0	10^0	15^0	20^0	25^0
0.151	-5^0	0^0	5^0	10^0	15^0	20^0	25^0
0.226	-5^0	0^0	5^0	10^0	15^0	20^0	25^0
0.302	-5^0	0^0	5^0	10^0	15^0	20^0	25^0
0.377	-5^0	0^0	5^0	10^0	15^0	20^0	25^0

. Lastly, all control surfaces defined in section 4.3.3 are modeled across their maximum deflection range defined by the experimental data (52), also see Table 4.2. The control devices are deflected through their entire deflection range for every angle-of-attack and for every Mach number.

Table 4.2 Device Deflection Angle Ranges (52)

Device	**Deflection Range**
Ailerons	-20^o to 20^o
LE Flaps	30^o
TE Flaps	0^o to 30^o
Spoilers	0^o to 45^o
Speed Brakes	10^o to 20^o
Elevator	-23^o to 17^o
AMHT	-5^o to 15^o
Rudder	-25^o to 25^o
Landing Gear	Fully Extended

4.2 Main Data Sheet (MDS)

The main data sheet compiles information from 25 difference sources about the B747-200F, (5) and (49) through (50). The purpose of the MDS is to bring all geometric, weights, and performance data for the aircraft together into a standard industry format that provides quick and easy access to consistent and up to date information about the aircraft. The entire main data sheet can be found in the appendix on page 143. The information contained in the MDS is shown in Table 4.3.

Table 4.3 B747-200F MDS Contents

Configuration Components	Control Devices	High Lift Devices
Fuselage	Ailerons	LE Flaps
Wing	Spoilers	TE Flaps
Hoizontal Tail	Speed Brakes	
Vertical Tail	Elevator	
	Rudder	
	Landing Gear	
	Power Plant	

Some information between sources is redundant. This is reassuring although some information is conflicting. For the conflicting information the newest version of information is used and the ignored conflicting information is marked red in the MDS. Other non-conflicting information from the same source as conflicting information is marked yellow, which signifies use this data with caution. The last color in the MDS, green, signifies information not directly available from the sources and is not used.

Lastly, the MDS serves as a Digital DATCOM and DATCOM MAX model building assistant, shown in Figure 4.2, for a TAC aircraft like the B747-200F. Links are placed between the 'References' tab and 'DATCOM Input' and 'DATCOM MAX Input' tabs that automatically categorize the corresponding information between the MDS and required input for Digital DATCOM and DATCOM MAX models.

Figure 4.2 MDS Assistant Function

4.3 Digital DATCOM Model

Using the information from the MDS 9 Digital DATCOM B747-200F models have been produced. The reason nine models are needed is because Digital DATCOM cannot run the entire aircraft configuration concept at once. Meaning all the control effectors available in Digital DATCOM that are applicable to the B747-200F aircraft cannot be added to a single Digital DATCOM model. The nine models are shown below in Table 4.4.

Table 4.4 B747-200F Digital DATCOM Model List

	Aircraft Configuration	**Component(s)**
1	WB	Clean
2	WB	Ailerons
3	WB	LE Flaps
4	WB	TE Flaps
5	WB	Spoilers
6	WB	Speed Brakes
7	WBHV	Clean
8	WBHV	Elevator
9	WBHV	AMHT+e

The aircraft geometry is the same for every model. The differences are in the control devices used and presence of the empennage. The reason for the empennage removal is explained later. The gross B747-200F geometries used for the Digital DATCOM and DATCOM

MAX models are summarized in Table 4.5. Sign convention is defined in the Digital DATCOM User's Manual (42).

Table 4.5 Digital DATCOM B747-200F Model Specifications Summary

	Digital DATCOM Variable		**Units**
Body			
Length		68.637	m
Wing (Straight Tapered Planform)			m
Theoretical Semi-Span	SSPN	29.8216	m
Root Chord	CHRDR	14.0663	m
Tip Chord	CHRDTP	4.064	m
Dihedral Angle	DHDADI	7	deg
Twist Angle	TWISTA	-3.5	deg
Airfoil		BACJ	
Horizontal Tail			
Theoretical Semi-Span	SSPN	11.0865	m
Root Chord	CHRDR	9.8552	m
Tip Chord	CHRDTP	2.4638	m
Dihedral Angle	DHDADI	8.5	deg
Airfoil		NACA-6-63-008	
Vertical Tail			
Theoretical Semi-Span	SSPN	9.8044	m
Root Chord	CHRDR	11.7348	m
Tip Chord	CHRDTP	3.9878	m
Airfoil		NACA-6-64-010	

To visualize the Digital DATCOM models 'DATCOM PLOT.exe' is used to produce a 'fort.7' file. For a description of the Digital DATCOM plot module see (45). Tecplot is then used to open the fort.7 file and visualize the geometry, shown below in Figure 4.3.

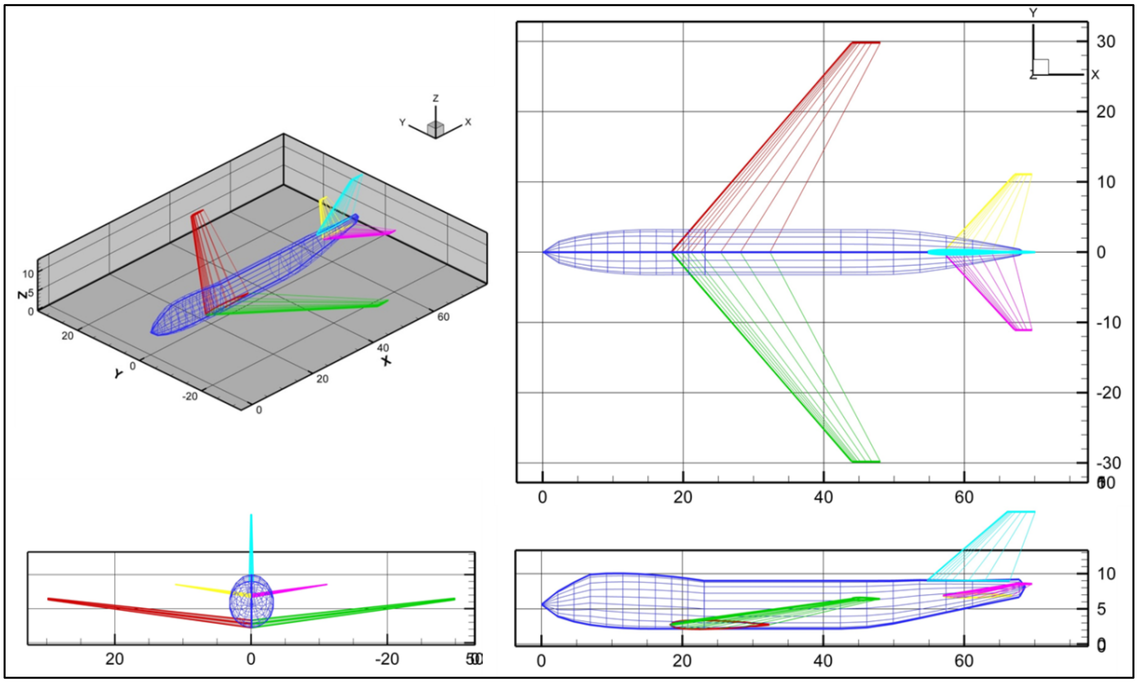
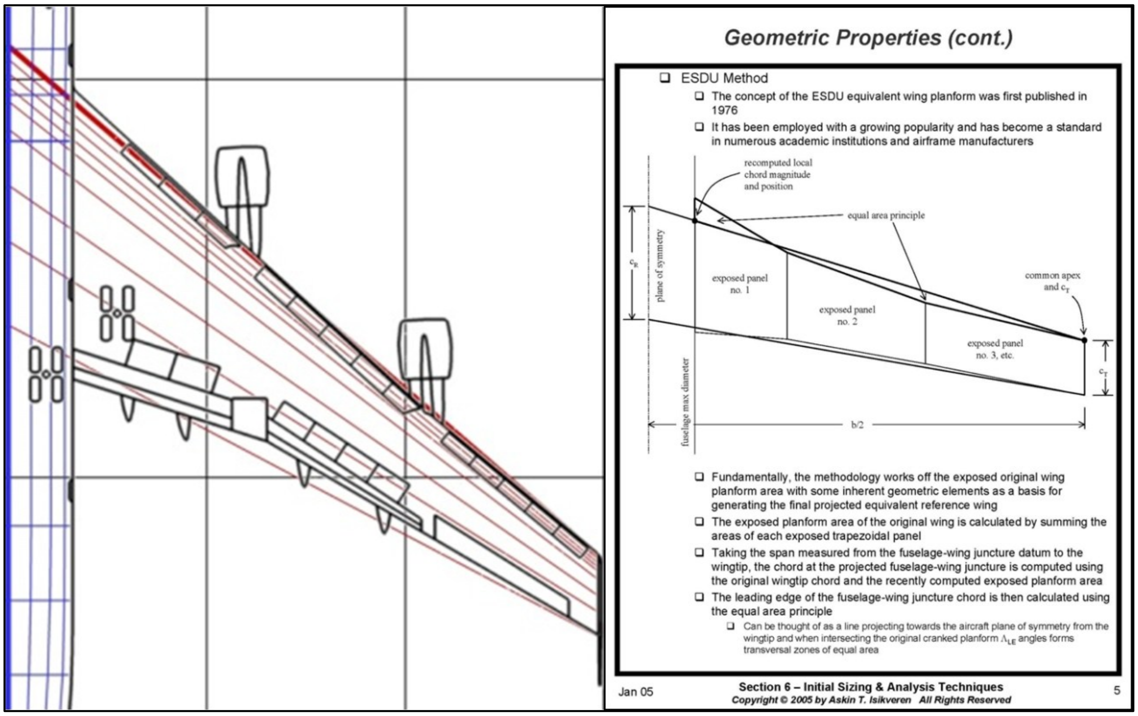


Figure 4.3 Digital DATCOM B747-200F 3-View

4.3.1 Equivalent Straight Tapered Wing

Special attention has been paid to defining the wing geometry. The B747-200F is a double crank wing. One crank is on the LE while the other one is on the TE. Digital DATCOM can handle a single crank or straight tapered planform wing but not a double crank wing. In addition, Digital DATCOM only provides transonic speed output for straight tapered wings. Even though transonic speeds are not addressed in this thesis an equivalent straight tapered wing has been calculated to allow the B747-200F models to be used in future development of DATCOM MAX. The Digital DATCOM User's manual (42) notes an equivalent wing should be used if choosing a straight tapered planform to represent a cranked wing but does not present any conversion methods. 'Geometry Construction' (53) by Askin T. Isikveren from the University of Bristol provides "An Overview of Equivalent Reference Wing Conventions". The three methods presented are: (a) weighted mean aerodynamic chord method, (b) ESDU method, and (c) simple trapezoid or net method. The ESDU method was selected because "it has been employed with a growing popularity and has become a standard in numerous academic institutions and airframe manufacturers" (53). For a complete description of the method please see (53). A top view of the B747-200F wing is overlaid with the Digital DATCOM model ESDU equivalent wing planform along with a brief description of the method in Figure 4.3.


Geometric Properties (cont.)

- ☐ ESDU Method
  - ☐ The concept of the ESDU equivalent wing planform was first published in 1976
  - ☐ It has been employed with a growing popularity and has become a standard in numerous academic institutions and airframe manufacturers
  - ☐ Fundamentally, the methodology works off the exposed original wing planform area with some inherent geometric elements as a basis for generating the final projected equivalent reference wing
  - ☐ The exposed planform area of the original wing is calculated by summing the areas of each exposed trapezoidal panel
  - ☐ Taking the span measured from the fuselage-wing juncture datum to the wingtip, the chord at the projected fuselage-wing juncture is computed using the original wingtip chord and the recently computed exposed planform area
  - ☐ The leading edge of the fuselage-wing juncture chord is then calculated using the equal area principle
    - ☐ Can be thought of as a line projecting towards the aircraft plane of symmetry from the wingtip and when intersecting the original cranked planform Λ_{LE} angles forms transversal zones of equal area

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Figure 4.4 B747-200F Top-View ESDU Equivalent Wing Planform and Method Summary (53)

4.3.2 Airfoil Selection

The wing, horizontal tail, and vertical tail require an airfoil selection. This can be done one of two ways in Digital DATCOM. The first option allows the user to specify and NACA designation, while the second option allows the user to input airfoil section coordinates. The methods used to calculate the airfoil properties vary depending on the speed regime. In general, the airfoil properties are calculated in incompressible, inviscid flow then correction factors are used to account for viscous effects, bring in line with experimental data, and account for transonic flow (if present). For a complete detailed explanation of Digital DATCOM's airfoil model see the Digital DATCOM User's Manual (42).

The wing airfoil sections are known to be Boeing proprietary airfoils with the designations starting at the root BAC 463 and ending at the tip with BAC 474. Unfortunately, the ordinates of these sections are not given and Digital DATCOM is restricted to one airfoil designation for the entire surface. The one attribute that is known about these airfoils is that they are supercritical. Fortunately, Boeing did release a general supercritical airfoil known as BACJ, shown below in Figure 4.5. The coordinates for the BACJ are in the appendix on page 189. The BACJ is the airfoil selected for the wing.

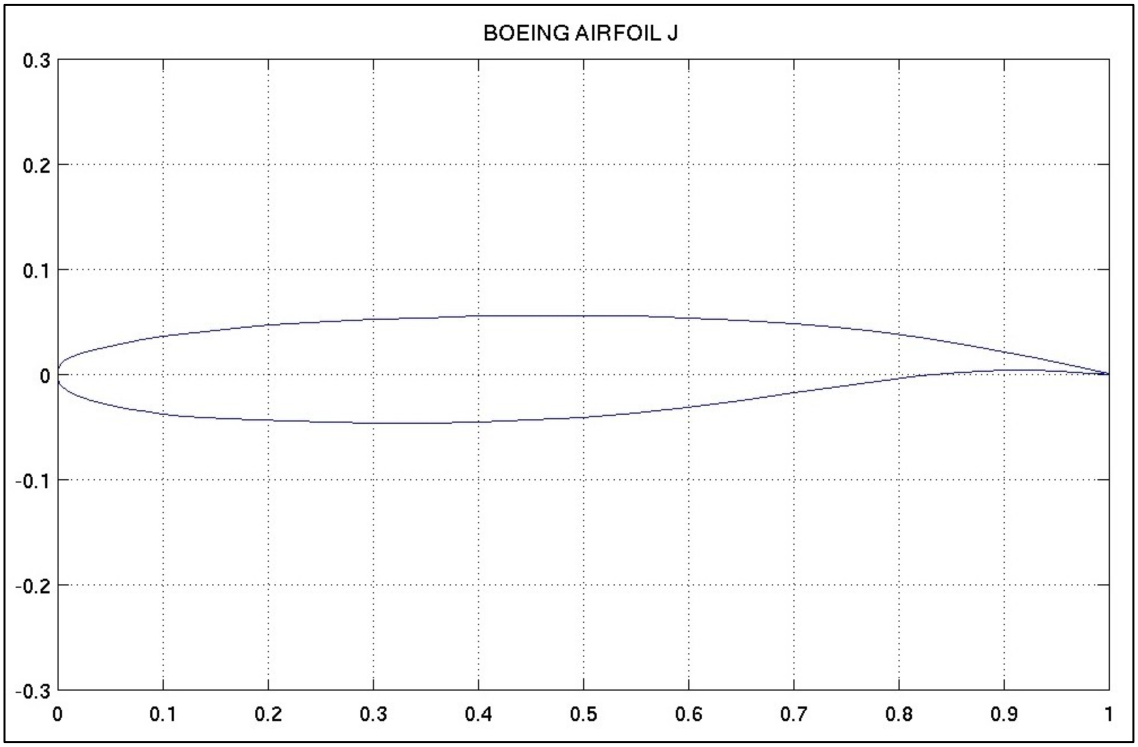


Figure 4.5 Boeing Airfoil J used as B747-200F Wing Airfoil in Digital DATCOM (54)

Next is the horizontal tail airfoil selection. No information is available on the airfoils used for the horizontal tail so previous project knowledge along with approximations made from the

Boeing 3-view drawing (55) was used. In a previous study done by the AVD Laboratory involving a B777-300ER aircraft (56) the closest horizontal tail airfoil was found to be a NACA 63A010. Taking measurements from the Boeing 3 view drawing (55) the average airfoil thickness is estimated to be 8%. The B777-300ER and airfoil thickness estimate lead to the selection of the NACA 63A008 series airfoil for the horizontal tail. The Digital DATCOM NACA card function was used to designate this airfoil section for the horizontal tail.

Last was the vertical tail airfoil selection. As with the horizontal tail no information on the airfoils used by Boeing for the vertical tail is published. The AVD Lab B777-300ER study (56) was used again along with approximations made from the Boeing 3 view drawing (55) to select an airfoil for the horizontal tail. The study determined the closest airfoil available for the vertical tail is the NACA 64A008 airfoil. Taking measurements from the Boeing 3 view drawing (55) the average airfoil thickness is estimated to be 10%. These two reasons are why the NACA 64A010 is selected for the vertical tail. The Digital DATCOM NACA card function was used to designate this airfoil section for the vertical tail.

4.3.3 Control Surfaces

All the control devices for the B747-200F are shown in Figure 4.6. Some control surfaces such as the ailerons, elevator, rudder, flaps, and spoilers have multiple surfaces. Each serves a different purpose depending on the flight regime and has different characteristics such as maximum deflection angles and deflection rate. To model these surfaces in Digital DATCOM some generalizations had to be made and are described in the sections below.

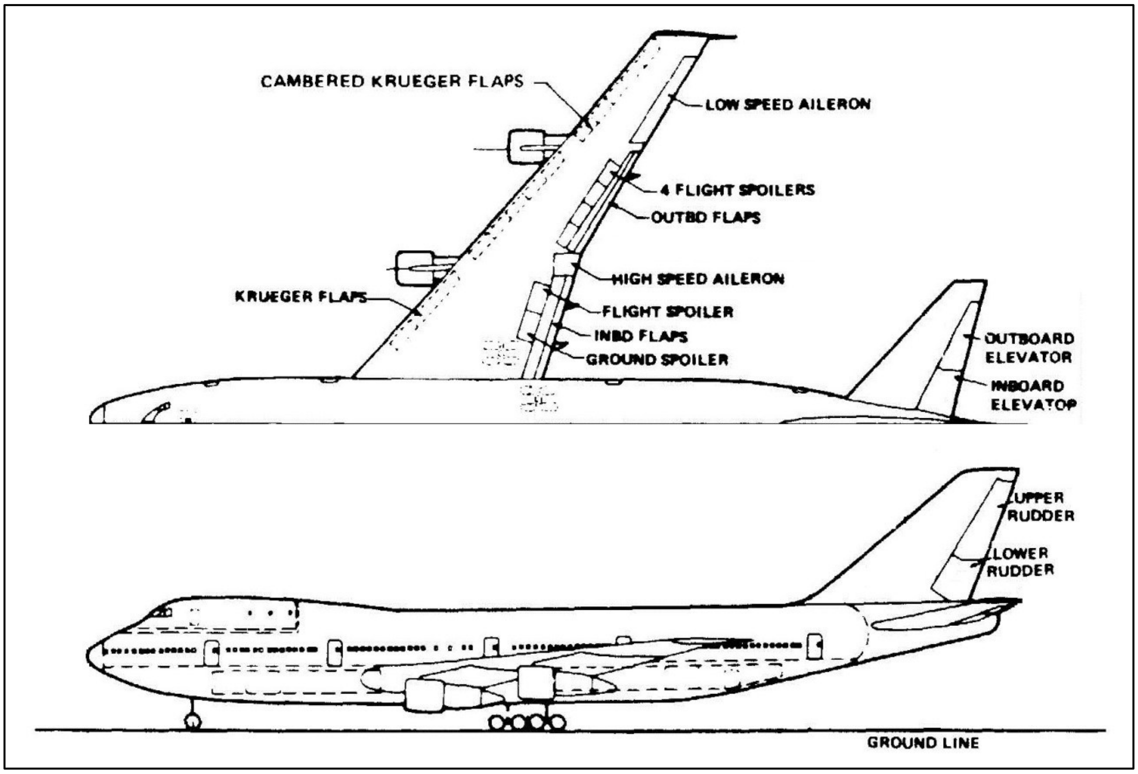


Figure 4.6 B747-200F Control Surfaces (reference volume 1)

Ailerons

The B747-200F has two ailerons, one inboard used for high speed flight and the other outboard for low speed flight (57). Digital DATCOM is limited to one aileron. The flight regime being tested is low speed so the high speed aileron is not modeled.

LE Flaps

There are two LE flaps, the inboard are Krueger while the outboard are cambered and slotted Krueger flaps (57). There is no information available on the camber of the outboard LE flaps and Digital DATCOM cannot handle a cambered Krueger flap. The LE flaps extend almost the entire length of the wing with gaps for the engine mounts. As an approximation the LE flaps are modeled as one continuous Krueger flap extending from the inboard span location of the inboard flap to the outboard span location of the outboard flap. No information was available for the chord length of the Krueger flaps so an approximation is made using the Boeing 3 view drawing (55) and other photos.

TE Flaps

There are two TE flaps, which inboard are and outboard triple slotted flaps (57). Digital DATCOM is not capable of modeling tripled slotted flaps. The two closest options to choose from in Digital DATCOM are double slotted and Fowler flaps. No information is available on making an approximated double slotted flap to a triple slotted flap. Designing an approximated double slotted flap for the B747-200F is beyond the scope of this thesis. After consulting with Wolfgang Heinze (58) it was decided to use a Fowler flap. An approximate Fowler flap was then made using the Boeing 3 view drawing (55)

Spoilers

There are a total of 12 spoilers with 1-4 and 9-12 classified as outboard and 5 and 8 classified as inboard (reference volume 2). The most inboard spoilers are neglected because they are used on the ground as speed breaks, as shown in Figure 4.6. The outboard spoilers are the primarily used during flight. Because of this and Digital DATCOM only being able to model one set of spoilers the outboard spoilers are modeled as one continuous spoiler.

Speed Brakes

The 6 and 7 spoilers left out during the discussion of the spoilers are considered speed breaks (52). These are modeled as split flaps in Digital DATCOM. The lift coefficient is assumed to be negative instead of positive and the moment calculation is neglected, while the coefficient of drag is used as-is. This model is not assumed to give perfect results but rather represent the sensitivities of a speed break during design.

AMHT+e

There is no change made to the horizontal tail to model it as all moving. The incidence angle of the horizontal tail is changed in Digital DATCOM to model it as all moving. The elevator, as shown in Figure 4.6, is spilt. The inboard section is used for low speed in conjunction with the outboard while only the outboard section is used for high speed. The inboard and outboard elevator sections are combined to model the elevator as a plain flap in Digital DATCOM.

4.3.4 Visual Geometry Check

As a final check the 3 view drawing of the B747-200F from Boeing (55) was overlaid with the Digital DATCOM models to double check that all geometries are defined as intended. The parameters that cannot be visually checked is the airfoils, wing twist, and control device geometries. The visual check is shown in Figure 4.7. Digital DATCOM is not capable of producing a visual of the control devices.

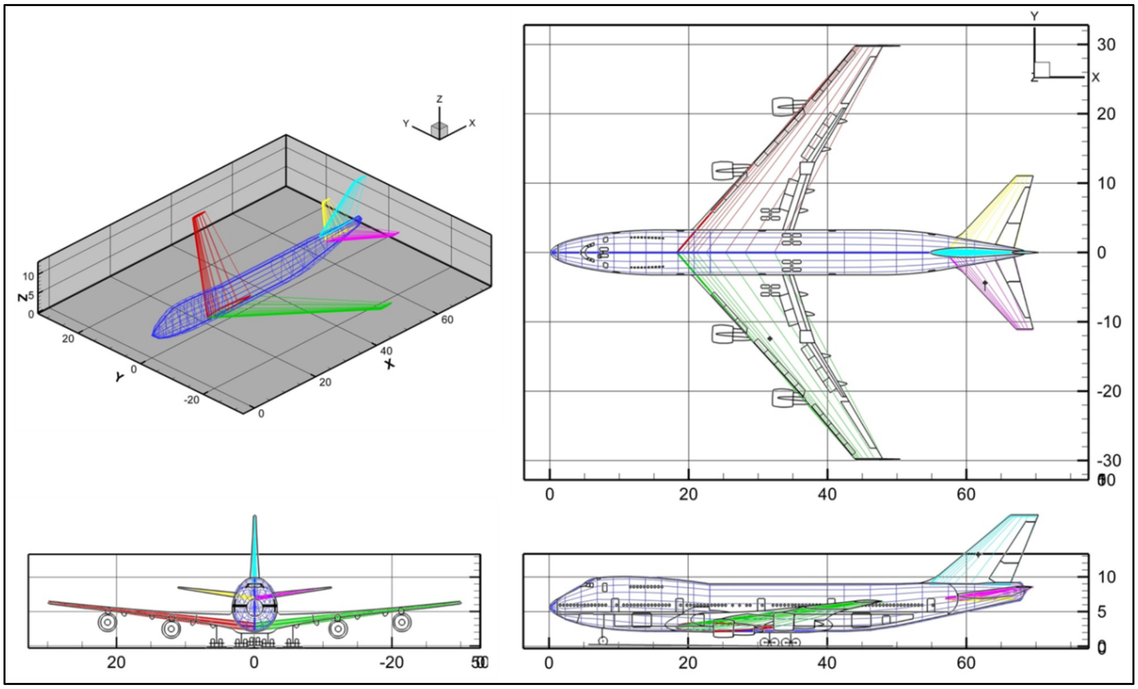


Figure 4.7 B747-200F Digital DATCOM Model Overlaid with Boeing 3 View (55)

Important attributes about the visual check, in Figure 4.7, to note are the airfoil thickness at the root of the wing, shown in Figure 4.4. These attributes of the model need to be remembered when reviewing the results.

The Digital DATCOM model of the B747-200F is a rough approximation of the actual aircraft. Approximations are made in the airfoil selection, control device modeling, high lift device modeling, and wing planform geometry. These approximations need to be kept in mind when reviewing the results.

4.3.5 Results

The results presented below are in the same order as Table 4.4. Output is produced for every Mach number, at every angle-of-attack, with every control surface deflection angle shown in Table 4.1 and Table 4.2. There are far too many results to show the component buildup for each aircraft configuration so the total aircraft configuration for each aircraft component is summarized with a selected analysis point that related to all flight regimes defined in Table 4.1. See the Digital DATCOM User's Manual (42) for a complete list of output produced. All results are untrimmed.

WB - Clean

Shown below in Figure 4.8 is the WB configuration used for all WB aircraft configurations. This model is exactly the same as the configuration shown in Figure 4.3 except the horizontal tail and vertical tail are removed. The removal is necessary due to an operational limitation of Digital DATCOM places high lift and control devices on the aft most lifting surface (42). The empennage is removed in order to place high lift and control devices on the wing.

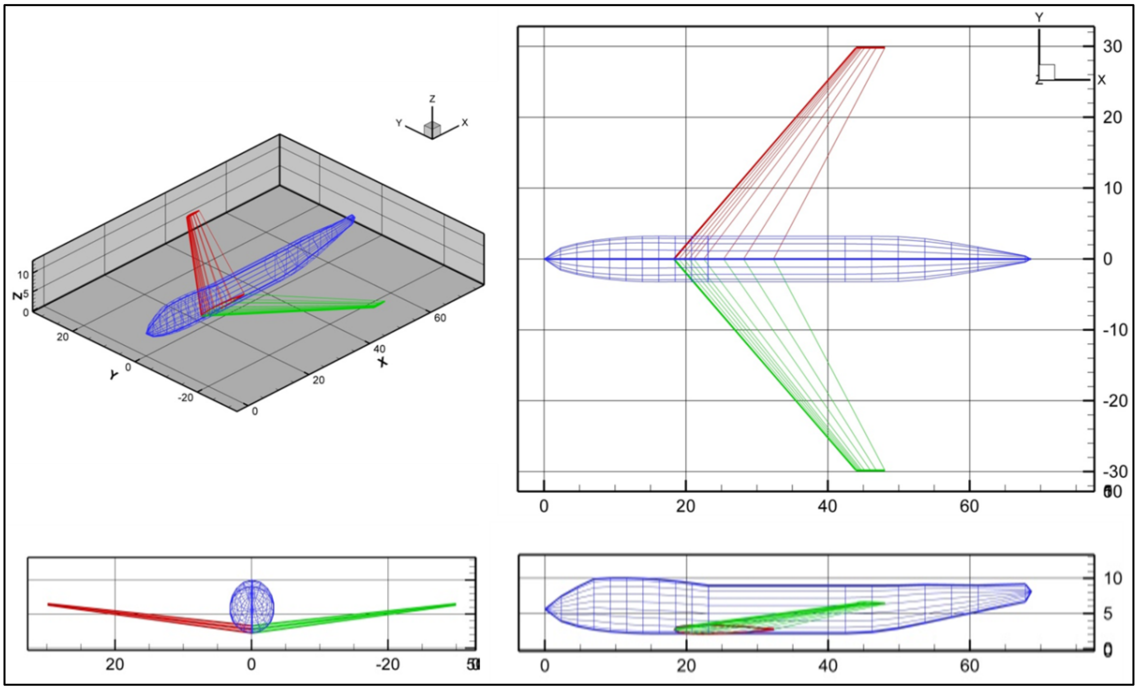


Figure 4.8 B747-200F Digital DATCOM WB-Clean Model

The purpose of the WB clean configuration is to provide a configuration that components can be added to and component contributions be calculated. Figure 4.9 shows the coefficients of drag, lift, and pitching moments for the WB clean configuration.

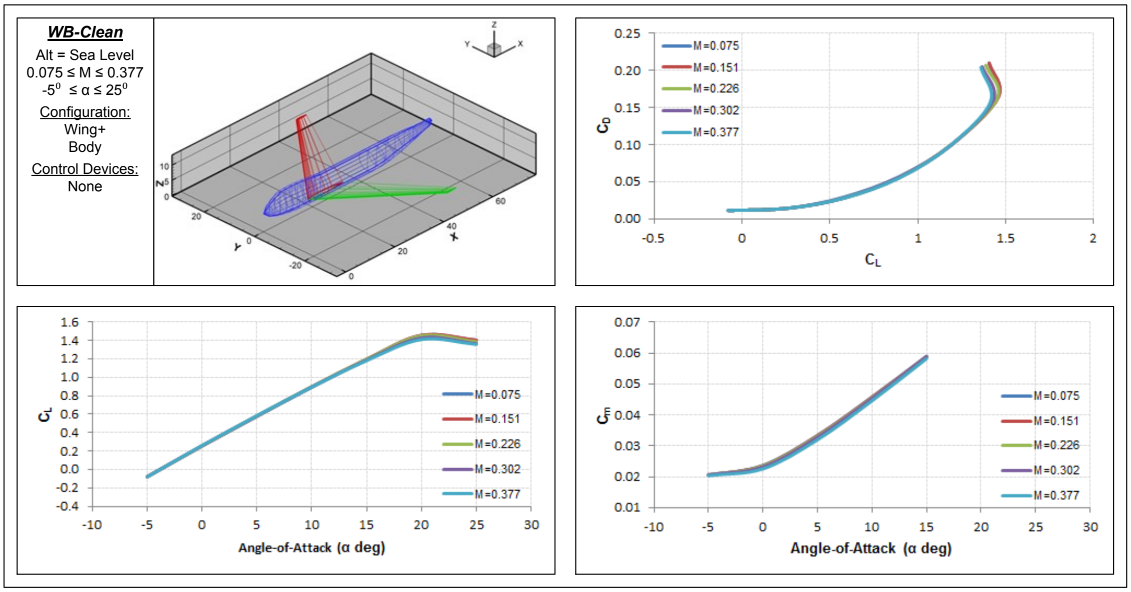
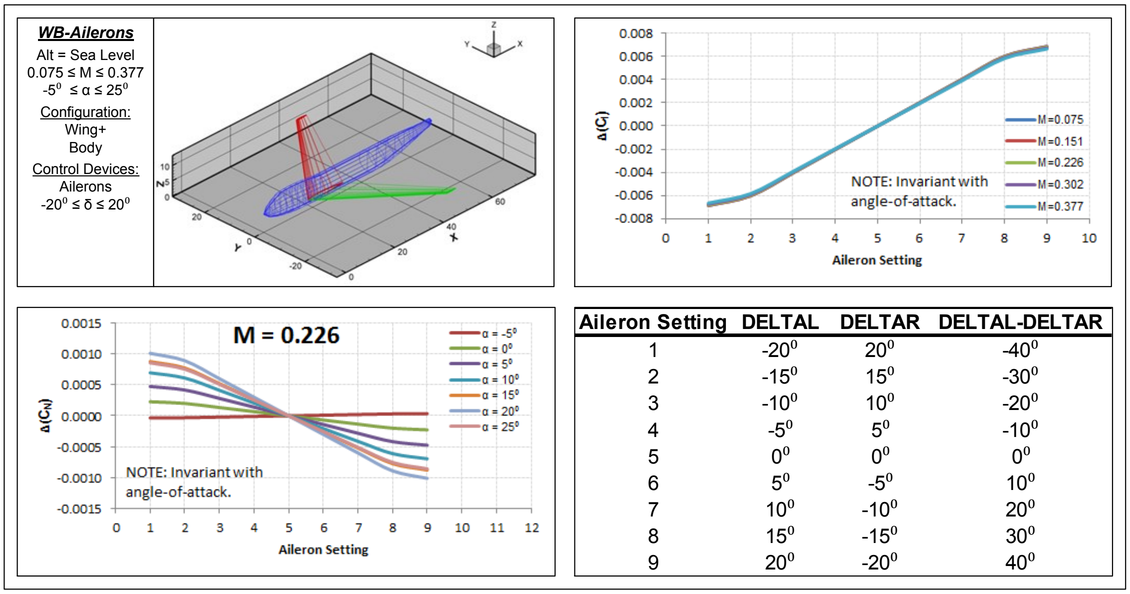


Figure 4.9 B747-200F Digital DATCOM WB-Clean WB Model Results Summary

The results shown in Figure 4.9 are the total coefficients of the entire WB clean configuration. Also, the nonlinear stall regions can clearly be seen.

WB - Ailerons

The ailerons are calculated in DATCOM by aileron settings, shown in the fourth quadrant of Figure 4.10. The results shown are not total aircraft coefficient but rather aileron contributions, signified by the “Δ”, that can be added to the base coefficients. Also, the nonlinear regions of the aileron contributions can clearly be seen. It should be noted the aileron contributions are assumed to be independent of angle-of-attack due to Digital DATCOM method limitations.



Aileron Setting	DELTAL	DELTAR	DELTAL-DELTAR
1	-20^0	20^0	-40^0
2	-15^0	15^0	-30^0
3	-10^0	10^0	-20^0
4	-5^0	5^0	-10^0
5	0^0	0^0	0^0
6	5^0	-5^0	10^0
7	10^0	-10^0	20^0
8	15^0	-15^0	30^0
9	20^0	-20^0	40^0

Figure 4.10 B747-200F Digital DATCOM Ailerons Model Results Summary

WB – LE Flaps

No DATCOM drag coefficient methods are applicable to the LE flap setting at the executed Mach numbers, shown in Table 4.1. Only the flap setting of 30º is shown because the only setting the B747-200F has for LE flaps is 0º and 30º (52). The results shown are not total aircraft coefficient but rather LE flap contributions, signified by the "Δ", that can be added to the base coefficients. Overall the contributions do not significantly vary for a change in Mach number and are assumed to not vary with angle-of-attack.

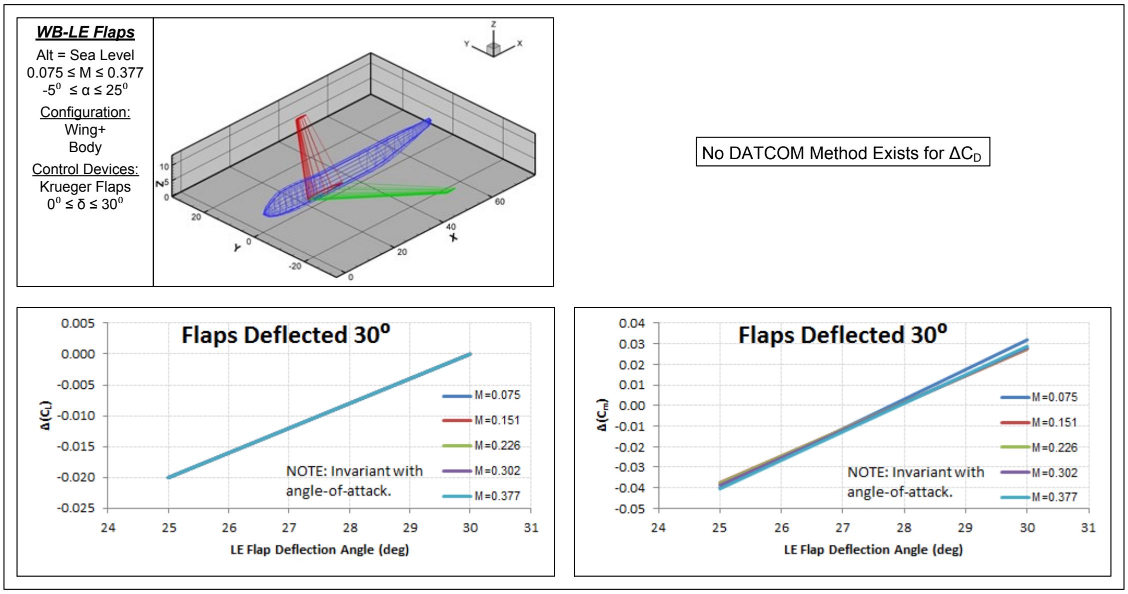


Figure 4.11 B747-200F Digital DATCOM LE Flaps Model Results Summary

WB – TE Flaps

The B747-200F has TE flap detents of 0º, 10º, 20º, 25º, and 30º but only 30º are shown in Figure 4.12 for a summary. The results shown are not total aircraft coefficient but rather TE flap contributions, signified by the “Δ”, that can be added to the base coefficients. The shown coefficients have nonlinear attributes that are clearly shown. Also, it should be noted that the TE flap contributions are assumed to be independent of angle-of-attack.

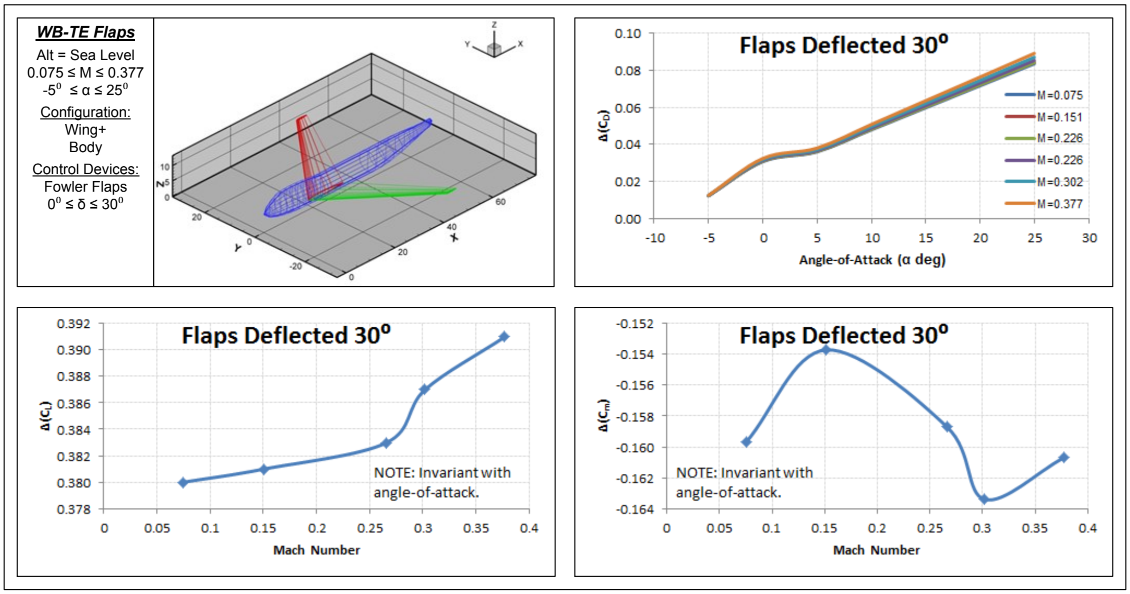


Figure 4.12 B747-200F Digital DATCOM TE Flaps Model Results Summary

WB - Spoilers

The spoiler output, shown in Figure 4.13, is assumed to not vary with angle-of-attack and for the most part does not vary with Mach number for low speeds. The results shown are not total aircraft coefficients but rather spoiler contributions, signified by the "Δ", that can be added to the base coefficients. Both rolling moment coefficient (C_l) and yawing moment coefficient (C_N) are nonlinear.

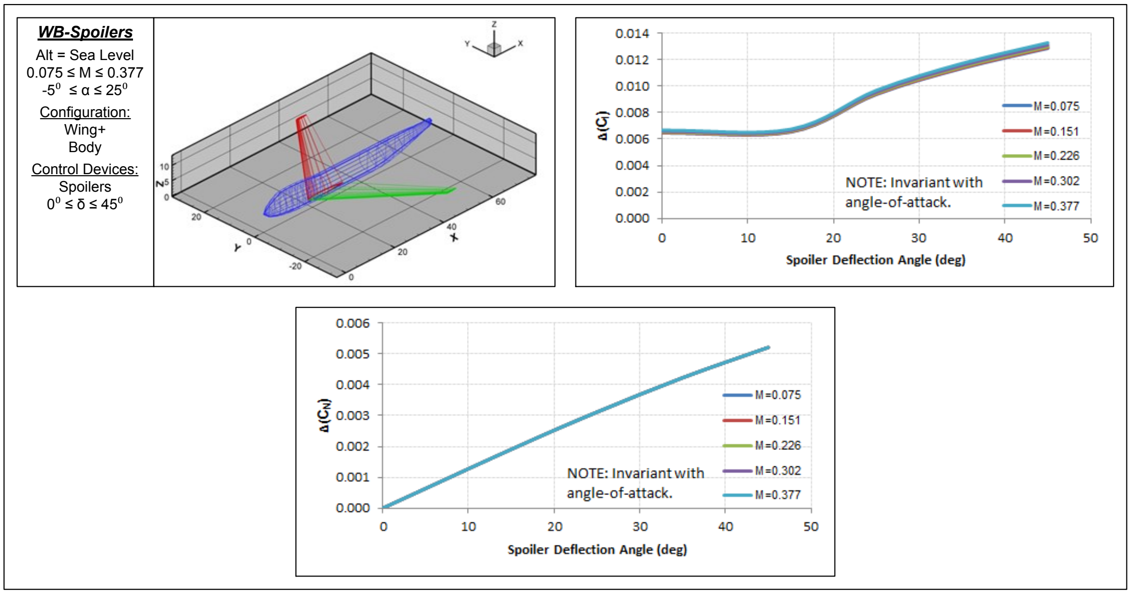


Figure 4.13 B747-200F Digital DATCOM Spoilers Model Results Summary

WB – Speed Brakes

The results shown are not total aircraft coefficient but rather spoiler contributions, signified by the “Δ”, that can be added to the base coefficients. It should be noted in quadrant three of Figure 4.14 the coefficient of lift contribution is shown as positive. As mentioned earlier the negative of this is taken to be used as the lift coefficient contribution. It is shown as positive because these are the raw Digital DATCOM results and are unmodified. Also, as mentioned before the moment calculation is neglected due to modeling differences.

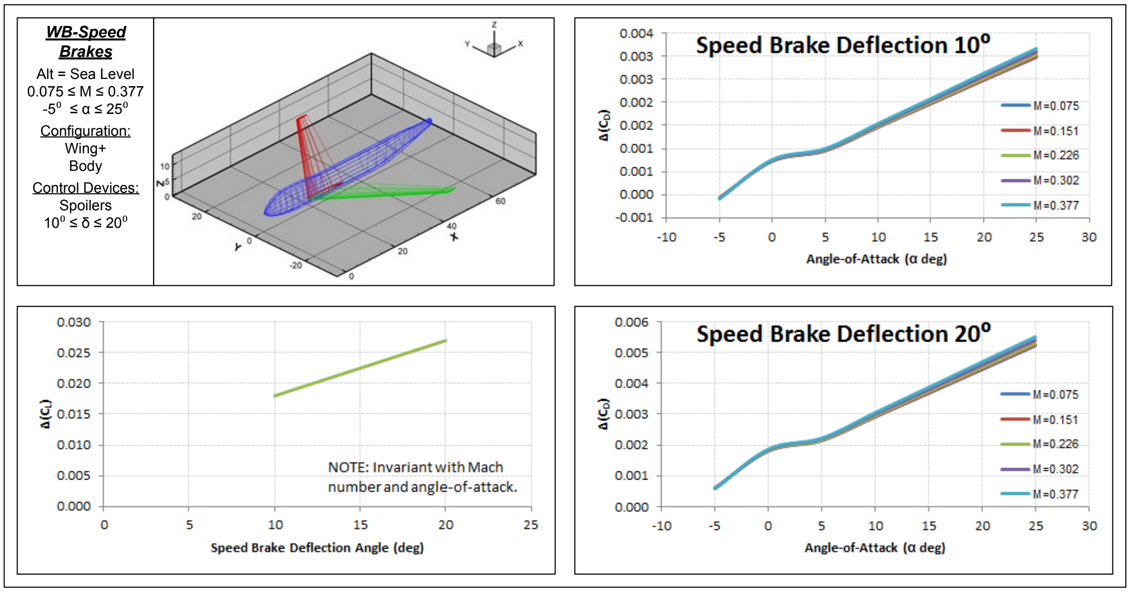


Figure 4.14 B747-200F Digital DATCOM Speed Brakes Results Summary

WBHV - Clean

Now that all the control devices have been modeled on the wing separately the empennage can be added. Figure 4.15 shows the total coefficients for the clean aircraft configuration. The purpose of this configuration is to provide a baseline that other components can be added to in order to build-up an aircraft configuration utilizing the control and high lift devices calculated earlier.

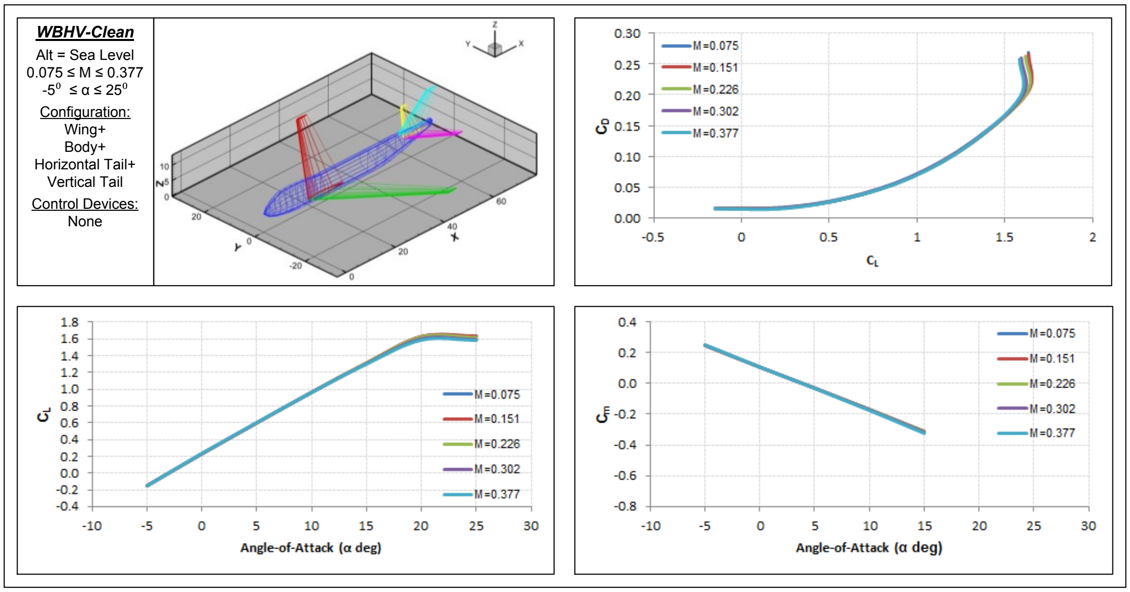


Figure 4.15 B747-200F Digital DATCOM Clean WBHV Model Results Summary

WBHV - Elevator

The results shown are not total aircraft coefficient but rather spoiler contributions, signified by the “Δ”, that can be added to the base coefficients. The drag coefficient is shown for only one Mach number and varies only slightly with change in Mach number but is available for the entire speed range, described in the Introduction. The lift, drag, and pitching moment coefficients are nonlinear and clearly shown. Also, the coefficient of lift (C_L) and coefficient of drag (C_D) contributions do not vary with angle-of-attack.

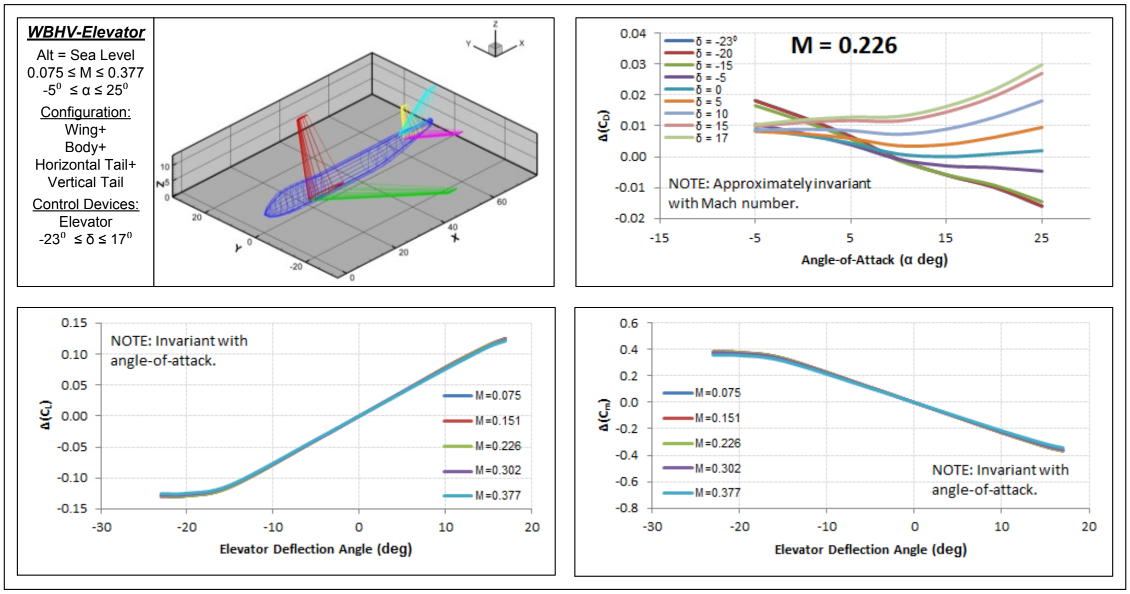


Figure 4.16 B747-200F Digital DATCOM Elevator Model Results Summary

WBHV – AMHT+e

The AMHT+e is the same as the elevator configuration except that the incidence angle of the horizontal tail is varied to represent an AMHT. The same Mach number is shown for the drag coefficient. An AMHT deflection of 15° is chosen to show the data for simplicity because it is the middle of the deflections angles for the AMHT but the entire range of deflection angles for the AMHT+e combination, as described in Table 4.2, is available. Also, just as with the elevator, the coefficient of lift (C_L) and coefficient of drag (C_D) contributions do not vary with angle-of-attack.

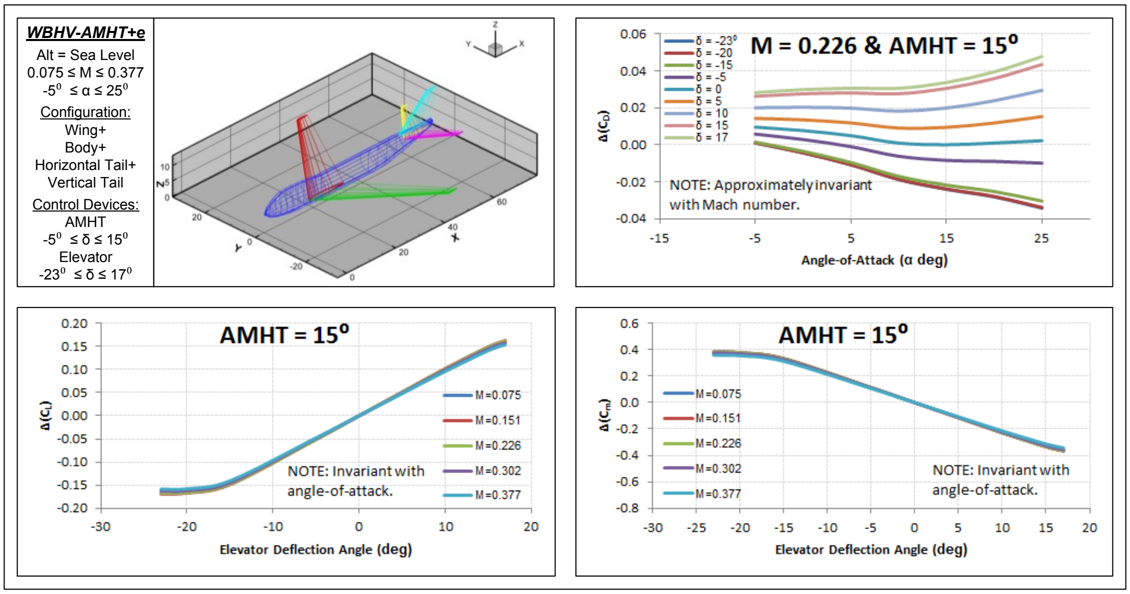


Figure 4.17 B747-200F Digital DATCOM AMHT+e Model Results Summary

4.4 DATCOM MAX Model

The DATCOM MAX model contains the entire aircraft configuration concept in every possible configuration. Since the entire aircraft configuration concept is modeled at once DATCOM MAX there is no need to build-up the components using multiple models, which is what is required with Digital DATCOM, shown in Table 4.4. The results described for DATCOM MAX contain the same components as Digital DATCOM, with the addition of landing gear and the rudder, but are all in the context of the full WBHV aircraft configuration. Table 4.6 shows the outputted components for the B747-200F DATCOM MAX model.

Table 4.6 B747-200F DATCOM MAX Model List

	Aircraft Configuration	**Component(s)**
1	WBHV	Clean
2	WBHV	Ailerons
3	WBHV	Flaps
4	WBHV	Spoilers
5	WBHV	Speed Brakes
6	WBHV	AMHT+e
7	WBHV	Rudder
8	WBHV	Landing Gear

4.4.1 Modeling Additions

As mentioned in chapter 3 on page 19 two additions have been made to DATCOM MAX. These are the ability to model a rudder and the landing gear contributions. For more information about the methods implemented please see chapter 3.

Rudder

There are not special considerations that are taken into account when modeling the rudder. The vertical tail attributes are declared in the Digital DATCOM for005.dat file as normal. The difference is an asymmetrical flap of type 6, which is not in Digital DATCOM, is declared in the for005.dat file. This is still a plain flap but is used as a flag in the code to use the rudder methods.

Landing Gear

The landing gear is modeled by declaring the frontal area, lengths, quantity, and location of each landing gear in the RUNDATCOM.in file. The B747-200F has two sets of main gear. These had to be approximated to one longitudinal location to since the method used only allows for one location to be declared for the main gear. The approximation is made by averaging the distance of the two sets of main landing gear. The main gear location approximation is shown in Figure 4.18.

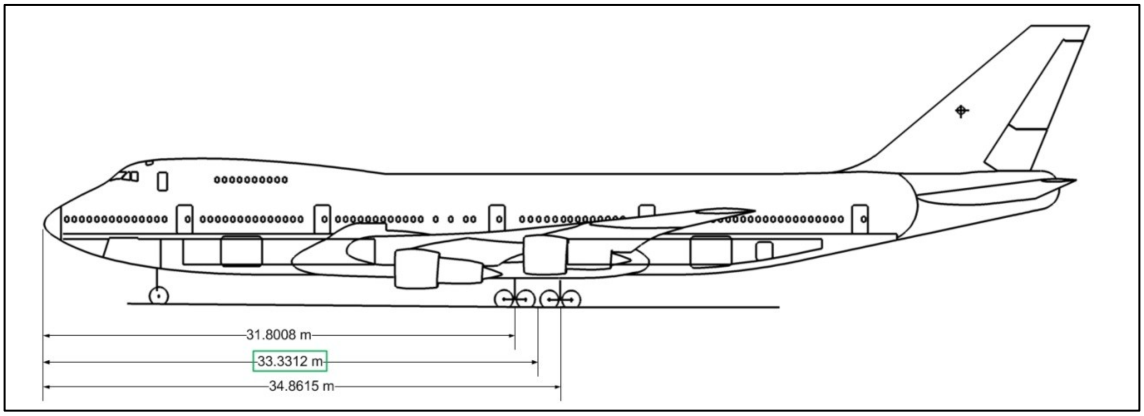


Figure 4.18 B747-200F DATCOM MAX Equivalent Main Landing Gear Location

4.4.2 Results

The B747-200F DATCOM MAX results follow the order of Table 4.6. Output is produced for every Mach number, at every angle-of-attack, with every control surface deflection angle shown in Table 4.1 and Table 4.2. There are far too many results to show the component buildup for each aircraft configuration so the total aircraft configuration for each aircraft component is summarized with a selected analysis point that related to all flight regimes defined in Table 4.1. Please see the DATCOM MAX V4 User's Manual in the appendix on page 91 for a complete list of output produced. All results are untrimmed.

WBHV – Clean

DATCOM MAX uses the WBHV clean configuration as the baseline for which all components are added to. Shown in Figure 4.19 is the DATCOM MAX B747-200F clean configuration. The results shown here are the total coefficients of the entire WBHV clean configuration. Also, the nonlinear stall regions can clearly be seen.

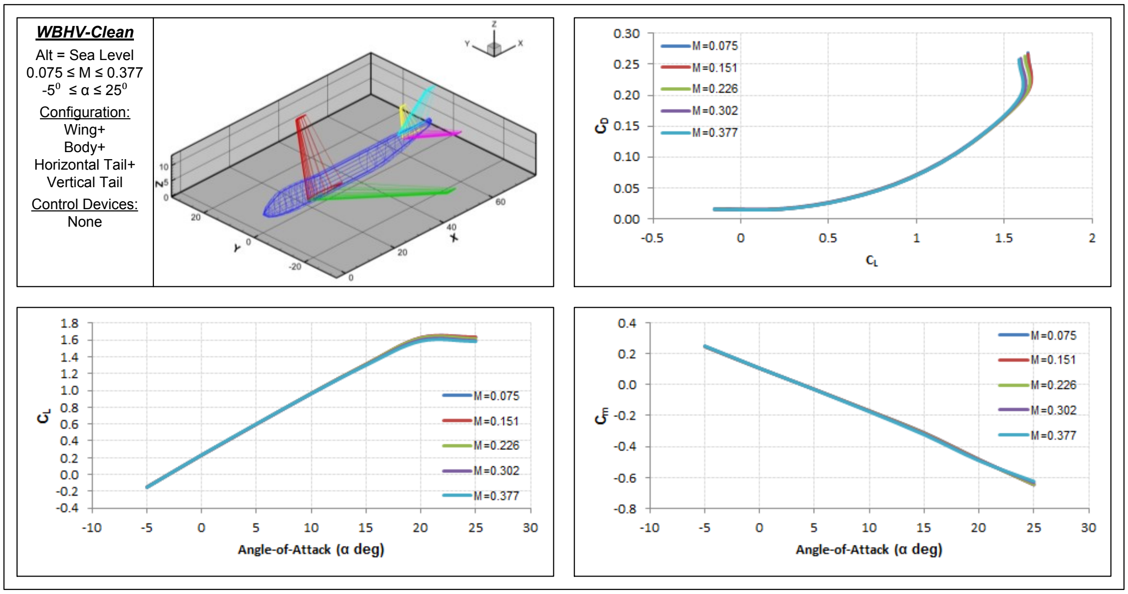
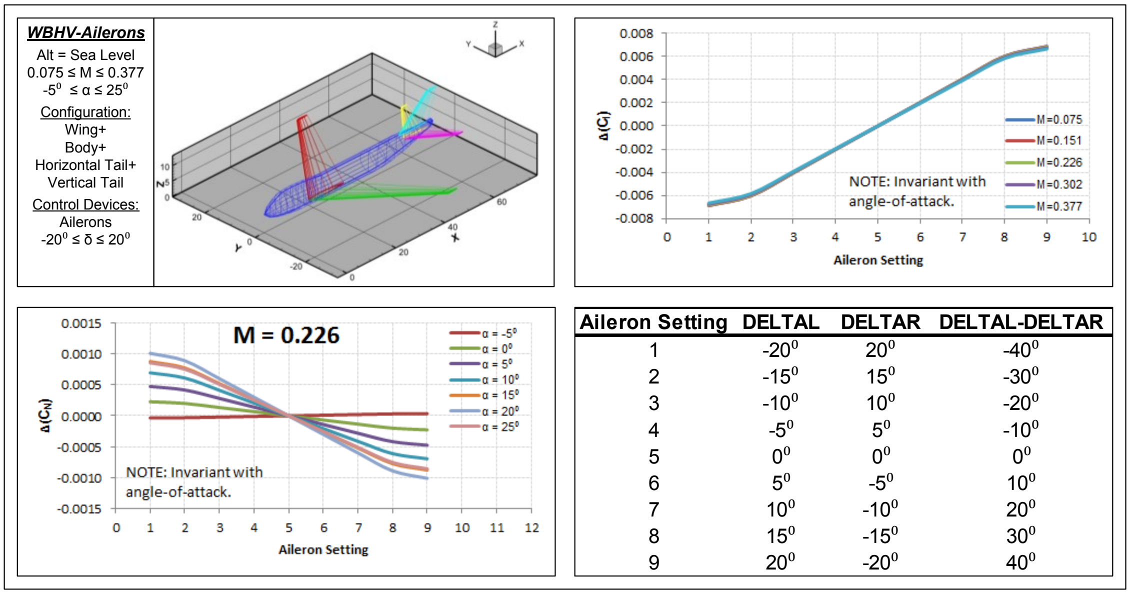


Figure 4.19 B747-200F DATCOM MAX Clean WBHV Model Results Summary

WBHV – Ailerons

Just as with Digital DATCOM in DATCOM MAX the ailerons are calculated by aileron settings, shown in the fourth quadrant of Figure 4.20. The results shown are not total aircraft coefficients but rather aileron contributions, signified by the "Δ", that can be added to the base coefficients. Also, the nonlinear regions of the aileron contributions can clearly be seen and should be noted that the aileron contributions are assumed to be independent of angle-of-attack.



Aileron Setting	DELTAL	DELTAR	DELTAL-DELTAR
1	-20^0	20^0	-40^0
2	-15^0	15^0	-30^0
3	-10^0	10^0	-20^0
4	-5^0	5^0	-10^0
5	0^0	0^0	0^0
6	5^0	-5^0	10^0
7	10^0	-10^0	20^0
8	15^0	-15^0	30^0
9	20^0	-20^0	40^0

Figure 4.20 B747-200F DATCOM MAX Ailerons Model Results Summary

WBHV – Flaps

The configuration chosen to represent the flaps is titled in the charts in Figure 4.21, which is full deflection of the leading and trailing edge flaps. Unlike Digital DATCOM the charts do not show the contributions of the flaps but rather the complete aircraft configuration with flaps deflected.

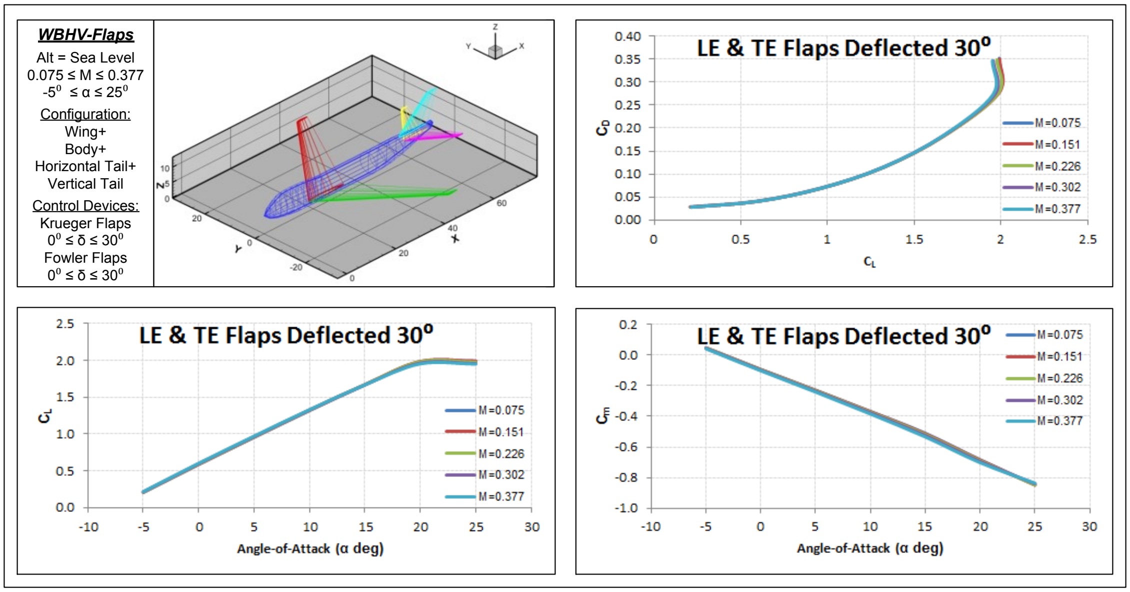


Figure 4.21 B747-200F DATCOM MAX Flaps Model Results Summary

WBHV – Spoilers

As with Digital DATCOM the spoiler output, shown in Figure 4.22, is assumed not to vary with angle-of-attack and for the most part does not vary with Mach number for low speeds. The results shown are not total aircraft coefficients but rather spoiler contributions, signified by the "Δ", that can be added to the base coefficients. Both rolling moment coefficient (C_l) and yawing moment coefficient (C_N) are nonlinear.

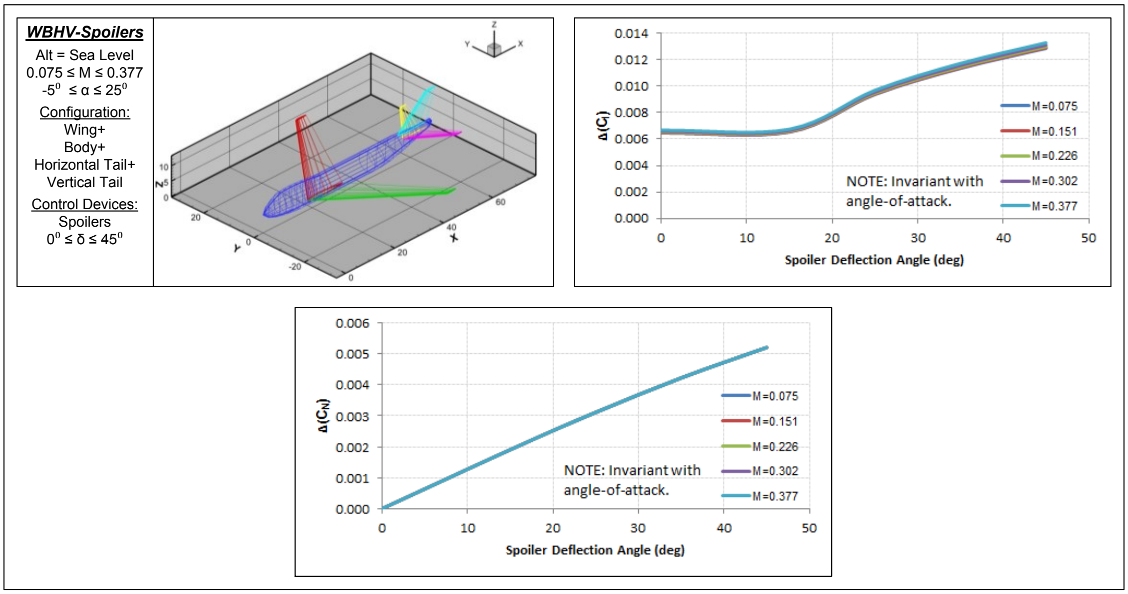


Figure 4.22 B747-200F DATCOM MAX Spoilers Model Results Summary

WBHV – Speed Brakes

The results shown are not total aircraft coefficient but rather spoiler contributions, signified by the “Δ”, that can be added to the base coefficients. It should be noted in quadrant three of Figure 4.23 the coefficient of lift contribution is shown as negative. As mentioned earlier for the Digital DATCOM model this was shown as positive. Also, as mentioned before the moment calculation is neglected due to modeling differences.

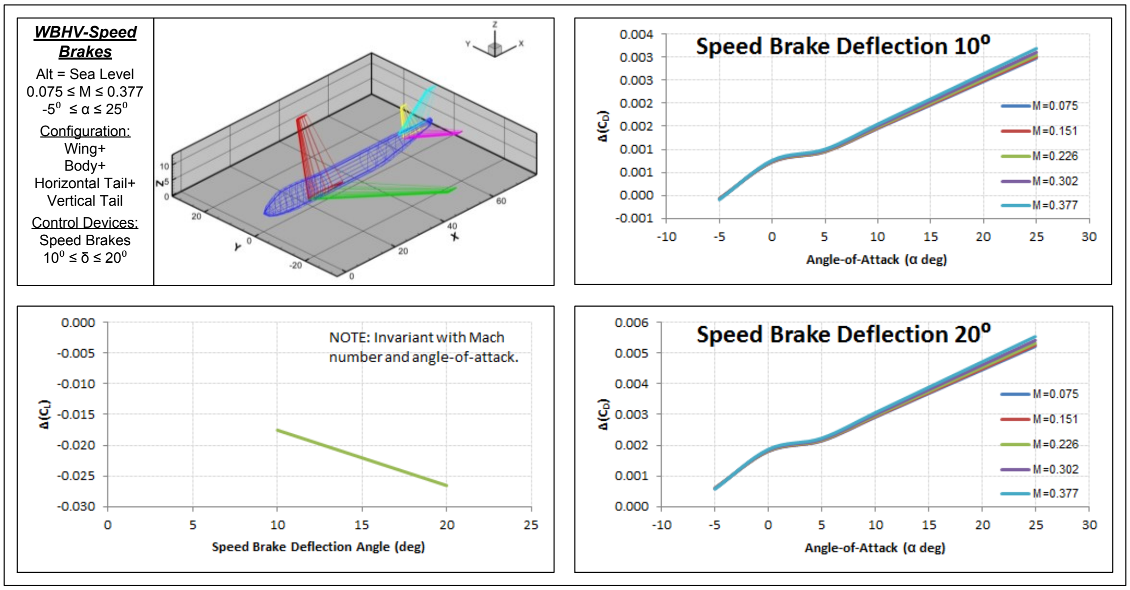


Figure 4.23 B747-200F DATCOM MAX Speed Brakes Model Results Summary

WBHV – AMHT+e

The elevator alone configuration is not shown because the only difference between the AMHT+e configuration and Elevator configuration is variation of horizontal tail incidence away from 0°. The results shown below are for the total coefficients for the WBHV configuration with an AMHT+e deflection of 15° each. 15° is arbitrarily chosen as the same conclusions are shown throughout the deflection sweep. Also, the nonlinear stall regions can clearly be seen.

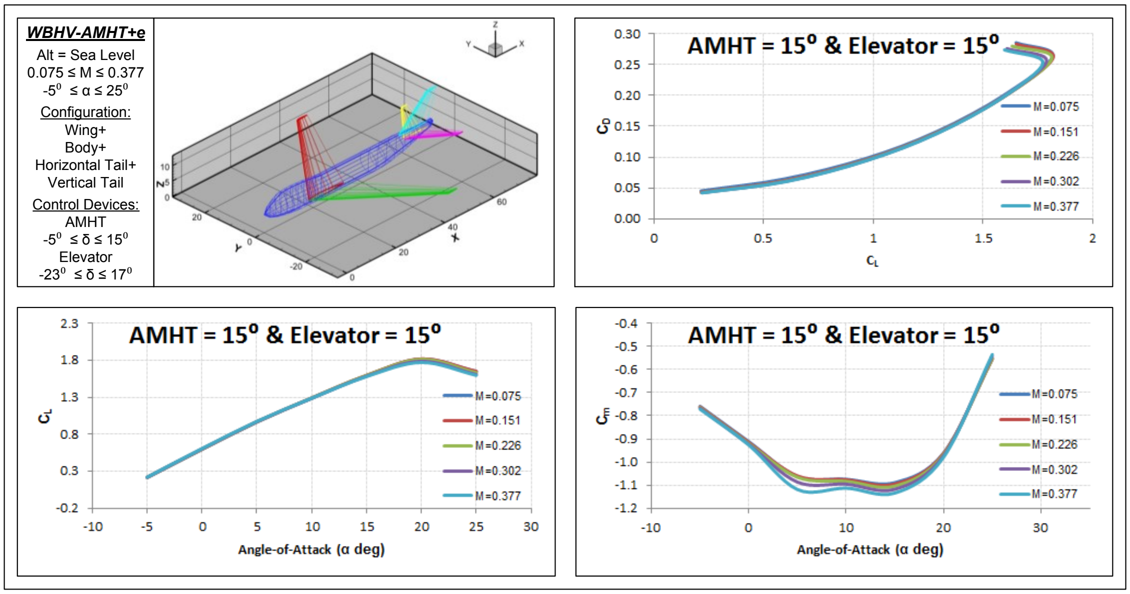
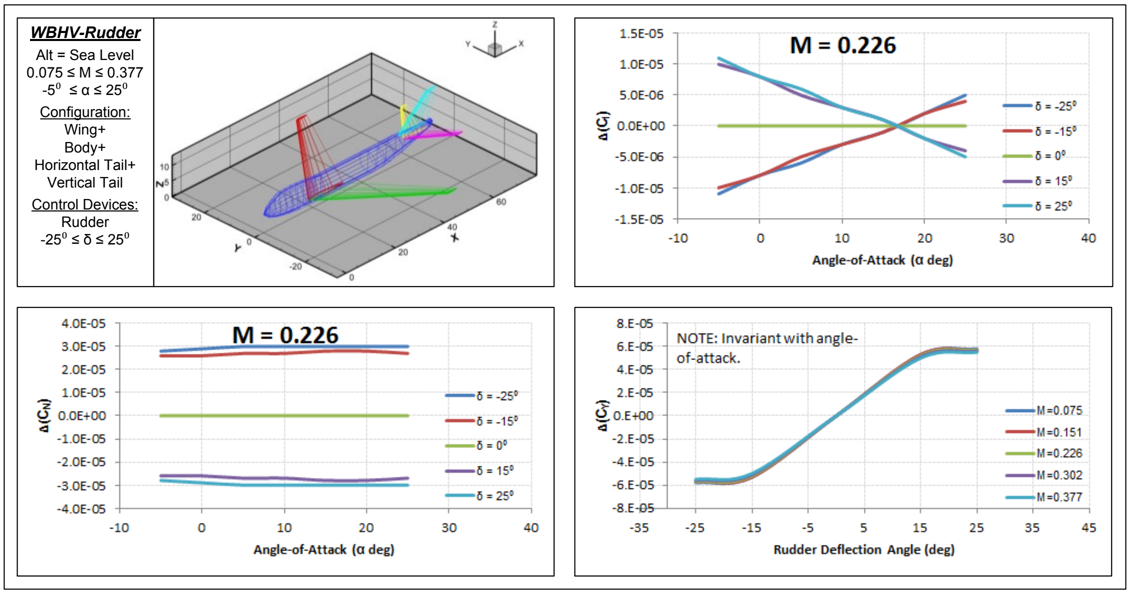


Figure 4.24 B747-200F DATCOM MAX AMHT+e Model Results Summary

WBHV – Rudder

The results shown in Figure 4.25 are contributions from the rudder and not total coefficients. The yawing moment (C_N), rolling moment (C_l), and side-force coefficient (C_Y) show all vary with Mach number, angle-of-attack, and rudder deflection angle but are only shown for one Mach number for simplicity but are available for the entire speed regime. Different conclusions cannot be drawing from changing the Mach number other than the magnitude of the coefficient. Also, the nonlinear regions can clearly be seen.



NOTE: Invariant with angle-of-attack.

Figure 4.25 B747-200F DATCOM MAX Rudder Model Results Summary

WBHV – Landing Gear

The only landing gear results, shown in Figure 4.26, available are the contribution drag (ΔC_D) and pitching moment (ΔC_m) coefficients. The drag coefficient does not vary with Mach number or angle-of-attack while the pitching moment coefficient varies with angle-of-attack.

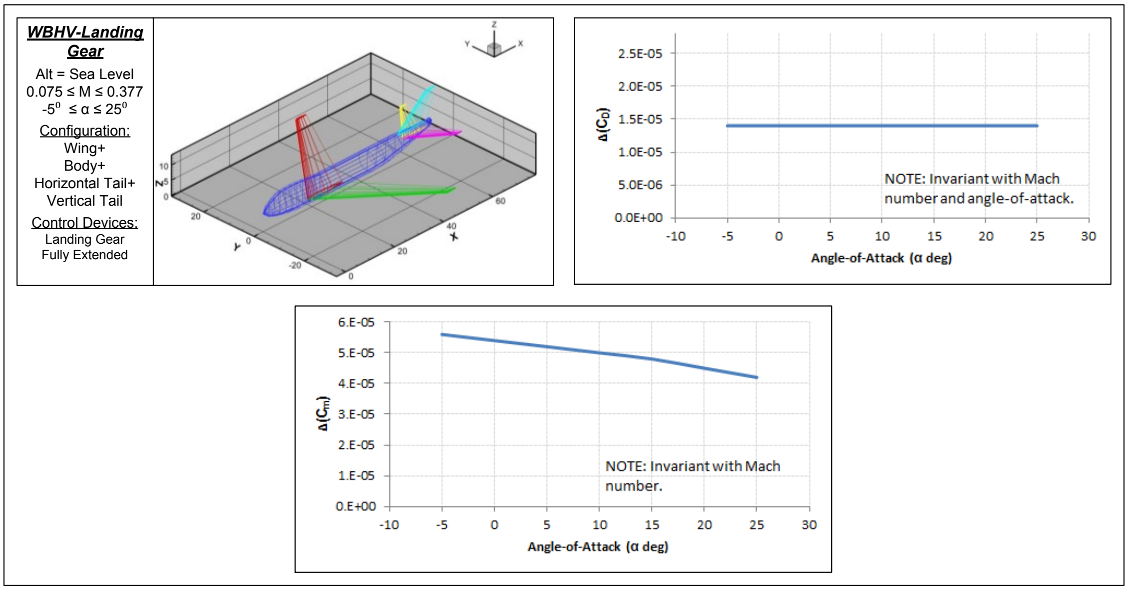


Figure 4.26 B747-200F DATCOM MAX Landing Gear Model Results Summary

4.5 Verification

Verification is the process of checking the DATCOM MAX output against the Digital DATCOM output. The purpose of this section is to show that DATCOM MAX is producing the same results for each component of the B747-200F model as Digital DATCOM. The process to verify DATCOM MAX output is configuration dependent and is described in the DATCOM MAX V4 User's Manual, shown in the appendix on page 91 . Just as with the results output the verification process is extensive, whereby each component is checked at each Mach number and altitude. This is required because when a method switch occurs the user is not notified and may not have been adapted for use in DATCOM MAX. The verification is available for all the output, as described in the Introduction and Table 4.2, but due to the vast amount of data the verification results are summarized below.

4.5.1 WBHV – Clean

The clean WBHV configuration must be checked first as it is the baseline and everything is based on this configuration. The comparison, shown in Table 4.7, gives the differences between the Digital DATCOM and DATCOM MAX results summarized earlier.

Table 4.7 B747-200F WBHV Clean Configuration Model Verification

M=0.226	**Digital DATCOM**			**DATCOM MAX**			**Difference**		
Alpha	**C_D**	**C_L**	**C_M**	**C_D**	**C_L**	**C_M**	**C_D**	**C_L**	**C_M**
-5°	0.015	-0.150	0.2493	0.015	-0.150	0.2493	0.000	0.000	0.0000
0°	0.016	0.232	0.1068	0.016	0.232	0.1068	0.000	0.000	0.0000
5°	0.032	0.601	-0.0297	0.032	0.601	-0.0297	0.000	0.000	0.0000
10°	0.066	0.966	-0.1699	0.066	0.966	-0.1699	0.000	0.000	0.0000
15°	0.122	1.313	-0.3154	0.122	1.313	-0.3154	0.000	0.000	0.0000
20°	0.203	1.623	NA	0.203	1.623	-0.4869	0.000	0.000	NA
25°	0.263	1.616	NA	0.263	1.616	-0.6458	0.000	0.000	NA

Note: NA signifies the DATCOM method applicability was exceeded

The same arbitrary Mach number is chosen as before and is shown for every angle-of-attack. All the results match within the significant figures. The one exception is the pitching moment coefficient past 15° angle-of-attack. DATCOM MAX does not recognize the method applicability was overrun. When this happens Digital DATCOM does not produce results and places a notification about the method overrun where the results normally would be. For this case DATCOM MAX is unable to recognize this and continues using the method and produces the results. This is ok as the data would be extrapolated in this region if ever required anyways but is good to note the extrapolation of the pitching moment coefficient for angles of attack past 15°. Because of this the results are declared to match. These conclusions hold true for all the output for the WBHV clean configuration.

4.5.2 Ailerons

The aileron verification data is available for all angles of attack, Mach numbers, and deflection angles defined in the Introduction and Table 4.2. One flap setting and Mach number is arbitrarily chosen to show the verification of the ailerons, shown in Table 4.8. Also, the rolling moment (C_l) does not vary with angle-of-attack. The values shown are the contribution of the speed brakes, shown by "Δ", and not the overall aircraft coefficients.

Table 4.8 B747-200F Aileron Model Verification

Flap Setting 9						
M=0.226	**Digital DATCOM**		**DATCOM MAX**		**Difference**	
Alpha	ΔC_N	ΔC_l	ΔC_N	ΔC_l	ΔC_N	ΔC_l
-5°	3.495E-05	6.8247E-03	3.500E-05	6.8250E-03	-5.000E-08	-3.000E-07
0°	-2.283E-04	6.8247E-03	-2.280E-04	6.8250E-03	-3.000E-07	-3.000E-07
5°	-4.783E-04	6.8247E-03	-4.770E-04	6.8250E-03	-1.300E-06	-3.000E-07
10°	-7.019E-04	6.8247E-03	-6.980E-04	6.8250E-03	-3.900E-06	-3.000E-07
15°	-8.877E-04	6.8247E-03	-8.810E-04	6.8250E-03	-6.700E-06	-3.000E-07
20°	-1.027E-03	6.8247E-03	-1.015E-03	6.8250E-03	-1.200E-05	-3.000E-07
25°	-8.811E-04	6.8247E-03	-8.600E-04	6.8250E-03	-2.110E-05	-3.000E-07

The flap setting chosen is 9, defined in the fourth quadrant of Figure 4.20 and Figure 4.10. The differences shown above are well out of the significant figures of the possible Digital DATCOM output so they are assumed to be zero. Because of this the results are declared to match. These conclusions hold true for all the output for the ailerons.

4.5.3 Spoilers

The spoiler verification data is available for all angles of attack, Mach numbers, and deflection angles defined in the Introduction and Table 4.2. One Mach number is arbitrarily chosen to show the verification of the spoilers, shown in Table 4.9. The spoiler data does not vary with angle-of-attack so all spoiler deflection angles are shown. The values shown are the contribution of the speed brakes, shown by "Δ", and not the overall aircraft coefficients.

Table 4.9 B747-200F Spoiler Model Verification

M=0.226	Digital DATCOM		DATCOM MAX		Difference	
Delta	ΔC_N	ΔC_l	ΔC_N	ΔC_l	ΔC_N	ΔC_l
0°	6.527E-03	0.000E+00	6.527E-03	0.000E+00	-3.000E-07	0.000E+00
15°	6.602E-03	1.909E-03	6.602E-03	1.909E-03	3.000E-07	0.000E+00
25°	9.486E-03	3.116E-03	9.486E-03	3.116E-03	-1.000E-07	0.000E+00
35°	1.148E-02	4.230E-03	1.148E-02	4.230E-03	0.000E+00	0.000E+00
45°	1.300E-02	5.214E-03	1.300E-02	5.214E-03	0.000E+00	0.000E+00

The differences shown above are well out of the significant figures of the possible Digital DATCOM output so they are assumed to be zero. Because of this the results are declared to match. These conclusions hold true for all the output for the spoilers.

4.5.4 Speed Brakes

The speed brake verification data is available for all angles of attack, deflection angles, and Mach numbers as defined in the Introduction and Table 4.2. A deflection angle of 20° was arbitrarily chosen to show the verification of the speed brakes. The values shown are the contribution of the speed brakes, shown by "Δ", and not the overall aircraft coefficients.

Table 4.10 B747-200F Speed Brake Model Verification

Speed Deflection of 20°						
M=0.226	**Digital DATCOM**		**DATCOM MAX**		**Difference**	
Alpha	ΔC_D	ΔC_L	ΔC_D	ΔC_L	ΔC_D	ΔC_L
-5°	5.91E-04	2.70E-02	5.93E-04	-2.68E-02	-2.00E-06	1.00E+01
0°	1.82E-03	2.70E-02	1.82E-03	-2.68E-02	-5.00E-06	1.38E-02
5°	2.16E-03	2.70E-02	2.17E-03	-2.68E-02	-1.10E-05	2.68E-02
10°	2.95E-03	2.70E-02	2.96E-03	-2.68E-02	-1.00E-05	2.68E-02
15°	3.74E-03	2.70E-02	3.75E-03	-2.68E-02	-8.00E-06	2.68E-02
20°	4.52E-03	2.70E-02	4.54E-03	-2.68E-02	-1.70E-05	2.68E-02
25°	5.310E-03	2.70E-02	5.33E-03	-2.68E-02	-1.60E-05	2.68E-02

The coefficient of lift (C_L) does not vary with angle-of-attack but does vary with Mach number and deflection angle. The differences shown for the coefficient of drag (C_D) are well out of the significant figures of the possible Digital DATCOM output while the coefficient of lift (C_L) differences are rounding differences between Digital DATCOM and DATCOM MAX. Because of this the results are declared to match. These conclusions hold true for all the output for the speed brakes.

4.5.5 Flaps

The flap verification is normally done in two parts, LE and TE separately. For simplicity, the LE and TE flaps are combined and both deflected to their maximum, 30°. The verification has previously been conducted with the flap separately and does not change the verification conclusions. One Mach number is arbitrarily chosen for the verification. The data shown is for the total aircraft configuration concept and not the individual component contributions.

Table 4.11 B747-200F Flaps Model Verification

LE & TE Flaps Deflected 30°									
M=0.226	**Digital DATCOM**			**DATCOM MAX**			**Difference**		
Alpha	C_D	C_L	C_m	C_D	C_L	C_m	C_D	C_L	C_m
-5°	0.027	0.233	0.118	0.028	0.209	0.047	0.000	0.024	0.072
0°	0.047	0.615	-0.024	0.040	0.592	-0.096	0.007	0.023	0.072
5°	0.069	0.984	-0.161	0.069	0.961	-0.232	0.000	0.023	0.072
10°	0.115	1.349	-0.301	0.115	1.325	-0.372	0.000	0.024	0.072
15°	0.183	1.696	-0.446	0.183	1.672	-0.518	0.000	0.024	0.072
20°	0.276	2.006	NA	0.276	1.983	-0.689	0.000	0.023	NA
25°	0.348	1.999	NA	0.349	1.975	-0.848	0.000	0.024	NA

The coefficient of drag (C_D) matches with a small outlier of 0.007 at 0° angle-of-attack. The coefficient of lift (C_L) and pitching moment coefficient (C_m) have nearly constant differences. After further investigation it is found that these constant differences as well as the single outlier for the coefficient of drag (C_D) are contributed to rounding differences between Digital DATCOM and DATCOM MAX. The differences shown are larger than a single rounding error and that is true. That is because each time a component contribution is calculated in Digital DATCOM it is sent to the output subroutine and rounded to the 3rd decimal place. Since DATCOM MAX calculates everything continuously the data is never sent to the output subroutine and rounded. Throughout the investigation it is unclear how Digital DATCOM rounds and is assumed to be from numerical differences between the two programs. The numerical differences add up through component buildup in DATCOM MAX and leads to the differences. Because the individual component results are similar and the numerical errors contribute to the differences the results are declared validated. These conclusions hold true for all output of the flaps.

4.5.6 AMHT+e

The AMHT+e verification is normally done in two parts, elevator alone and AMHT+e. For simplicity, the AMHT+e is only shown. The AMHT and elevator deflections are arbitrarily chosen to be 15°. The data shown, in Table 4.12, is for the AMHT+e contribution, shown by the "Δ", and is not the total aircraft coefficients.

Table 4.12 B747-200F AMHT+e Model Verification

AMHT+e Both Deflected 15°									
M=0.226	**Digital DATCOM**			**DATCOM MAX**			**Difference**		
Alpha	**ΔC_D**	**ΔC_L**	**ΔC_m**	**ΔC_D**	**ΔC_L**	**ΔC_m**	**ΔC_D**	**ΔC_L**	**ΔC_m**
-5°	0.026	0.148	-0.333	0.022	0.148	-0.334	0.005	0.000	0.001
0°	0.028	0.148	-0.333	0.025	0.148	-0.334	0.003	0.000	0.001
5°	0.028	0.148	-0.333	0.028	0.148	-0.334	0.000	0.000	0.001
10°	0.028	0.148	-0.333	0.032	0.148	-0.334	-0.004	0.000	0.001
15°	0.031	0.148	-0.333	0.035	0.148	-0.334	-0.005	0.000	0.001
20°	0.036	0.148	-0.333	0.040	0.148	-0.334	-0.004	0.000	0.001
25°	0.043	0.148	-0.333	0.046	0.148	-0.334	-0.003	0.000	0.001

As described with the flaps numerical rounding error can be seen for the drag coefficient (ΔC_D) and pitching moment coefficient (ΔC_m). Additionally, the drag coefficient (ΔC_D) shows a greater non-constant error than the pitching moment (ΔC_m) does. This is because the drag coefficient (ΔC_D) is the addition of the incremental minimum drag coefficient ($\Delta C_{D_{min}}$) due to flap control and the incremental induced-drag coefficient (ΔC_{D_i}) due to flap deflection.

4.6 Validation

Even though Digital DATCOM contains verified legacy methods it is stated in the Digital DATCOM User's Manual that "differences between DATCOM and Digital DATCOM do exist" (reference). For this reason the output from DATCOM MAX must also be validated against experimental aerodynamic data, if available.

The validation presented for the B747-200F is not the primary focus of the work and is limited in scope. The source of the aerodynamic data for this case study is "*The Simulation of a Jumbo Jet Transport Aircraft Volume II: Modeling Data*" (52). The purpose of that study by NASA was to build a simulator for the B747-100/200 family of aircraft, so ample aerodynamic data is available. Two AVD Lab research students, Taylor Cook and Jasmine Kendricks, took the report and digitized the data into Microsoft Excel. The comparisons presented below are possible in part to their work.

4.6.1 Drag Polar

Below is the drag polar for the clean B747-100/200 for low speed flight, shown in Figure 4.27. The experimental drag polar data stops right at stall, which is at the same drag coefficient (C_D) that DATCOM MAX shows stall.

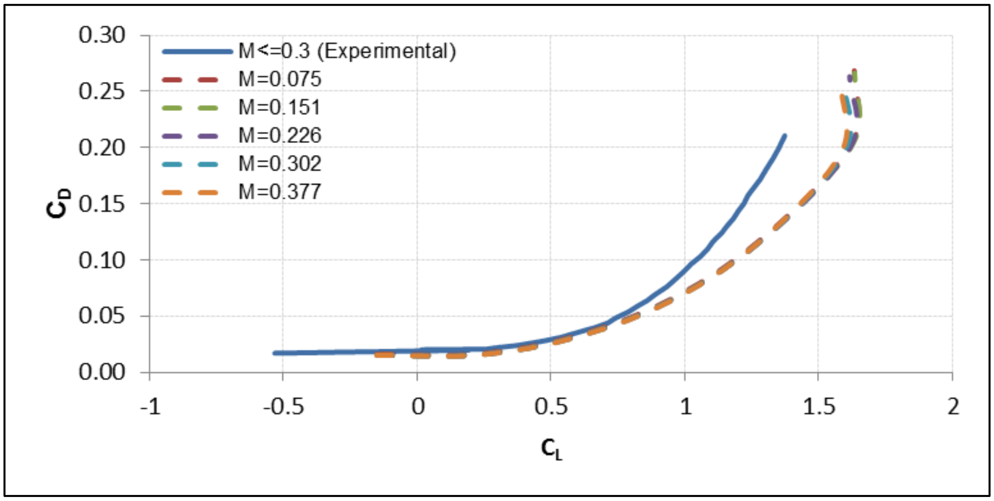


Figure 4.27 B747-200F Drag Polar Validation

It also clearly shows the coefficient of lift (C_L) is being over predicted for all speed ranges.

4.6.2 Lift Curve Slope

The coefficient of lift (C_L) versus angle-of-attack is shown in Figure 4.28 and reinforces the results from the drag polar. Shown as a dotted red line the clean DATCOM MAX B747-200F model's coefficient of lift (C_L) is over predicted. Also, note the differences in angle-of-attack at which stall appears. Low speed is assumed to be less than or equal to Mach 0.3.

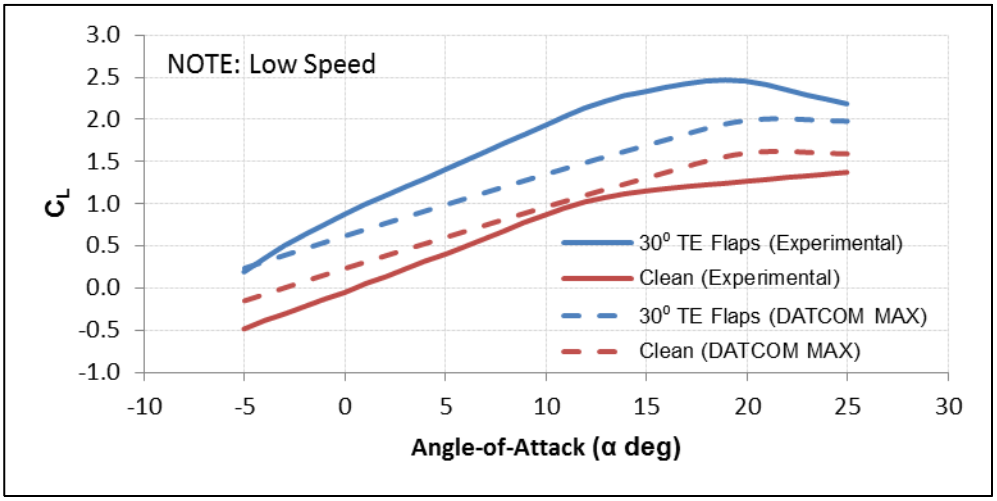


Figure 4.28 B747-200F Lift Curve Slope Validation

Lastly, the TE flaps selected, Fowler flaps, clearly underestimate the tripled slotted flap lift curve at full deflection.

4.6.3 AMHT

The change in lift coefficient equals the change in the total lift coefficient due to change in AMHT deflection angle times the effectiveness factor of the AMHT deflection angle. For the DATCOM MAX data effectiveness factor is not available so assumed to be one at all Mach locations. Additionally, the DATCOM MAX data is not trimmed.

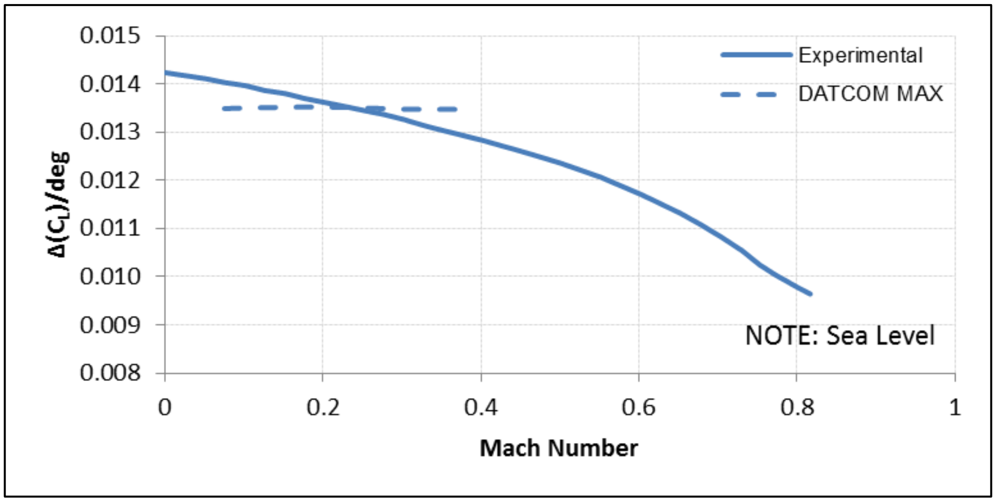


Figure 4.29 B747-200F AMHT Lift Curve per Degree Validation

As shown in Figure 4.29 only low speed data is generated for the B747-200F using DATCOM MAX.

4.6.4 Elevator

The change in lift coefficient equals the change in the total lift coefficient due to change in elevator deflection angle times the effectiveness factor of the elevator deflection angle. For the DATCOM MAX data effectiveness factor is not available so assumed to be one at all Mach locations. Also, DATCOM MAX results are not trimmed.

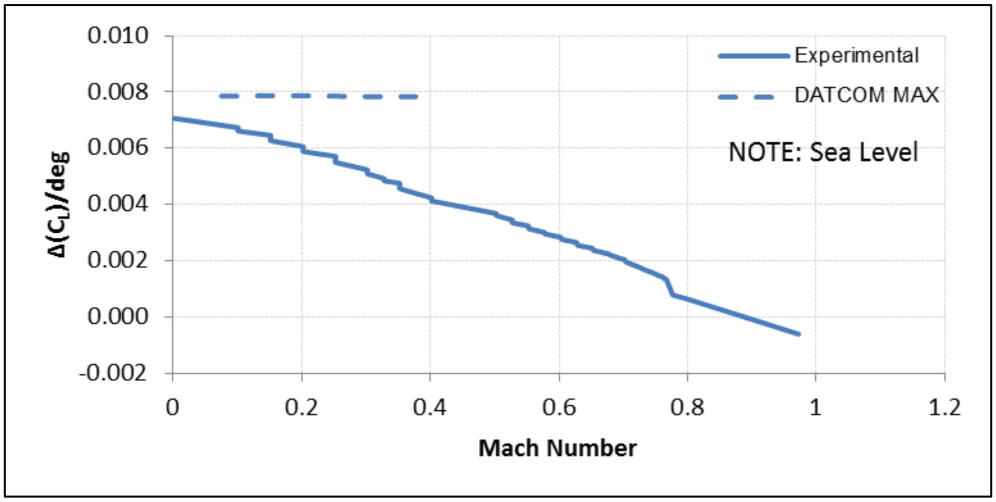


Figure 4.30 B747-200F Elevator Lift Curve per Degree Validation

As shown in Figure 4.30 only low speed data is generated for the B747-200F using DATCOM MAX.

4.7 Chapter Summary

In conclusion, this chapter defines the B747-200F case study aircraft by developing a MDS. From there the aircraft is modeled in Digital DATCOM and DATCOM MAX using the MDS. Modeling approximations are made and described. The DATCOM MAX model is then verified against the Digital DATCOM models to check the operational correctness of DATCOM MAX. Lastly, a brief comparison between the B747-200F DATCOM MAX results and aerodynamic data is made.

This case study demonstrates the application and accuracy of the DATCOM MAX prototype system. This study has shown that DATCOM MAX's predictions show trends and sensitivities needed during the conceptual design phase. Overall, the case study has modeled, analyzed, and compared results for the B747-200F.

CHAPTER 5

CONTRIBUTIONS SUMMARY AND RECOMMENDATIONS

5.1 Contributions Summary

The debugging and capability expansion of the software DATCOM MAX consist of (a) building a B747-200F MDS (b) using the MDS to build B747-200F Digital DATCOM models (c) the debugging and capability expansion of the stand-alone DATCOM MAX software with user's manual (d) verification and brief validation of the B747-200F DATCOM MAX model.

The goals of the present research project have been achieved, consisting of debugging and capability expansion of a complex legacy aerodynamic prediction software, verification, brief validation, and application of the stand-alone software DATCOM MAX. The specific tasks below have been carried out to meet these overall research objectives.

1. **Aerodynamic tool survey and selection.** Method applicability, turnaround time, and tool accuracy have been assessed for analytical, semi-empirical and empirical, and numerical aerodynamic tools. With the aim at providing fast turn-around times combined with, verified legacy methods for a wide range of aircraft configurations, these key factors identified Digital DATCOM for inclusion into the AVDS methods library.
2. **Research previous DATCOM MAX work and source code familiarization**. Previous AVD Lab work started with Gary Coleman and Amit Oza laying the framework for modifying the original Digital DATCOM implementation. With limited source code documentation at hand for the 357+ subroutines the pertinent code modules have been identified, studied and documented.

3. **Debug and capability expansion of Digital DATCOM to generate an aerodynamic database compatible with AeroMech and VATES.** Debugging consumed the largest effort of this work fixing DATCOM MAX errors as well as Digital DATCOM errors. Reducing the problem to isolate debugging issues as well as leaving behind the framework for future researcher to expand the addressable configurations, has been the overall research strategy.
4. **Build B747-200F MDS, Digital DATCOM models, and DATCOM MAX model.** Using the B747-200F case study, a MDS in the appendix on page 91 has been compiled to provide quick and easy access to consistent and up to date information about the aircraft. The MDS has been instrumental for building the Digital DATCOM and DATCOM MAX models, thereby providing transparent documentation related to input data and underlying assumptions taken.
5. **Verify and briefly validate DATCOM MAX using B747-200F data.** Digital DATCOM has been developed by multiple teams of engineers over 22 years, resulting in significant code inconsistency. Typical for legacy-code modifications, any modification to the code can cause undesired results. To make sure the modifications implemented result in the desired prediction results, DATCOM MAX has been verified against Digital DATCOM using the B747-200F models in parts. This approach provided assurance that the modifications have been incorporated correctly.

DATCOM MAX provides the vital aerodynamic database required for AeroMech and VATES in the AVDS process. Capturing the aerodynamic trends and sensitivities of an aircraft configuration concept during the conceptual design phase provides the designer with the desired fact-based decision making, which leads to identification of the solution space with the least amount of risk.

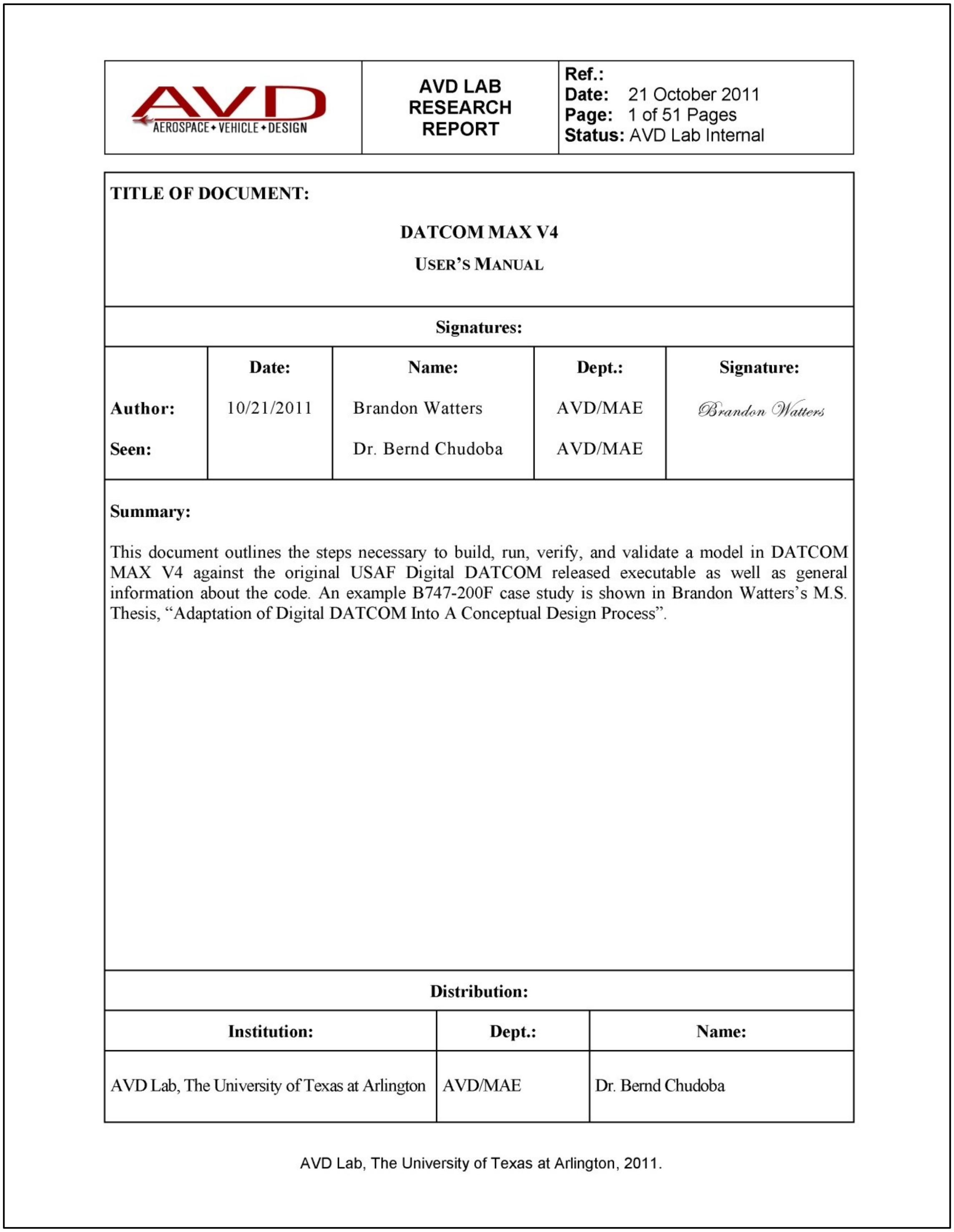
5.2 Recommendations for Future Work

Although the goal of debugging and capability expansion of DATCOM MAX has been achieved, there are still broader objectives to be met. These recommendations for future studies include:

1. Development of DATCOM MAX to fully utilize Digital DATCOM. The current version of DATCOM MAX V4 does not cover the full capability of Digital DATCOM. Expanding the capability with verification and validation studies would greatly increase the robustness and capability of this tool.
2. In depth validation studies. For the most part this research has to assume that legacy semi-empirical DATCOM methods are accurate. Consequently, only a brief validation comparison for the B747-200F is provided. A thorough transonic transport aircraft validation study should investigate how accurate the DATCOM methods are for the conceptual design phase.
3. Finally, utilizing all of Digital DATCOM's capability in DATCOM MAX, and the coupling/complementing of DATCOM MAX with VORSTAB, this would result in a significant contribution to the aerodynamic prediction challenge the conceptual designers are faced with.

APPENDIX A

DATCOM MAX V4 USER'S MANUAL



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TITLE OF DOCUMENT:

DATCOM MAX V4

USER'S MANUAL

Signatures:

	Date:	Name:	Dept.:	Signature:
Author:	10/21/2011	Brandon Watters	AVD/MAE	Brandon Watters
Seen:		Dr. Bernd Chudoba	AVD/MAE	

Summary:

This document outlines the steps necessary to build, run, verify, and validate a model in DATCOM MAX V4 against the original USAF Digital DATCOM released executable as well as general information about the code. An example B747-200F case study is shown in Brandon Watters's M.S. Thesis, "Adaptation of Digital DATCOM Into A Conceptual Design Process".

Distribution:

Institution:	Dept.:	Name:
AVD Lab, The University of Texas at Arlington	AVD/MAE	Dr. Bernd Chudoba

AVD Lab, The University of Texas at Arlington, 2011.

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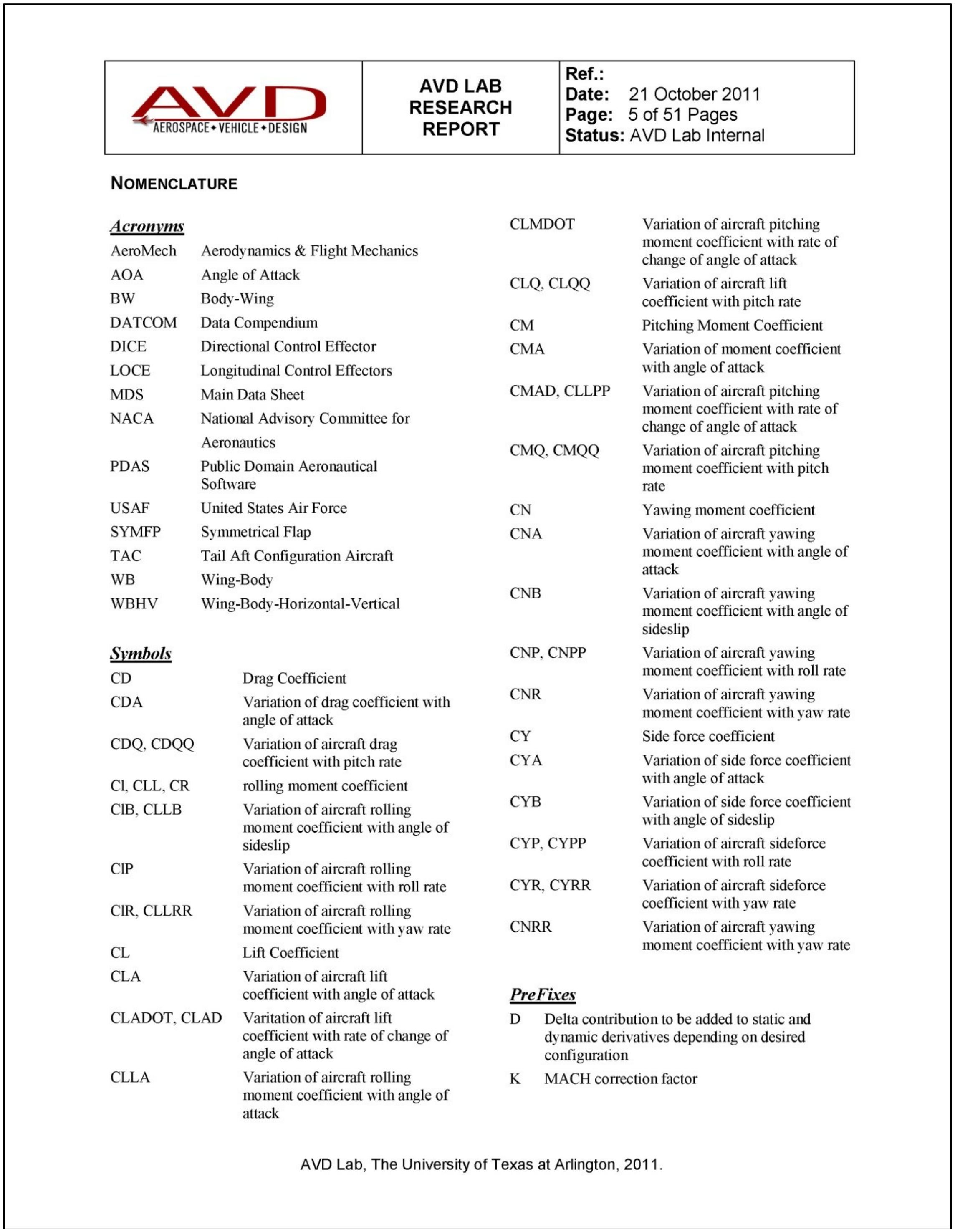

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NOMENCLATURE

Acronyms

AeroMech	Aerodynamics & Flight Mechanics
AOA	Angle of Attack
BW	Body-Wing
DATCOM	Data Compendium
DICE	Directional Control Effector
LOCE	Longitudinal Control Effectors
MDS	Main Data Sheet
NACA	National Advisory Committee for Aeronautics
PDAS	Public Domain Aeronautical Software
USAF	United States Air Force
SYMFP	Symmetrical Flap
TAC	Tail Aft Configuration Aircraft
WB	Wing-Body
WBHV	Wing-Body-Horizontal-Vertical

Symbols

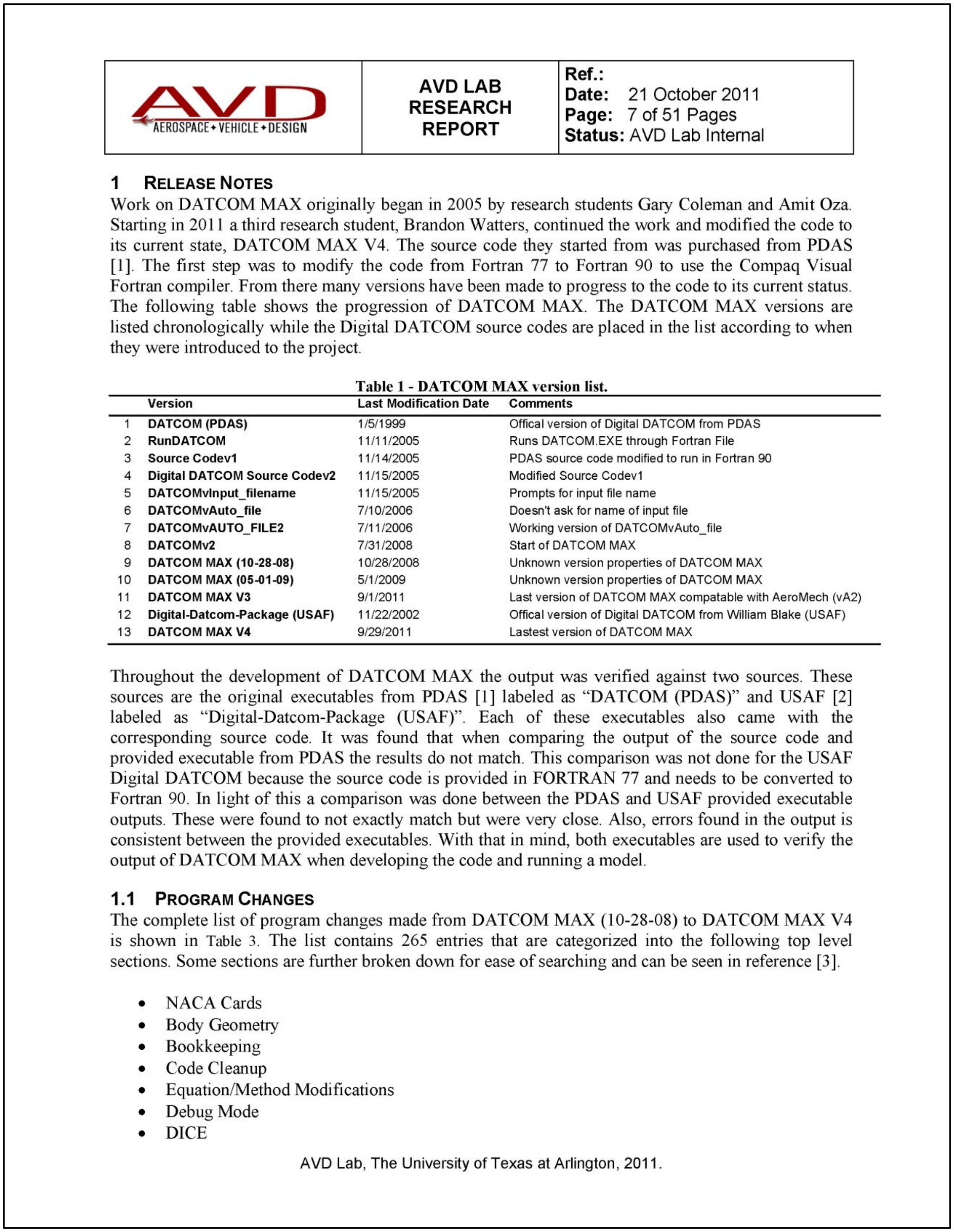
CD	Drag Coefficient
CDA	Variation of drag coefficient with angle of attack
CDQ, CDQQ	Variation of aircraft drag coefficient with pitch rate
Cl, CLL, CR	rolling moment coefficient
ClB, CLLB	Variation of aircraft rolling moment coefficient with angle of sideslip
ClP	Variation of aircraft rolling moment coefficient with roll rate
ClR, CLLRR	Variation of aircraft rolling moment coefficient with yaw rate
CL	Lift Coefficient
CLA	Variation of aircraft lift coefficient with angle of attack
CLADOT, CLAD	Varitation of aircraft lift coefficient with rate of change of angle of attack
CLLA	Variation of aircraft rolling moment coefficient with angle of attack
CLMDOT	Variation of aircraft pitching moment coefficient with rate of change of angle of attack
CLQ, CLQQ	Variation of aircraft lift coefficient with pitch rate
CM	Pitching Moment Coefficient
CMA	Variation of moment coefficient with angle of attack
CMAD, CLLPP	Variation of aircraft pitching moment coefficient with rate of change of angle of attack
CMQ, CMQQ	Variation of aircraft pitching moment coefficient with pitch rate
CN	Yawing moment coefficient
CNA	Variation of aircraft yawing moment coefficient with angle of attack
CNB	Variation of aircraft yawing moment coefficient with angle of sideslip
CNP, CNPP	Variation of aircraft yawing moment coefficient with roll rate
CNR	Variation of aircraft yawing moment coefficient with yaw rate
CY	Side force coefficient
CYA	Variation of side force coefficient with angle of attack
CYB	Variation of side force coefficient with angle of sideslip
CYP, CYPP	Variation of aircraft sideforce coefficient with roll rate
CYR, CYRR	Variation of aircraft sideforce coefficient with yaw rate
CNRR	Variation of aircraft yawing moment coefficient with yaw rate

PreFixes

D	Delta contribution to be added to static and dynamic derivatives depending on desired configuration
K	MACH correction factor

Suffixes

HT, IHT	Horizontal tail
HTE	Horizontal tail with elevator
LG, LGMAX	Landing gear
RU	Rudder
S	Static
SPB	Speed brakes
WB	Clean configuration or wing-body



1 RELEASE NOTES

Work on DATCOM MAX originally began in 2005 by research students Gary Coleman and Amit Oza. Starting in 2011 a third research student, Brandon Watters, continued the work and modified the code to its current state, DATCOM MAX V4. The source code they started from was purchased from PDAS [1]. The first step was to modify the code from Fortran 77 to Fortran 90 to use the Compaq Visual Fortran compiler. From there many versions have been made to progress to the code to its current status. The following table shows the progression of DATCOM MAX. The DATCOM MAX versions are listed chronologically while the Digital DATCOM source codes are placed in the list according to when they were introduced to the project.

Table 1 - DATCOM MAX version list.

	Version	Last Modification Date	Comments
1	**DATCOM (PDAS)**	1/5/1999	Offical version of Digital DATCOM from PDAS
2	**RunDATCOM**	11/11/2005	Runs DATCOM.EXE through Fortran File
3	**Source Codev1**	11/14/2005	PDAS source code modified to run in Fortran 90
4	**Digital DATCOM Source Codev2**	11/15/2005	Modified Source Codev1
5	**DATCOMvInput_filename**	11/15/2005	Prompts for input file name
6	**DATCOMvAuto_file**	7/10/2006	Doesn't ask for name of input file
7	**DATCOMvAUTO_FILE2**	7/11/2006	Working version of DATCOMvAuto_file
8	**DATCOMv2**	7/31/2008	Start of DATCOM MAX
9	**DATCOM MAX (10-28-08)**	10/28/2008	Unknown version properties of DATCOM MAX
10	**DATCOM MAX (05-01-09)**	5/1/2009	Unknown version properties of DATCOM MAX
11	**DATCOM MAX V3**	9/1/2011	Last version of DATCOM MAX compatable with AeroMech (vA2)
12	**Digital-Datcom-Package (USAF)**	11/22/2002	Offical version of Digital DATCOM from William Blake (USAF)
13	**DATCOM MAX V4**	9/29/2011	Lastest version of DATCOM MAX

Throughout the development of DATCOM MAX the output was verified against two sources. These sources are the original executables from PDAS [1] labeled as “DATCOM (PDAS)” and USAF [2] labeled as “Digital-Datcom-Package (USAF)”. Each of these executables also came with the corresponding source code. It was found that when comparing the output of the source code and provided executable from PDAS the results do not match. This comparison was not done for the USAF Digital DATCOM because the source code is provided in FORTRAN 77 and needs to be converted to Fortran 90. In light of this a comparison was done between the PDAS and USAF provided executable outputs. These were found to not exactly match but were very close. Also, errors found in the output is consistent between the provided executables. With that in mind, both executables are used to verify the output of DATCOM MAX when developing the code and running a model.

1.1 PROGRAM CHANGES

The complete list of program changes made from DATCOM MAX (10-28-08) to DATCOM MAX V4 is shown in Table 3. The list contains 265 entries that are categorized into the following top level sections. Some sections are further broken down for ease of searching and can be seen in reference [3].

- NACA Cards
- Body Geometry
- Bookkeeping
- Code Cleanup
- Equation/Method Modifications
- Debug Mode
- DICE

- Double Slotted Flaps
- Ground Effect
- LOCE
- Output
- Program Run Time
- Speed Brakes
- Spoilers
- SYMFP

Reference [3] contains the purpose, location, and date of every modification performed on DATCOM MAX (10-28-08). Each top level modification is summarized below.

NACA Cards

The NACA card "x-coordinates where airfoil coordinates are to be calculated" output differed from the provided DATCOM.EXE and was corrected to match.

Body Geometry

When the aft most coordinates of the body are input as the same to "close" the body the code would incorporate some numerical error around 10^-6 rather than "0.0D0" [4]. This fix was ultimately commented out because from the evidence gathered DATCOM.EXE does this as well.

Bookkeeping

This consists of adding or modifying common blocks from DATCOM MAX (10-28-08). No modification of common blocks have been done from the original PDAS code although copying and pasting them to some subroutines that originally did not have them has been done.

Code Cleanup

Changes in comments, variable definitions, and removal of unused variables were changed from the DATCOM MAX (10-28-08) source. No "code cleanup" has been done in regards to the original PDAS source code other than to change it to be compatible with .F90 in Compaq Visual Fortran.

Equation/Method Modifications

The methods modified are listed below.

- The C_m calculation in the CMALPH subroutine equation was incorrect in the original PDAS source code and was corrected.
- The "quick fix" was removed to shift the aerodynamic center computation to the center line in the CMALPH subroutine. The "quick fix" is not part of the original PDAS source code.
- In the DRAGFP subroutine while calculating DCDI the drag was purposely being over predicted due to modification of the original PDAS source code. This over prediction was being performed to compensate for bookkeeping errors in DATCOM MAX (10-28-08) unknowingly.
- The C_m calculation in subroutine WBCM was corrected from the original PDAS source code.

Debug Mode

This mode was added to allow trouble shooting and verification of DATCOM MAX's output. This mode allows the user to simplify the output to the DOS window. Regardless if this mode if on or off the code will also save text file, "PROTOCOL.DAT", which contains all the text that would be output to the DOS window if the debug mode is turned on.

DICE

Formatting was not done in "AERO OUTPUT FILE", which is named by default as "AERO01.DAT", for the DICE. This was done to be consistent with all other control effector formatting.

Double Slotted Flaps

Two major modifications were required to add double slotted flap capability in the presence of a horizontal tail to DATCOM MAX.

1) Modify the PDAS source code to correctly execute double slotted flaps.
2) Add the necessary bookkeeping to add the contributions where and when needed in the code.

The original PDAS source code had a for loop counter error and resulted in an out of bounds array when attempting to use double slotted flaps. The bookkeeping modification is part of DATCOM MAX's addition and modification of Digital DATCOM's output storage and order of execution.

Ground Effect

Modification of common blocks, equations, and buildup is required for proper ground effect calculations. Ground effect is a function of flap setting, AMHT setting, elevator deflection, angle of attack, height, and MACH number. The original Digital DATCOM cannot handle all of these without the user performing component buildup by hand. The modifications of the GRDEFF subroutine are NOT complete and any ground effect output is incorrect.

LOCE

Modifications similar to Double Slotted Flaps bookkeeping were required to implement an AMHT with an elevator in the presence of a wing with an ASYFLP and or SYMFLP.

Output

The output was cleanup up to be consistent for every control effector as well as added variables left out previously.

Program Run Time

Serves no real purpose other than to track the run time of the program.

Speed Brakes

Corrected component buildup for the speed brakes.

Spoilers

Corrected component buildup for the spoilers.

SYMFP

Changed the bookkeeping, added troubleshooting output, component buildup, and order in which the code operates.

1.2 KNOWN PROBLEMS

DATCOM MAX V4 is by no means a complete modification of Digital DATCOM. In addition Digital DATCOM was found to contain errors as well. With that in mind all known problems with Digital DATCOM and DATCOM MAX are listed below.

1.2.1 DIGITAL DATCOM

Some errors found have no impact on the result while others lead to incorrect results based upon how the model is setup. Below is a list of known errors. The problems below have been corrected for use in DATCOM MAX V4.

- LEARN.OUT file is created and opened but not closed by the program
- The delta induced drag, “D(CDI)”, of the body in the presence of a high lift device is not calculated correctly in most cases due to errors in switching flags within the code. This is especially true depending on how many angles of attack and deflections are chosen. A good rule of thumb is more than 2 of each and the more the merrier. This is because linear interpolation is used.
- The delta coefficient of moment, “D(CM)”, is dependent on how many deflection angles are used. This is because linear interpolation is used. Based on results using multiple angles is not a good idea. Stick with one deflection angle when possible.
- The delta coefficient of lift, “D(CL)”, when declaring SYMFLP as “FTYPE=8.0”. The Krueger D(CL) produced negative lift when it should produce a positive delta contribution.

1.2.2 DATCOM MAX V4

As stated earlier DATCOM MAX V4 is not a complete rework of Digital DATCOM. Because of this only certain configurations and flight regimes are known to be correctly working. Please read the capabilities and limitations sections for further description on what can and cannot be done in DATCOM MAX V4. Below is a list showing what is known to give incorrect answers.

- Down Wash
- Ground Effect
- Transonic Speeds
- “TRIM” Function
- Output Extrapolation

The original source code in these areas has not been adapted to function in the context of DATCOM MAX V4. An effort was started for Ground Effect but is not complete. The down wash uses the clean configuration and the bookkeeping within the DWASH function for each configuration needs to be updated.

Lastly, due to how data is being stored in DATCOM MAX V4 there is a warning displayed when compiling the code and is as follows.

“Warning LNK4084: total image size 353763328 exceeds max (268435456); image may not run”

“What this means is as long as the program is run on Windows 98 or newer operating system it will work. Windows 95 and NT 4.0 (prior to SP3) have a limit on the virtual address space of process or applications of 256 MB. Windows XP/2000/NT 4.0 (SP3+)/Me/98 have a limit of 2GB.” [5]

DATCOM MAX V4 AERO01.DAT information may provide information that is extrapolated past Digital DATCOM's applicability. To correct this the "OUTPUT EXTRACTION" portion in the "DATCOM" subroutine must be moved to the end of the "DATCOM" subroutine.

2 PROGRAM GUIDELINES

The modifications to the original Digital DATCOM source code provided by PDAS [1] are a wrapper as well as integrated changes. These changes automate many functions that would otherwise require extensive user work. For example, in order to run a TAC with a high lift device, say double slotted flaps, a BW configuration needs to run with the high lift devices. Then the output needs to be compiled by the user from the datcom.out file. After that the compiled data needs to be input as wing experimental data for the full TAC. This is only one example while many additions were made and are described below. The purpose of this chapter is to describe DATCOM MAX V4, not Digital DATCOM, for information on Digital DATCOM see [6].

2.1 PROGRAM ROUTINE

While DATCOM MAX V4 is integrated directly into Digital DATCOM. The first input file to be read is RUNDATCOM.IN and establishes how many times Digital DATCOM is going to be run with the number of flap settings. From there Digital DATCOM is executed for each flap setting and each time Digital DATCOM runs it reads the for005.dat input file. This routine is shown in Figure 1. One should note at least one, normally the first, flap setting needs to be with no flaps to provide a clean configuration baseline. For each flap setting all cases in the for005.dat are executed.

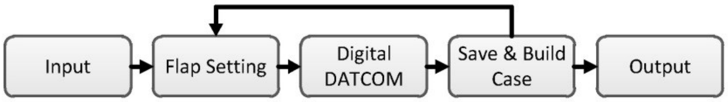


Figure 1 - DATCOM MAX V4 Program Routine

Digital DATCOM executes each case as normal from the for005.dat file when no flap settings are present in the RUNDATCOM.IN file. The order in which the cases appear in the for005.dat file does not matter as long as the LOCE cases are grouped consecutively. Specifically, the AMHT and elevator deflections are grouped together. The AMHT deflection is changed by changing the incidence angle of the horizontal tail using the variable "ALIH" and creating multiple cases for multiple deflections. The elevator deflections are placed in every AMHT case, including clean (ALIH = 0.0). That being said there is a "good practice" order in which is used and shown in Figure 2.

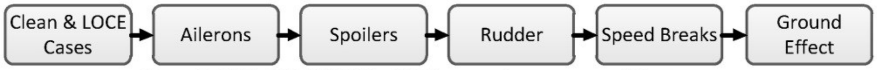


Figure 2 - Digital DATCOM for005.dat execution process and file structure.

The order in which these cases are placed in the for005.dat file is the order in which they will be executed during the "Digital DATCOM" block in Figure 1.

2.2 CAPABILITIES

DATCOM MAX V4 has been verified for a limited number of configurations. There are two categories used to build a single configuration, which directly correspond to the RUNDATCOM.IN file. These categories are:

- CONFIGURATION CODE
- LOCE CONFIGURATION

These categories are directly related to the RUNDATCOM.DAT on page 18.

CONFIGURATION CODE

This is the configuration of the aircraft and has the following options:

6 = Body-Wing
11 = Body-Wing-Horizontal-Vertical

LOCE CONFIGURATION

There are two possible LOCE configurations.

2 = AMHT (Not verified)
3 = AMHT+e (All moving horizontal tail with an elevator)

The code is expandable to any configuration involving the surfaces listed below but is limited to the configurations listed above due the development of the code being programed on a need basis. The additions that will need to be made to the code revolved around the output files, RUNDATOM.IN, and component buildup.

- Body
- Wing
- Horizontal Tail
- Vertical Tail
- High Lift Devices

2.3 LIMITATIONS

Many functions in the original Digital DATCOM have not been addressed or verified. These include the following:

- CASE CONTROL
  - TRIM – Will not work, AeroMech used instead
- NAMELIST NAME
  - PROPWR – Untested
  - JETPWR – Untested
  - TVTPAN – Untested
  - LARWB – Untested
  - TRANJET – Untested
  - HYPEFF – Untested
  - CONTAB – Untested

- SYMFLP
    - PLAIN FLAPS – Will not work, RUNDATCOM.IN needs modification
    - JET FLAPS – Will not work, RUNDATCOM.IN needs modification
- ASYFLP
    - AMHT (STYPE=5) – Do not use. Implemented through RUNDATCOM.IN instead
- Program Subroutines
    - DWASH – Incomplete, uses only clean configuration.

3 OUTPUT FORMATS

DATCOM MAX outputs two main groups of output files. One group is intended for AeroMech & VATES while the other is the original Digital DATCOM output files. All the files are text files with extension ".DAT", ".dat", ".OUT", and ".out", which can be opened in any text editing program although normally notepad is used. The last file is fort.7 if DATCOM PLOT.EXE is used. Tecplot is used to view this file and allows the user to visually check the geometry that was input into the program.

PROTOCOL.DAT is used for troubleshooting and verification against the two provided Digital DATCOM executables. This file contains all the output from the command prompt so it may be viewed afterwards. For more information on this output see the "VALIDATION PROCESS" on page 22.

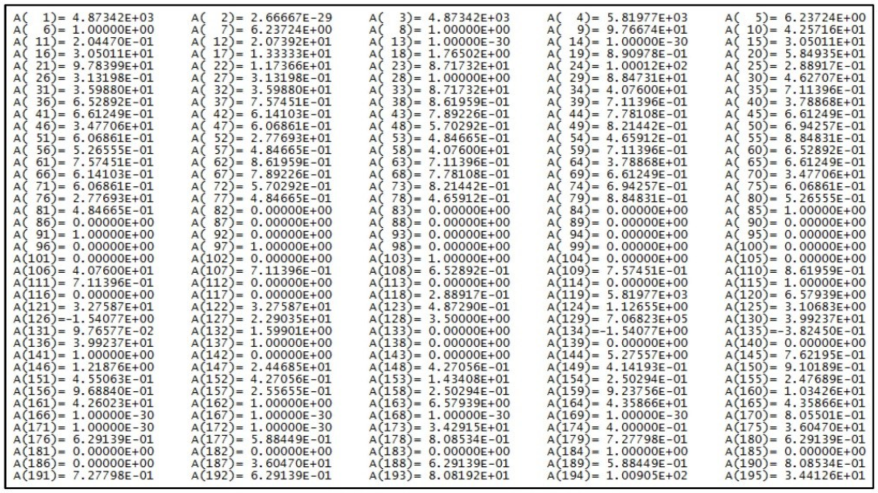
3.1 DIGITAL DATCOM

The files associated with Digital DATCOM are the following:

- for013.dat
- for014.dat
- LEARN.OUT
- datcom.out

for013.dat, for014.dat, and LEARN.OUT do not contain any information and are reminisce of the original Digital DATCOM code. Outputting these files was not removed in DATCOM MAX because it is unclear if they are needed during execution.

datcom.out contains output arrays (if specified in for005.dat using the "DUMP CASE" command), control surface information (if specified in for005.dat), aerodynamic buildup, and high lift devices (if specified in for005.dat). An example of an output array is shown in Figure 3. All the output arrays are defined in Reference 2 and contain all input variables, output variables, as well as intermediate calculated variables. These are very useful to debug errors.

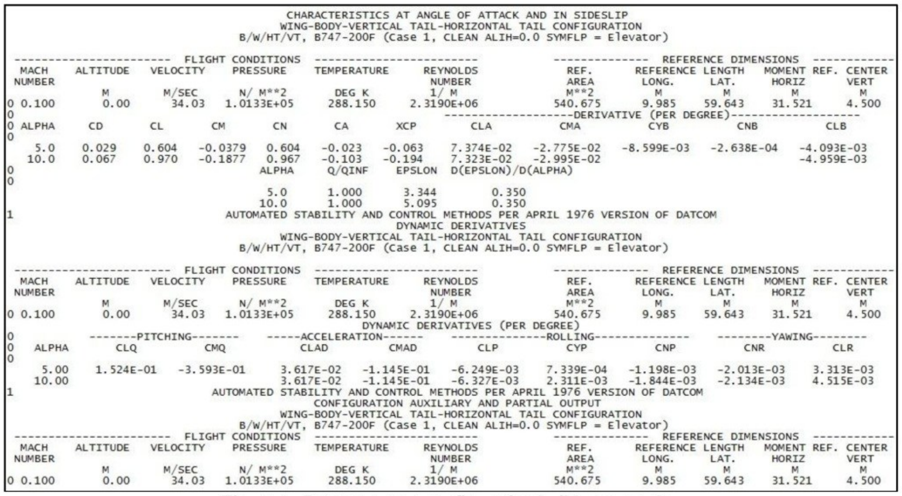


```
A(  1)= 4.87342E+03     A(  2)= 2.66667E-29     A(  3)= 4.87342E+03     A(  4)= 5.81977E+03     A(  5)= 6.23724E+00
A(  6)= 1.00000E+00     A(  7)= 6.23724E+00     A(  8)= 1.00000E+00     A(  9)= 9.76674E+01     A( 10)= 4.25716E+01
A( 11)= 2.04470E-01     A( 12)= 2.07392E+01     A( 13)= 1.00000E-30     A( 14)= 1.00000E-30     A( 15)= 3.05011E+01
A( 16)= 3.05011E+01     A( 17)= 1.33333E+01     A( 18)= 1.76502E+00     A( 19)= 8.90978E-01     A( 20)= 5.84935E+01
A( 21)= 9.78399E+01     A( 22)= 1.17366E+01     A( 23)= 8.71732E+01     A( 24)= 1.00012E+02     A( 25)= 2.88917E-01
A( 26)= 3.13198E-01     A( 27)= 3.13198E-01     A( 28)= 1.00000E+00     A( 29)= 8.84731E+01     A( 30)= 4.62707E+01
A( 31)= 3.59880E+01     A( 32)= 3.59880E+01     A( 33)= 8.71732E+01     A( 34)= 4.07600E+01     A( 35)= 7.11396E-01
A( 36)= 6.52892E-01     A( 37)= 7.57451E-01     A( 38)= 8.61959E-01     A( 39)= 7.11396E-01     A( 40)= 3.78868E+01
A( 41)= 6.61249E-01     A( 42)= 6.14103E-01     A( 43)= 7.89226E-01     A( 44)= 7.78108E-01     A( 45)= 6.61249E-01
A( 46)= 3.47706E+01     A( 47)= 6.06861E-01     A( 48)= 5.70292E-01     A( 49)= 8.21442E-01     A( 50)= 6.94257E-01
A( 51)= 6.06861E-01     A( 52)= 2.77693E+01     A( 53)= 4.84665E-01     A( 54)= 4.65912E-01     A( 55)= 8.84831E-01
A( 56)= 5.26555E-01     A( 57)= 4.84665E-01     A( 58)= 4.07600E+01     A( 59)= 7.11396E-01     A( 60)= 6.52892E-01
A( 61)= 7.57451E-01     A( 62)= 8.61959E-01     A( 63)= 7.11396E-01     A( 64)= 3.78868E+01     A( 65)= 6.61249E-01
A( 66)= 6.14103E-01     A( 67)= 7.89226E-01     A( 68)= 7.78108E-01     A( 69)= 6.61249E-01     A( 70)= 3.47706E+01
A( 71)= 6.06861E-01     A( 72)= 5.70292E-01     A( 73)= 8.21442E-01     A( 74)= 6.94257E-01     A( 75)= 6.06861E-01
A( 76)= 2.77693E+01     A( 77)= 4.84665E-01     A( 78)= 4.65912E-01     A( 79)= 8.84831E-01     A( 80)= 5.26555E-01
A( 81)= 4.84665E-01     A( 82)= 0.00000E+00     A( 83)= 0.00000E+00     A( 84)= 0.00000E+00     A( 85)= 1.00000E+00
A( 86)= 0.00000E+00     A( 87)= 0.00000E+00     A( 88)= 0.00000E+00     A( 89)= 0.00000E+00     A( 90)= 0.00000E+00
A( 91)= 1.00000E+00     A( 92)= 0.00000E+00     A( 93)= 0.00000E+00     A( 94)= 0.00000E+00     A( 95)= 0.00000E+00
A( 96)= 0.00000E+00     A( 97)= 1.00000E+00     A( 98)= 0.00000E+00     A( 99)= 0.00000E+00     A(100)= 0.00000E+00
A(101)= 0.00000E+00     A(102)= 0.00000E+00     A(103)= 1.00000E+00     A(104)= 0.00000E+00     A(105)= 0.00000E+00
A(106)= 4.07600E+01     A(107)= 7.11396E-01     A(108)= 6.52892E-01     A(109)= 7.57451E-01     A(110)= 8.61959E-01
A(111)= 7.11396E-01     A(112)= 0.00000E+00     A(113)= 0.00000E+00     A(114)= 0.00000E+00     A(115)= 1.00000E+00
A(116)= 0.00000E+00     A(117)= 0.00000E+00     A(118)= 2.88917E-01     A(119)= 5.81977E+03     A(120)= 6.57939E+00
A(121)= 3.27587E+01     A(122)= 3.27587E+01     A(123)= 4.87290E-01     A(124)= 1.12655E+00     A(125)= 3.10683E+00
A(126)=-1.54077E+00     A(127)= 2.29035E+01     A(128)= 3.50000E+00     A(129)= 7.06823E+05     A(130)= 3.99237E+01
A(131)= 9.76577E-02     A(132)= 1.59901E+00     A(133)= 0.00000E+00     A(134)=-1.54077E+00     A(135)=-3.82450E-01
A(136)= 3.99237E+01     A(137)= 1.00000E+00     A(138)= 0.00000E+00     A(139)= 0.00000E+00     A(140)= 0.00000E+00
A(141)= 1.00000E+00     A(142)= 0.00000E+00     A(143)= 0.00000E+00     A(144)= 5.27557E+00     A(145)= 7.62195E-01
A(146)= 1.21876E+00     A(147)= 2.44685E+01     A(148)= 4.27056E-01     A(149)= 4.14193E-01     A(150)= 9.10189E-01
A(151)= 4.55063E-01     A(152)= 4.27056E-01     A(153)= 1.43408E+01     A(154)= 2.50294E-01     A(155)= 2.47689E-01
A(156)= 9.68840E-01     A(157)= 2.55655E-01     A(158)= 2.50294E-01     A(159)= 9.23756E-01     A(160)= 1.03426E+01
A(161)= 4.26023E+01     A(162)= 1.00000E+00     A(163)= 6.57939E+00     A(164)= 4.35866E+01     A(165)= 4.35866E+01
A(166)= 1.00000E-30     A(167)= 1.00000E-30     A(168)= 1.00000E-30     A(169)= 1.00000E-30     A(170)= 8.05501E-01
A(171)= 1.00000E-30     A(172)= 1.00000E-30     A(173)= 3.42915E+01     A(174)= 4.00000E-01     A(175)= 3.60470E+01
A(176)= 6.29139E-01     A(177)= 5.88449E-01     A(178)= 8.08534E-01     A(179)= 7.27798E-01     A(180)= 6.29139E-01
A(181)= 0.00000E+00     A(182)= 0.00000E+00     A(183)= 0.00000E+00     A(184)= 1.00000E+00     A(185)= 0.00000E+00
A(186)= 0.00000E+00     A(187)= 3.60470E+01     A(188)= 6.29139E-01     A(189)= 5.88449E-01     A(190)= 8.08534E-01
A(191)= 7.27798E-01     A(192)= 6.29139E-01     A(193)= 8.08192E+01     A(194)= 1.00905E+02     A(195)= 3.44126E+01
```

Figure 3 - "A" Output array using "DUMP" option.

The aerodynamic buildup takes place in parts. Each surface and/or body is calculated independently but with respect to the same reference location and added together one by one until an entire component buildup is achieved. An example of the output during component buildup is shown in Figure 4. The example in Figure 4 is a complete configuration, wing-body-vertical tail-horizontal tail, at sea level, Mach 0.1 and two angles of attack, 5 and 10 degrees. This output will look the same for each individual component and component build ups. The order at which a body-wing-horizontal tail-vertical tail configuration with symmetric or asymmetrical control surface and ground effect will appear in datcom.out is:

1) Body Alone
2) Wing Alone
3) Horizontal Tail
4) Vertical Tail
5) Wing-Body
6) Body-Horizontal Tail
7) Body-Vertical Tail
8) Wing-Body-Horizontal Tail
9) Wing-Body-Vertical Tail
10) Wing-Body-Vertical Tail-Horizontal Tail
11) Control surface delta contribution
12) Ground Effect



```
                                CHARACTERISTICS AT ANGLE OF ATTACK AND IN SIDESLIP
                                WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CONFIGURATION
                             B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYMFLP = Elevator)

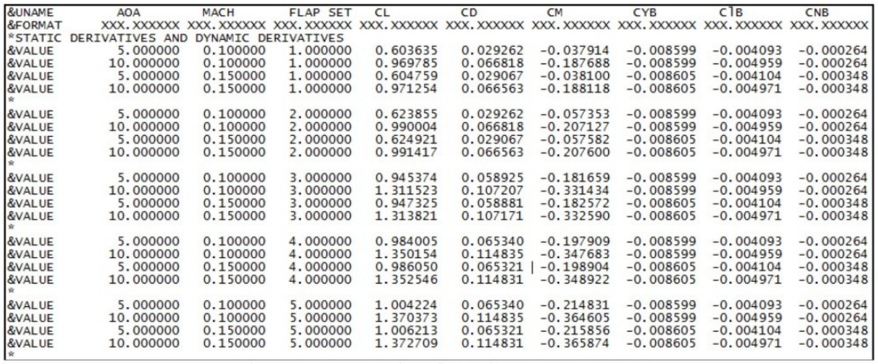
 ----------------------- FLIGHT CONDITIONS  ------------------------           --------------  REFERENCE DIMENSIONS  ------------
  MACH    ALTITUDE   VELOCITY   PRESSURE   TEMPERATURE     REYNOLDS               REF.     REFERENCE LENGTH   MOMENT REF. CENTER
 NUMBER                                                     NUMBER                AREA       LONG.     LAT.     HORIZ      VERT
              M        M/SEC     N/ M**2      DEG K          1/ M                 M**2         M         M        M          M
0 0.100      0.00      34.03   1.0133E+05    288.150     2.3190E+06             540.675      9.985    59.643    31.521     4.500
0                                                             -------------------DERIVATIVE (PER DEGREE)-------------------
0 ALPHA     CD      CL       CM       CN       CA       XCP        CLA         CMA          CYB          CNB          CLB
0
   5.0    0.029   0.604  -0.0379   0.604   -0.023   -0.063    7.374E-02   -2.775E-02   -8.599E-03   -2.638E-04   -4.093E-03
  10.0    0.067   0.970  -0.1877   0.967   -0.103   -0.194    7.323E-02   -2.995E-02                             -4.959E-03
0                                 ALPHA     Q/QINF    EPSLON  D(EPSLON)/D(ALPHA)
0
                                    5.0     1.000     3.344      0.350
                                   10.0     1.000     5.095      0.350
1                              AUTOMATED STABILITY AND CONTROL METHODS PER APRIL 1976 VERSION OF DATCOM
                                                       DYNAMIC DERIVATIVES
                                WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CONFIGURATION
                             B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYMFLP = Elevator)

 ----------------------- FLIGHT CONDITIONS  ------------------------           --------------  REFERENCE DIMENSIONS  ------------
  MACH    ALTITUDE   VELOCITY   PRESSURE   TEMPERATURE     REYNOLDS               REF.     REFERENCE LENGTH   MOMENT REF. CENTER
 NUMBER                                                     NUMBER                AREA       LONG.     LAT.     HORIZ      VERT
              M        M/SEC     N/ M**2      DEG K          1/ M                 M**2         M         M        M          M
0 0.100      0.00      34.03   1.0133E+05    288.150     2.3190E+06             540.675      9.985    59.643    31.521     4.500
                                               DYNAMIC DERIVATIVES (PER DEGREE)
0            -------PITCHING-------     -----ACCELERATION------    --------------ROLLING--------------    --------YAWING--------
0   ALPHA        CLQ          CMQ            CLAD        CMAD         CLP          CYP          CNP          CNR          CLR
0
    5.00     1.524E-01   -3.593E-01      3.617E-02   -1.145E-01   -6.249E-03    7.339E-04   -1.198E-03   -2.013E-03    3.313E-03
   10.00                                 3.617E-02   -1.145E-01   -6.327E-03    2.311E-03   -1.844E-03   -2.134E-03    4.515E-03
1                            AUTOMATED STABILITY AND CONTROL METHODS PER APRIL 1976 VERSION OF DATCOM
                                          CONFIGURATION AUXILIARY AND PARTIAL OUTPUT
                                WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CONFIGURATION
                             B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYMFLP = Elevator)
 ----------------------- FLIGHT CONDITIONS  ------------------------           --------------  REFERENCE DIMENSIONS  ------------
  MACH    ALTITUDE   VELOCITY   PRESSURE   TEMPERATURE     REYNOLDS               REF.     REFERENCE LENGTH   MOMENT REF. CENTER
 NUMBER                                                     NUMBER                AREA       LONG.     LAT.     HORIZ      VERT
              M        M/SEC     N/ M**2      DEG K          1/ M                 M**2         M         M        M          M
0 0.100      0.00      34.03   1.0133E+05    288.150     2.3190E+06             540.675      9.985    59.643    31.521     4.500
```

Figure 4 - Datcom output configuration buildup example.

3.2 AEROMECH

The only file associated with AeroMech is AERO01.DAT and contains various output blocks, which can be combined to determine aerodynamic properties in various aircraft configuration settings. Notepad is generally used to view the data. An example of one of the data blocks output is shown in Figure 5. When multiple data blocks are output they will be printed below each other.



```
&UNAME        AOA        MACH       FLAP SET   CL         CD         CM         CYB        ClB        CNB
&FORMAT    XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX XXX.XXXXXX
*STATIC DERIVATIVES AND DYNAMIC DERIVATIVES
&VALUE       5.000000   0.100000   1.000000   0.603635   0.029262  -0.037914  -0.008599  -0.004093  -0.000264
&VALUE      10.000000   0.100000   1.000000   0.969785   0.066818  -0.187688  -0.008599  -0.004959  -0.000264
&VALUE       5.000000   0.150000   1.000000   0.604759   0.029067  -0.038100  -0.008605  -0.004104  -0.000348
&VALUE      10.000000   0.150000   1.000000   0.971254   0.066563  -0.188118  -0.008605  -0.004971  -0.000348
*
&VALUE       5.000000   0.100000   2.000000   0.623855   0.029262  -0.057353  -0.008599  -0.004093  -0.000264
&VALUE      10.000000   0.100000   2.000000   0.990004   0.066818  -0.207127  -0.008599  -0.004959  -0.000264
&VALUE       5.000000   0.150000   2.000000   0.624921   0.029067  -0.057582  -0.008605  -0.004104  -0.000348
&VALUE      10.000000   0.150000   2.000000   0.991417   0.066563  -0.207600  -0.008605  -0.004971  -0.000348
*
&VALUE       5.000000   0.100000   3.000000   0.945374   0.058925  -0.181659  -0.008599  -0.004093  -0.000264
&VALUE      10.000000   0.100000   3.000000   1.311523   0.107207  -0.331434  -0.008599  -0.004959  -0.000264
&VALUE       5.000000   0.150000   3.000000   0.947325   0.058881  -0.182572  -0.008605  -0.004104  -0.000348
&VALUE      10.000000   0.150000   3.000000   1.313821   0.107171  -0.332590  -0.008605  -0.004971  -0.000348
*
&VALUE       5.000000   0.100000   4.000000   0.984005   0.065340  -0.197909  -0.008599  -0.004093  -0.000264
&VALUE      10.000000   0.100000   4.000000   1.350154   0.114835  -0.347683  -0.008599  -0.004959  -0.000264
&VALUE       5.000000   0.150000   4.000000   0.986050   0.065321 |-0.198904  -0.008605  -0.004104  -0.000348
&VALUE      10.000000   0.150000   4.000000   1.352546   0.114831  -0.348922  -0.008605  -0.004971  -0.000348
*
&VALUE       5.000000   0.100000   5.000000   1.004224   0.065340  -0.214831  -0.008599  -0.004093  -0.000264
&VALUE      10.000000   0.100000   5.000000   1.370373   0.114835  -0.364605  -0.008599  -0.004959  -0.000264
&VALUE       5.000000   0.150000   5.000000   1.006213   0.065321  -0.215856  -0.008605  -0.004104  -0.000348
&VALUE      10.000000   0.150000   5.000000   1.372709   0.114831  -0.365874  -0.008605  -0.004971  -0.000348
*
```

Figure 5 - Example AERO01.DAT output data block.

The output for each data block is a function of angle of attack (AOA), MACH number, and aircraft configuration settings. The aircraft configuration settings are dependent on the data block. The data blocks output depend on the aircraft configuration. Below is a list, in order, of every possible data block that is output.

- Static Derivatives and Dynamic Derivatives
- Ground Effect
- Longitudinal Control Effectors
- Longitudinal Control Effector MACH Correction
- Lateral Control Effectors (Up to 10 separate)
- Directional Control Effectors
- Speed Brakes Extended
- Landing Gear

Each data block is a function multiple factors, some more than others. Below shows what each data block is a function of as well as all available output for each data block. The Static Derivatives and Dynamic Derivatives serve as the basis for building up any aircraft configuration setting set of aerodynamic data. To build the data for a particular aircraft configuration setting add all relevant databases with corresponding angle of attack, MACH number, and flap setting to the Static Derivatives and Dynamic Derivatives data.

Static Derivatives and Dynamic Derivatives

$$f(AOA, MACH, FLAP\ SET) \\ = (CL, CD, CM, CYB, ClB, CNB, CLADOT, CLMDOT, CLQ, CDQ, CMQ, CYP, ClP, CNP, CYR, ClR, CNR)$$

Ground Effect

$$f(AOA, MACH, FLAP\ SET, HGE, DAMHT, DCE) = (DCL, DCD, DCM)$$

Longitudinal Control Effectors

$$f(AOA, MACH, FLAP\ SET, DAMHT, DCE) = (DCL, DCD, DCM, DCY, DCl, DCN)$$

Longitudinal Control Effector MACH Correction

$$f(AOA, MACH, FLAP\ SET) = (KCLHT, KCDHT, KCMHT)$$

Lateral Control Effectors

$$f(AOA, MACH, DLACE) = (DCL, DCD, DCM, DCY, DCl, DCN)$$

Directional Control Effectors

$$f(AOA, MACH, DDICE) = (DCL, DCD, DCM, DCY, DCl, DCN)$$

Speed Brakes Extended

$$f(AOA, MACH, DSPB) = (DCLSPB, DCDSPB, DCMSPB)$$

Landing Gear

$$f(AOA, MACH, FLAP\ SET) = (DCDLG, DCMLG)$$

3.3 VATES

There are 27 files associated with VATES. In order to use these in VATES further manual manipulation is required and how to do that is in Amit Oza's thesis [7]. Below the files are described.

VATES is the reason a MACH correction factor is used for the LOCE. This correction factor reduces the interpolation VATES needs to do for the DLOCE to 4 dimensional rather than 5 dimensional. This reduction can be seen in DLOCE+01.DAT and KLOCE.DAT. The MACH number is evaluated at the first MACH number listed and for005.dat and KLOCE.DAT is used to correct the DLOCE+01.DAT results for any difference in MACH number needed. For more information on this please see Amit Oza's thesis [7].

DCLEAN1.DAT – Clean Static Derivatives

$$f(AOA, MACH, FLAP\ SET) = (CLWB, CDWB, CMWB, CYB, CLLB, CNB, CLAD, CMAD)$$

DCLEAN1.DAT – Clean Dynamic Derivatives

$$f(AOA, MACH, FLAP\ SET) = (CLQQ, CDQQ, CMQQ, CYPP, CLLPP, CNPP, CYRR, CLLRR, CNRR)$$

GRDEFT+01.DAT – Ground Effects at Up to 10 Different Heights

$$f(AOA, MACH, FLAP\ SET, HGE, STABILZR, ELEVATOR) = (DCL, DCD, DCM)$$

DLOCE+01.DAT – Longitudinal Control Effector Effects, Up to 9 AMHT Deflections

$$f(AOA, MACH, FLAP\ SET, STABILZR, ELEVATOR) \\ = (DCLHTE, DCDHTE, DCMHTE, DCY, DCLL, DCN)$$

KLOCE.DAT – Longitudinal Control Effector Mach Correction Factors

$$f(AOA, MACH, FLAP\ SET) = (KCLIHT, KCDIHT, KCMIHT)$$

DLACE1.DAT – Lateral Control Effector Static Derivatives

$$f(AOA, MACH, AILERON) = (DCLA, DCDA, DCMA, DCYA, DCLLA, DCNA)$$

DLACE2.DAT – Lateral Control Effector Dynamic Derivatives

$$f(AOA, MACH, SPOILER) = (DCLS, DCDS, DCMS, DCYS, DCLLS, DCNS)$$

DDICE.DAT – Directional Control Effector Static Derivatives

$$f(AOA, MACH, RUDDER) = (DCLRU, DCDRU, DCMRU, DCYRU, DCRRU, DCNRU)$$

SPDBRK.DAT – Speed Break Static Derivatives

$$f(AOA, MACH, SPEED\ BR) = (DCLSPB, DCDSPB, DCMSPB)$$

LDGR.DAT – Landing Gear Static Derivatives

$$f(AOA, MACH, FLAP\ SET) = (DCDLGMAX, DCMLGMAX)$$

4 INPUT FILES

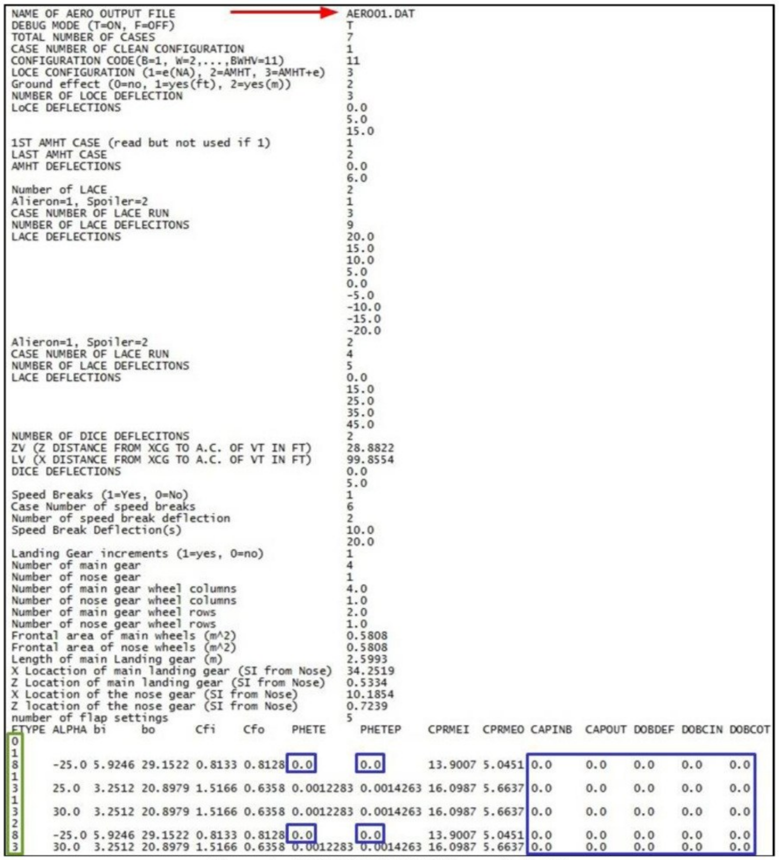
There are two input files needed to run DATCOM MAX V4. They are for005.dat and RUNDATCOM.IN, which contain some overlapping information but due to the program routine this is necessary.

4.1 FOR005.DAT

The for005.dat is built as described in the Digital DATCOM manual [6]. The exception is the order in which the cases need to be placed. The order is shown in Figure 2. For a quick overview of how to build a Digital DATCOM input file please see [8].

4.2 RUNDATCOM.DAT

The RUNDATCOM.DAT has a different file structure than for005.dat and if not done correctly the program may still run without notifying the user of any errors. It may also cause a runtime errors or array out of bounds error if not done correctly. Figure 6 shows an example of the RUNDATCOM.IN file.



```
NAME OF AERO OUTPUT FILE                        AER001.DAT
DEBUG MODE (T=ON, F=OFF)                        T
TOTAL NUMBER OF CASES                           7
CASE NUMBER OF CLEAN CONFIGURATION              1
CONFIGURATION CODE(B=1, W=2,...,BWHV=11)        11
LOCE CONFIGURATION (1=e(NA), 2=AMHT, 3=AMHT+e)  3
Ground effect (0=no, 1=yes(ft), 2=yes(m))       2
NUMBER OF LOCE DEFLECTION                       3
LoCE DEFLECTIONS                                0.0
                                                5.0
                                                15.0
1ST AMHT CASE (read but not used if 1)          1
LAST AMHT CASE                                  2
AMHT DEFLECTIONS                                0.0
                                                6.0
Number of LACE                                  2
Alieron=1, Spoiler=2                            1
CASE NUMBER OF LACE RUN                         3
NUMBER OF LACE DEFLECITONS                      9
LACE DEFLECTIONS                                20.0
                                                15.0
                                                10.0
                                                5.0
                                                0.0
                                                -5.0
                                                -10.0
                                                -15.0
                                                -20.0
Alieron=1, Spoiler=2                            2
CASE NUMBER OF LACE RUN                         4
NUMBER OF LACE DEFLECITONS                      5
LACE DEFLECTIONS                                0.0
                                                15.0
                                                25.0
                                                35.0
                                                45.0
NUMBER OF DICE DEFLECITONS                      2
ZV (Z DISTANCE FROM XCG TO A.C. OF VT IN FT)    28.8822
LV (X DISTANCE FROM XCG TO A.C. OF VT IN FT)    99.8554
DICE DEFLECTIONS                                0.0
                                                5.0
Speed Breaks (1=Yes, 0=No)                      1
Case Number of speed breaks                     6
Number of speed break deflection                2
Speed Break Deflection(s)                       10.0
                                                20.0
Landing Gear increments (1=yes, 0=no)           1
Number of main gear                             4
Number of nose gear                             1
Number of main gear wheel columns               4.0
Number of nose gear wheel columns               1.0
Number of main gear wheel rows                  2.0
Number of nose gear wheel rows                  1.0
Frontal area of main wheels (m^2)               0.5808
Frontal area of nose wheels (m^2)               0.5808
Length of main Landing gear (m)                 2.5993
X Locaction of main landing gear (SI from Nose) 34.2519
Z Location of main landing gear (SI from Nose)  0.5334
X Location of the nose gear (SI from Nose)      10.1854
Z location of the nose gear (SI from Nose)      0.7239
number of flap settings                         5
FTYPE ALPHA bi     bo      Cfi    Cfo    PHETE     PHETEP    CPRMEI  CPRMEO CAPINB  CAPOUT DOBDEF DOBCIN DOBCOT
0
1
8     -25.0 5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0     0.0    0.0    0.0    0.0
1
3     25.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0     0.0    0.0    0.0    0.0
1
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0     0.0    0.0    0.0    0.0
2
8     -25.0 5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0     0.0    0.0    0.0    0.0
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0     0.0    0.0    0.0    0.0
```

Figure 6 - RUNDATCOM.IN Example Build

Some basics about the file structure, everything needs to start 49 spaces over. Anything before those 49 spaces will be ignored. That is why everything can be seen starting from the same column shown by a red arrow in Figure 6 other than the SYMFP information at the bottom. The SYMFP information is placed evenly spaced solely for ease of reading and does not have a spacing constraint. For the SYMFP settings at the bottom, the program reads 15 different variables for each setting and depending on the SYMFP type some variables will not be needed. If this is the case "0.0" still needs to be put in place of that variable, shown in blue. The green outlines the start of the SYMFP information. Up to 20 different SYMFLP settings can be declared. For each setting up to 20 flap combinations can be declared. The order of this information needs to be as follows.

1) 1st Number of SYMFP devices

    a. SYMFP type (1st device)
    b. SYMFP type (2nd device)
    c. …
    d. SYMFP type (20th device)
2) 2nd Number of SYMFP devices
    a. SYMFP type (1st device)
    b. SYMFP type (2nd device)
    c. …
    d. SYMFP type (20th device)
3) …
    a. SYMFP type (1st device)
    b. SYMFP type (2nd device)
    c. …
    d. SYMFP type (20th device)
4) 20th Number of SYMFP devices
    a. SYMFP type (1st device)
    b. SYMFP type (2nd device)
    c. …
    d. SYMFP type (20th device)

To declare a clean configuration at least one flap setting, usually the first one, needs to be set to zero indicated by the zero at the top of the green box in Figure 6. The variables for the SYMFP section are the same as declared in the Digital DATCOM manual [6]. Below are nontrivial sections of the RUNDATCOM.IN file described.

NAME OF AERO OUTPUT FILE

Enter any name and will be used as the output filename for AeroMech. The default is AERO01.DAT.

DEBUG MODE (T=ON, F=OFF)

Enter in caps “T” or “F” to turn the output to the command prompt on or off.

TOTAL NUMBER OF CASES

Enter the total number of cases used in the for005.dat file.

CASE NUMBER OF CLEAN CONFIGURATION

Enter the case number of the clean configuration. This case needs to have 0 degree deflections for all control surfaces. This does not include incidence angles for the wing, horizontal tail, or vertical tail. If an AMHT is used the incidence angle of the horizontal tail is normally set to 0 degrees for the clean configuration.

CONFIGURATION CODE(B=1, W=2,…,BWHV=11)

This is asking what aircraft configuration you wish to run. There are two possible options for this section although more can be programed in.

6 = Body-Wing
12 = Body-Wing-Horizontal-Vertical

LOCE CONFIGURATION (1=e(NA), 2=AMHT, 3=AMHT+e)

This is asking what type of LOCE is to be used. There are two possible options for this setting although more can be program in.

2 = AMHT (Use with caution: Not verified)
3 = AMHT+e (All moving horizontal tail with an elevator)

Ground effect (0=no, 1=yes(ft), 2=yes(m))
If ground effect is one of the cases in the for005.dat this needs to either be 1 or 2 depending on what units are input to the for005.dat.

NUMBER OF LOCE DEFLECTION
This is asking how many elevator deflections are to be used. This corresponds to how many "DELTA"s in the for005.dat under SYMFP, normally of "FTYPE = 1.0". If no elevator is present this will be "0" and the following section, "LoCE DEFLECTIONS", should be deleted from the RUNDATCOM.IN file. Max of 10 deflections.

LoCE DEFLECTIONS
Contains every deflection of the elevator. Max of 10 deflections.

1ST AMHT CASE (read but not used if 1)
First case number used for the AMHT. If no AMHT is present set to zero and delete "AMHT DEFLECTIONS" section.

LAST AMHT CASE
Second case number used for the AMHT. If no AMHT is present set to zero and delete "AMHT DEFLECTIONS" section.

LoCE DEFLECTIONS
Contains every deflection of the AMHT. Max of 10 deflections.

Number of LACE
This can be set to 0, 1, or 2. There can be a maximum of 1 spoiler and 1 alieron and is limited by the output file routine for VATES. The first one declared needs to be an aileron due to VATES output file routine. More will be output to AERO01.dat for AeroMech if more are declared up to a maximum of 10 spoilers and ailerons. If set to 0 the following lines need to be deleted Aileron=1, Spoiler=2, CASE NUMBER OF LACE RUN, NUMBER OF LACE DEFLECTIONS, and LACE DEFLECTIONS.

Landing Gear increments (1=yes, 0=no)
This signifies if you have landing gear present or not. If landing gear are not present place 0.0 in the following sections and do not delete them. Number of main gear, Number of nose gear, Number of main gear wheel columns, Number of nose gear wheel columns, Number of main gear wheel rows, Number of nose gear wheel rows, Frontal area of main wheels (m^2), Frontal area of nose wheels (m^2), Length of main Landing gear (m), X Location of main landing gear (SI from Nose), Z Location of main landing gear (SI from Nose), X Location of the nose gear (SI from the Nose), and Z location of the nose gear (SI from Nose).

Number of main gear wheel columns

Number of nose gear wheel columns
This is valid for the nose or main gear columns. Imagine looking down at the top of the aircraft while placing a grid over the aircraft. From this perspective count the number of columns of main and nose gear.

Number of main gear wheel rows
Number of nose gear wheel rows
This is the same as the columns above except count the rows instead for the main and nose gear.

Frontal area of main wheels (m^2)
Frontal area of nose wheels (m^2)
This is valid for the nose and main gear. Only input the frontal area of one tire, not the total of all the tires.

X Location of main landing gear (SI from Nose)
Z Location of main landing gear (SI from Nose)
X Location of the nose gear (SI from Nose)
Z Location of the nose gear (SI from Nose)
This is valid for the X and Z locations of the nose and main landing gear. Self-explanatory except if multiple rows of nose of main landing gear exist then an equivalent nose or main landing gear needs to be made because only one location or each can be input.

number of flap settings
This is the total number of flap settings including the clean configuration. An example can be seen in Figure 6 on page 19.

If there is still question of how the RUNDATOM.IN file is read please see Figure 25 on page 38.

5 VALIDATION PROCESS

The first validation check that must be made is a "sanity" check of the geometry using "DATCOM PLOT.EXE" with the for005.dat file to make sure what the user input is what the user intended. A fort.7 is generated from this and Tecplot opens this file to visually check the geometry. From there a .jpg file can be saved and overlayed with actual pictures of the aircraft. When scaled properly all the geometries should match. A third party detailed example of this can be seen in [9].

When using DATCOM MAX the results must be verified then validated. Verifying is the act of comparing DATCOM MAX V4 results against the two provided excutables, DATCOM.EXE and "digdat.exe", to check and see if they match taking into consideration the known errors of all the programs. This is because all these programs are very complicated and numerous unknown errors are known to exist and this check helps to point out any obvious DATCOM MAX V4 errors. The known errors are listed in section "DIGITAL DATCOM" on page 10. Validation is the act of comparing DATCOM MAX V4 results against experimental aerodynamic data, if available. This is to check the "correctness" of DATCOM's methods used. In previous projects it has been found much better methods exist for particular calculations for specific scenarios. Also, methods do not exist for particular aircraft geometries but DATCOM will sometimes extrapolate a method's applicability in order to continue. It's very important to know when this happens because the results may not resemble the trend that should be represented.

5.1 VERIFICATION

Verification is the process of checking DATCOM MAX V4 results against two provided executables. These executables are DATCOM.EXE from PDAS and digdat.exe from the USAF. The reason for using both executables is when comparing the results from each executable there are differences and there is no way to prove which one is "more" correct. WinMerge is a very useful tool when comparing output files and can be found here http://winmerge.org/.

The verification process presented here is for DATCOM MAX V4 and is not generic for Digital DATCOM. If DATCOM MAX's capabilities are expanded the verification process will need to be modified. This is because of the differences in the component buildup processes in Digital DATCOM and DATCOM MAX, which makes the verification process different for most control effectors.

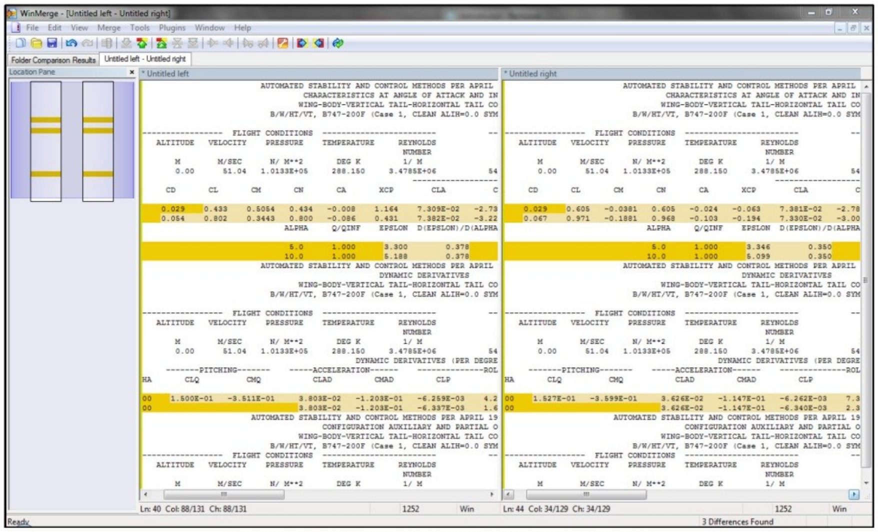
There is only one output file from each of the given executables and are as follows. Using WinMerge these two output files can be compared and more often than not only numerical errors can be seen. If an errors is found it should be noted.

- DATCOM.EXE → datcom.out
- digdat.exe → for006.dat

Each configuration and component combination to be checked in order is listed below. The reason it is done as a buildup is to narrow down where any errors might be coming from and because a complete configuration cannot be tested in Digital DATCOM due to its limitations. The list below shows the configurations to be used to check each component used. This is because certain components can only be used in certain configurations within Digital DATCOM. For more information on available components please see [6]. Also, under each configuration and component shown to be checked the output location for DATCOM MAX V4 is shown.

1) WB – Clean
    - datcom.out
2) WB – Ailerons
    - datcom.out
3) WB – Spoilers
    - datcom.out
4) WB – Speed Brakes
    - datcom.out
5) WB – TE Flaps
    - PROTOCOL.DAT
6) WB – LE Flaps
    - PROTOCOL.DAT
7) WBHV – Clean
    - datcom.out
8) WBHV – Elevator
    - PROTOCOL.DAT
9) WBHV – AMHT+e
    - PROTOCOL.DAT

For each case involving the datcom.out output from DATCOM MAX V4 all available output can be checked and is straight forward using WinMerge, shown in Figure 7. All data for every flight condition, altitude and MACH number, needs to be checked because Digital DATCOM performs method switching without notifying the user and may be incorrect. This is done by finding the corresponding locations in the datcom.out output files from DATCOM MAX V4 and Digital DATCOM excutables, datcom.out and for006.dat.



```
                        AUTOMATED STABILITY AND CONTROL METHODS PER APRIL
                                CHARACTERISTICS AT ANGLE OF ATTACK AND IN
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM

----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
    0.00      51.04    1.0133E+05     288.150     3.4785E+06            54
                                                          ------------------
    CD        CL        CM        CN        CA       XCP        CLA          C

    0.029    0.433    0.5054    0.434    -0.008     1.164    7.309E-02   -2.73
    0.054    0.802    0.3443    0.800    -0.086     0.431    7.382E-02   -3.22
                            ALPHA      Q/QINF     EPSLON  D(EPSLON)/D(ALPHA

                              5.0       1.000     3.300        0.378
                             10.0       1.000     5.188        0.378
                        AUTOMATED STABILITY AND CONTROL METHODS PER APRIL
                                                DYNAMIC DERIVATIVES
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM

----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
    0.00      51.04    1.0133E+05     288.150     3.4785E+06            54
                                             DYNAMIC DERIVATIVES (PER DEGRE
     -------PITCHING-------     -----ACCELERATION------     -------------ROL
HA       CLQ          CMQ            CLAD         CMAD          CLP

00    1.500E-01   -3.511E-01      3.803E-02   -1.203E-01    -6.259E-03    4.2
00                                3.803E-02   -1.203E-01    -6.337E-03    1.6
                       AUTOMATED STABILITY AND CONTROL METHODS PER APRIL 19
                                       CONFIGURATION AUXILIARY AND PARTIAL O
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM
----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
```

```
                        AUTOMATED STABILITY AND CONTROL METHODS PER APRIL
                                CHARACTERISTICS AT ANGLE OF ATTACK AND IN
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM

----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
    0.00      51.04    1.0133E+05     288.150     3.4785E+06            54
                                                          ------------------
    CD        CL        CM        CN        CA       XCP        CLA          C

    0.029    0.605   -0.0381    0.605    -0.024    -0.063    7.381E-02   -2.78
    0.067    0.971   -0.1881    0.968    -0.103    -0.194    7.330E-02   -3.00
                            ALPHA      Q/QINF     EPSLON  D(EPSLON)/D(ALPHA

                              5.0       1.000     3.346        0.350
                             10.0       1.000     5.099        0.350
                        AUTOMATED STABILITY AND CONTROL METHODS PER APRIL
                                                DYNAMIC DERIVATIVES
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM

----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
    0.00      51.04    1.0133E+05     288.150     3.4785E+06            54
                                             DYNAMIC DERIVATIVES (PER DEGRE
     -------PITCHING-------     -----ACCELERATION------     -------------ROL
HA       CLQ          CMQ            CLAD         CMAD          CLP

00    1.527E-01   -3.599E-01      3.626E-02   -1.147E-01    -6.262E-03    7.3
00                                3.626E-02   -1.147E-01    -6.340E-03    2.3
                       AUTOMATED STABILITY AND CONTROL METHODS PER APRIL 19
                                       CONFIGURATION AUXILIARY AND PARTIAL O
                               WING-BODY-VERTICAL TAIL-HORIZONTAL TAIL CO
                          B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYM
----------------- FLIGHT CONDITIONS ------------------------            --
  ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS
                                                      NUMBER
     M        M/SEC       N/ M**2       DEG K         1/ M
```

Figure 7 - WinMerge datcom.out comparison example.

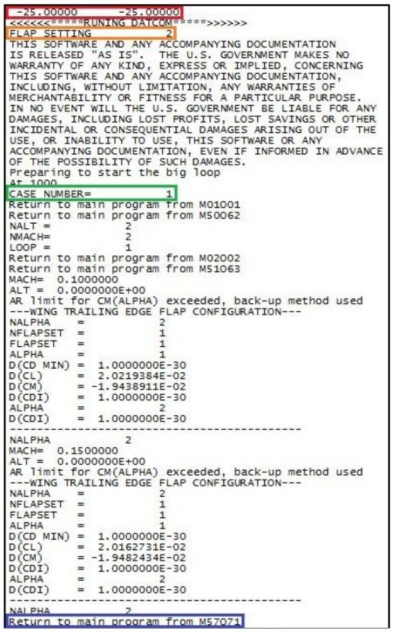
For configuration and component combinations that do not allow comparisons using the datom.out file from DATCOM MAX V4 a little more work by the user is required. After an overview of the PROTOCOL.DAT file this process is described.

For comparisons using the PROTOCOL.DAT output file from DATCOM MAX V4 the user must find the corresponding locations within the PROTOCOL.DAT file first. The PROTOCOL.DAT file organization is dependent upon the setup of the for005.dat and RUNDATCOM.IN files. Figure 1 and Figure 2 outline the general file structure but a general example is shown below.

1) Flap Setting 1 from RUNDATCOM.IN
    a. Case 1 from for005.dat
    b. Case 2 from for005.dat
    c. …
    d. Case 300 (Up to 300) from for005.dat
2) Flap Setting 2 from RUNDATCOM.IN
    a. Case 1 from for005.dat
    b. Case 2 from for005.dat

   c. …
   d. Case 300 (Up to 300) from for005.dat
3) ...
   a. Case 1 from for005.dat
   b. Case 2 from for005.dat
   c. …
   d. Case 300 (Up to 300) from for005.dat
4) Flap Setting 20 (Up to 20) from RUNDATCOM.IN
   a. Case 1 from for005.dat
   b. Case 2 from for005.dat
   c. …
   d. Case 300 (Up to 300) from for005.dat

During every full clean configuration case the flap settings will be applied, which is the reason the first flap setting needs to be no flaps. Flap settings will also be applied during the ground effect cases but since this portion is not complete it can be neglected. Figure 8 shows an excerpt from the from the PROTOCOL.DAT output file. Before running each set of cases, the entire for005.dat, the flap setting to be used for those run will be declared and is shown in orange while the deflection of the flap setting is shown in red. After that the case number to be ran will be declared. While in each case return statements from major subroutines will appear to show at what point the code is at running as will the MACH number and altitudes if multiple are set. When the entire case is complete the statement in blue will appear. When a flap setting is finished running the statement "SO FAR SO GOOD" will appear. The other notes are for the verification of the parts 5, 6, 8, and 9 listed above.



```
 -25.00000      -25.00000
<<<<<<*****RUNING DATCOM*****>>>>>>
FLAP SETTING           2
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION
IS RELEASED "AS IS".  THE U.S. GOVERNMENT MAKES NO
WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, CONCERNING
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION,
INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF
MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
IN NO EVENT WILL THE U.S. GOVERNMENT BE LIABLE FOR ANY
DAMAGES, INCLUDING LOST PROFITS, LOST SAVINGS OR OTHER
INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE
USE, OR INABILITY TO USE, THIS SOFTWARE OR ANY
ACCOMPANYING DOCUMENTATION, EVEN IF INFORMED IN ADVANCE
OF THE POSSIBILITY OF SUCH DAMAGES.
Preparing to start the big loop
At 1000
CASE NUMBER=           1
Return to main program from M01001
Return to main program from M50062
NALT =           2
NMACH=           2
LOOP =           1
Return to main program from M02002
Return to main program from M51063
MACH=  0.1000000
ALT =  0.0000000E+00
AR limit for CM(ALPHA) exceeded, back-up method used
---WING TRAILING EDGE FLAP CONFIGURATION---
NALPHA    =           2
NFLAPSET  =           1
FLAPSET   =           1
ALPHA     =           1
D(CD MIN) =  1.0000000E-30
D(CL)     =  2.0219384E-02
D(CM)     = -1.9438911E-02
D(CDI)    =  1.0000000E-30
ALPHA     =           2
D(CDI)    =  1.0000000E-30
-------------------------------------------
NALPHA           2
MACH=  0.1500000
ALT =  0.0000000E+00
AR limit for CM(ALPHA) exceeded, back-up method used
---WING TRAILING EDGE FLAP CONFIGURATION---
NALPHA    =           2
NFLAPSET  =           1
FLAPSET   =           1
ALPHA     =           1
D(CD MIN) =  1.0000000E-30
D(CL)     =  2.0162731E-02
D(CM)     = -1.9482434E-02
D(CDI)    =  1.0000000E-30
ALPHA     =           2
D(CDI)    =  1.0000000E-30
-------------------------------------------
NALPHA           2
Return to main program from M57071
```

Figure 8 - PROTOCOL.DAT output format example.

Below are the four parts that require the PROTOCOL.DAT file for verification as well as a description of how to do this.

5) WB – TE Flaps
    a. PROTOCOL.DAT
6) WB – LE Flaps
    a. PROTOCOL.DAT
8) WBHV – Elevator
    - PROTOCOL.DAT
9) WBHV – AMHT+e
    - PROTOCOL.DAT

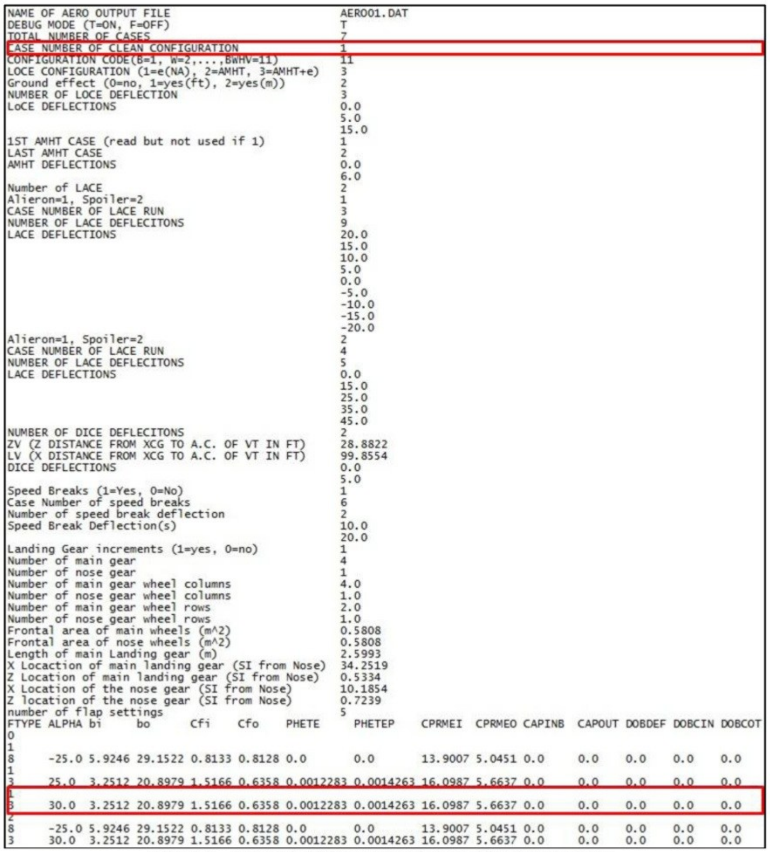
WB – TE Flaps

First determine what flap setting, clean case number, MACH number, and altitude in that order to be verified. Let’s take the following example. Keep in mind gathering the information from DATCOM MAX V4 is done with the complete model, clearly shown in Figure 10. The verification models in Digital DATCOM is a WB model because in Digital DATCOM flaps are automatically added to the aft most lifting surface, which if an elevator was present would add the flaps to the elevator.

- Flap Setting = 4, from RUNDATOM.IN

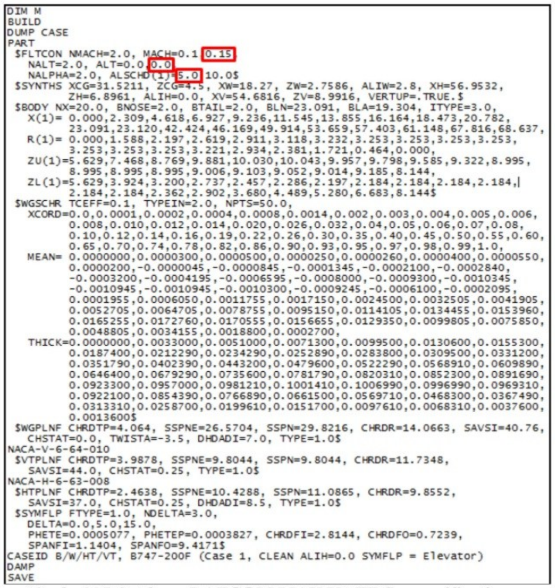
- Clean Case Number = 1, from RUNDATCOM.IN
- MACH = 0.1, from for005.dat
- Altitude = 0.0 m, from for005.dat
- Angle of Attack = 5.0 deg, from for005.dat

Figure 9 and Figure 10 provide the information to find what data is to be verified from the PROTOCOL.DAT file, shown in Figure 11.



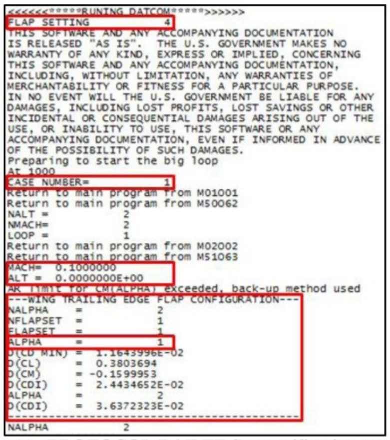
```
NAME OF AERO OUTPUT FILE                        AERO01.DAT
DEBUG MODE (T=ON, F=OFF)                        T
TOTAL NUMBER OF CASES                           7
CASE NUMBER OF CLEAN CONFIGURATION              1
CONFIGURATION CODE(B=1, W=2,...,BWHV=11)        11
LOCE CONFIGURATION (1=e(NA), 2=AMHT, 3=AMHT+e)  3
Ground effect (0=no, 1=yes(ft), 2=yes(m))       2
NUMBER OF LOCE DEFLECTION                       3
LoCE DEFLECTIONS                                0.0
                                                5.0
                                                15.0
1ST AMHT CASE (read but not used if 1)          1
LAST AMHT CASE                                  2
AMHT DEFLECTIONS                                0.0
                                                6.0
Number of LACE                                  2
Alieron=1, Spoiler=2                            1
CASE NUMBER OF LACE RUN                         3
NUMBER OF LACE DEFLECITONS                      9
LACE DEFLECTIONS                                20.0
                                                15.0
                                                10.0
                                                5.0
                                                0.0
                                                -5.0
                                                -10.0
                                                -15.0
                                                -20.0
Alieron=1, Spoiler=2                            2
CASE NUMBER OF LACE RUN                         4
NUMBER OF LACE DEFLECITONS                      5
LACE DEFLECTIONS                                0.0
                                                15.0
                                                25.0
                                                35.0
                                                45.0
NUMBER OF DICE DEFLECITONS                      2
ZV (Z DISTANCE FROM XCG TO A.C. OF VT IN FT)    28.8822
LV (X DISTANCE FROM XCG TO A.C. OF VT IN FT)    99.8554
DICE DEFLECTIONS                                0.0
                                                5.0
Speed Breaks (1=Yes, 0=No)                      1
Case Number of speed breaks                     6
Number of speed break deflection                2
Speed Break Deflection(s)                       10.0
                                                20.0
Landing Gear increments (1=yes, 0=no)           1
Number of main gear                             4
Number of nose gear                             1
Number of main gear wheel columns               4.0
Number of nose gear wheel columns               1.0
Number of main gear wheel rows                  2.0
Number of nose gear wheel rows                  1.0
Frontal area of main wheels (m^2)               0.5808
Frontal area of nose wheels (m^2)               0.5808
Length of main Landing gear (m)                 2.5993
X Locaction of main landing gear (SI from Nose) 34.2519
Z Location of main landing gear (SI from Nose)  0.5334
X Location of the nose gear (SI from Nose)      10.1854
Z location of the nose gear (SI from Nose)      0.7239
number of flap settings                         5
FTYPE ALPHA bi     bo      Cfi    Cfo    PHETE     PHETEP    CPRMEI  CPRMEO CAPINB CAPOUT DOBDEF DOBCIN DOBCOT
0
1
8     -25.0 5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0    0.0    0.0    0.0    0.0
1
3     25.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0    0.0    0.0    0.0    0.0
1
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0    0.0    0.0    0.0    0.0
2
8     -25.0 5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0    0.0    0.0    0.0    0.0
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0    0.0    0.0    0.0    0.0
```

Figure 9 - RUNDATCOM.IN TE flap verification example.



```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=2.0, MACH=0.1 0.15
   NALT=2.0, ALT=0.0 0.0
   NALPHA=2.0, ALSCHD(1)=5.0 10.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
         ZH=6.8961, ALIH=0.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
         23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
         3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
         8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,|
         2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
         0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
         0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
         0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
         0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
         -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
         -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
         0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
         0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
         0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
         0.0048805,0.0034155,0.0018800,0.0002700,
   THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
         0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
         0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
         0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
         0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
         0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
         0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
         0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663, SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6-64-010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
   SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6-63-008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
   SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
 $SYMFLP FTYPE=1.0, NDELTA=3.0,
   DELTA=0.0,5.0,15.0,
   PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
   SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYMFLP = Elevator)
DAMP
SAVE
```

Figure 10 - for005.dat from DATCOM MAX V4 TE flap verification example.

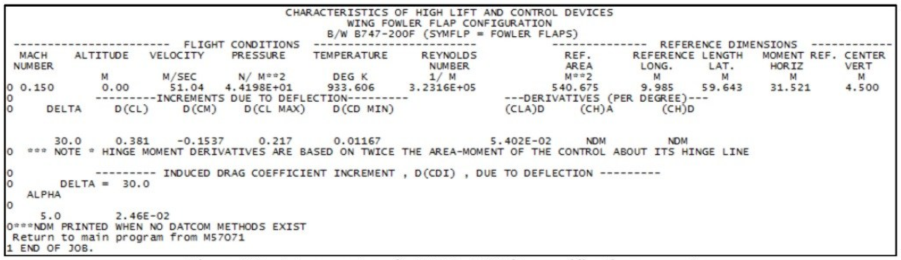


```
<<<<<<*****RUNING DATCOM*****>>>>>>
FLAP SETTING                4
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION
IS RELEASED "AS IS".  THE U.S. GOVERNMENT MAKES NO
WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, CONCERNING
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION,
INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF
MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
IN NO EVENT WILL THE U.S. GOVERNMENT BE LIABLE FOR ANY
DAMAGES, INCLUDING LOST PROFITS, LOST SAVINGS OR OTHER
INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE
USE, OR INABILITY TO USE, THIS SOFTWARE OR ANY
ACCOMPANYING DOCUMENTATION, EVEN IF INFORMED IN ADVANCE
OF THE POSSIBILITY OF SUCH DAMAGES.
Preparing to start the big loop
At 1000
CASE NUMBER=                1
Return to main program from M01001
Return to main program from M50062
NALT =             2
NMACH=             2
LOOP =             1
Return to main program from M02002
Return to main program from M51063
MACH=  0.1000000
ALT =  0.0000000E+00
AR limit for CM(ALPHA) exceeded, back-up method used
---WING TRAILING EDGE FLAP CONFIGURATION---
NALPHA      =            2
NFLAPSET    =            1
FLAPSET     =            1
ALPHA       =            1
D(CD MIN) =  1.1643996E-02
D(CL)       =  0.3803694
D(CM)       = -0.1599953
D(CDI)      =  2.4434652E-02
ALPHA       =            2
D(CDI)      =  3.6372323E-02
-------------------------------------------
NALPHA             2
```

Figure 11 - PROTOCOL.DAT TE flap verification example.

The flap setting, case number, MACH number, and altitude information from for005.dat and RUNDATCOM.IN files allow you to find in the PROTOCOL.DAT file, shown in Figure 11, the desired

TE flap information to be verified. The information is labeled exactly the same as it is in the datcom.out and for006.dat from Digital DATCOM, shown in Figure 12. These labels are D(CL), D(CM), D(CL MAX), D(CD MIN), and D(CDI). Please note only one Digital DATCOM output file is shown for simplicity but they will be exactly the same format. Also, note in Figure 11 the "ALPHA" does not give a degree but rather a "1". This is due to bookkeeping difficulty and instead that "1" is telling the user the information provided is for the first angle of attack declared in the for005.dat, which is outlined in red in Figure 10.



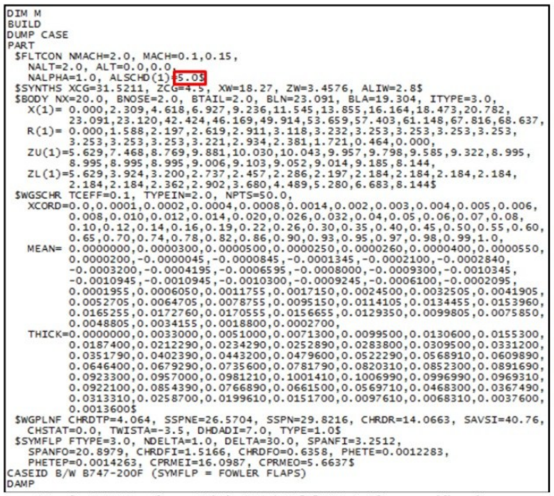
```
                                        CHARACTERISTICS OF HIGH LIFT AND CONTROL DEVICES
                                             WING FOWLER FLAP CONFIGURATION
                                           B/W B747-200F (SYMFLP = FOWLER FLAPS)
 ----------------------- FLIGHT CONDITIONS ------------------------           -------------- REFERENCE DIMENSIONS ------------
  MACH    ALTITUDE   VELOCITY    PRESSURE    TEMPERATURE     REYNOLDS              REF.      REFERENCE LENGTH   MOMENT REF. CENTER
 NUMBER                                                       NUMBER               AREA       LONG.     LAT.      HORIZ       VERT
              M        M/SEC      N/ M**2       DEG K          1/ M                M**2         M        M          M           M
0 0.150      0.00      51.04   4.4198E+01     933.606      3.2316E+05             540.675     9.985    59.643     31.521      4.500
0              ---------INCREMENTS DUE TO DEFLECTION---------                ---DERIVATIVES (PER DEGREE)---
0     DELTA     D(CL)      D(CM)      D(CL MAX)     D(CD MIN)                (CLA)D      (CH)A        (CH)D


       30.0     0.381     -0.1537      0.217        0.01167               5.402E-02      NDM          NDM
0   *** NOTE * HINGE MOMENT DERIVATIVES ARE BASED ON TWICE THE AREA-MOMENT OF THE CONTROL ABOUT ITS HINGE LINE

0              --------- INDUCED DRAG COEFFICIENT INCREMENT , D(CDI) , DUE TO DEFLECTION ---------
0        DELTA =  30.0
   ALPHA
0
     5.0        2.46E-02
0***NDM PRINTED WHEN NO DATCOM METHODS EXIST
 Return to main program from M57071
1 END OF JOB.
```

Figure 12 - datcom.out or for006.dat TE flap verification example.

After inspection all the numbers match up from the PROTOCOL.DAT, Figure 11, and datcom.out or for006.dat, Figure 12, except for the D(CDI). The reason for the is because DATCOM MAX V4 in this example was ran with two angles of attack, shown in Figure 10, while the two Digital DATCOM executables were ran with one angle of attack, shown in Figure 13. This is the reason it is important to run all cases with the same "FLTCON", or flight conditions, because a linear interpolation function is used in Digital DATCOM to calculate the D(CDI) from however many angles of attack are used.

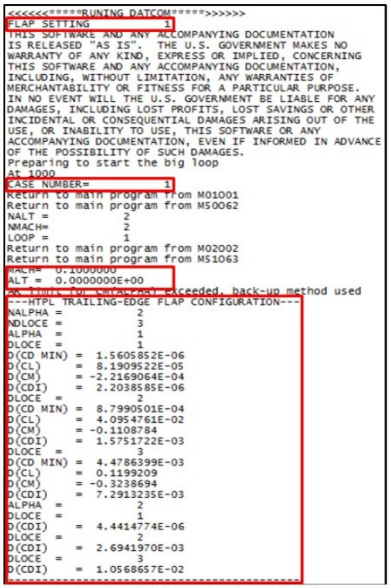


```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=2.0, MACH=0.1,0.15,
   NALT=2.0, ALT=0.0,0.0,
   NALPHA=1.0, ALSCHD(1)=5.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=3.4576, ALIW=2.8$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
         23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
         3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
         8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
         2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
         0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
         0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
         0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
         0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
         -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
         -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
         0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
         0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
         0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
         0.0048805,0.0034155,0.0018800,0.0002700,
   THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
         0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
         0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
         0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
         0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
         0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
         0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
         0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663, SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $SYMFLP FTYPE=3.0, NDELTA=1.0, DELTA=30.0, SPANFI=3.2512,
   SPANFO=20.8979, CHRDFI=1.5166, CHRDFO=0.6358, PHETE=0.0012283,
   PHETEP=0.0014263, CPRMEI=16.0987, CPRMEO=5.6637$
CASEID B/W B747-200F (SYMFLP = FOWLER FLAPS)
DAMP
```

Figure 13 - for005.dat from Digital DATCOM TE flap verification example.

WB – LE Flaps
WBHV – Elevator
WBHV – AMHT+e

This process for these configurations is exactly the same from above. The only differences are the models build, self-explanatory, and what sections to look through in the PROTOCOL.DAT. The sections one must look in are declared by the case number associated with the elevator deflections and/or the AMHT+e in the for005.dat file. When looking through the PROTOCOL.DAT file at the LOCE cases the output will look similar to the one shown in Figure 11 except with a few differences. These differences can be seen in Figure 14. The WB with LE flaps is exactly like the example shown above.



```
<<<<<<*****RUNING DATCOM*****>>>>>>
FLAP SETTING                  1
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION
IS RELEASED "AS IS".  THE U.S. GOVERNMENT MAKES NO
WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, CONCERNING
THIS SOFTWARE AND ANY ACCOMPANYING DOCUMENTATION,
INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF
MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
IN NO EVENT WILL THE U.S. GOVERNMENT BE LIABLE FOR ANY
DAMAGES, INCLUDING LOST PROFITS, LOST SAVINGS OR OTHER
INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE
USE, OR INABILITY TO USE, THIS SOFTWARE OR ANY
ACCOMPANYING DOCUMENTATION, EVEN IF INFORMED IN ADVANCE
OF THE POSSIBILITY OF SUCH DAMAGES.
Preparing to start the big loop
At 1000
CASE NUMBER=                  1
Return to main program from M01001
Return to main program from M50062
NALT =                 2
NMACH=                 2
LOOP =                 1
Return to main program from M02002
Return to main program from M51063
MACH=   0.1000000
ALT =   0.0000000E+00
AR limit for CM(ALPHA) exceeded, back-up method used
---HTPL TRAILING-EDGE FLAP CONFIGURATION---
NALPHA =                 2
NDLOCE =                 3
ALPHA  =                 1
DLOCE  =                 1
D(CD MIN) =  1.5605852E-06
D(CL)     =  8.1909522E-05
D(CM)     = -2.2169064E-04
D(CDI)    =  2.2038585E-06
DLOCE  =                 2
D(CD MIN) =  8.7990501E-04
D(CL)     =  4.0954761E-02
D(CM)     = -0.1108784
D(CDI)    =  1.5751722E-03
DLOCE  =                 3
D(CD MIN) =  4.4786399E-03
D(CL)     =  0.1199209
D(CM)     = -0.3238694
D(CDI)    =  7.2913235E-03
ALPHA  =                 2
DLOCE  =                 1
D(CDI)    =  4.4414774E-06
DLOCE  =                 2
D(CDI)    =  2.6941970E-03
DLOCE  =                 3
D(CDI)    =  1.0568657E-02
-------------------------------------------
```

Figure 14 - PROTOCOL.DAT for LOCE's example.

Some attributes shown here that are not shown in Figure 11 are the multiple elevator deflection angles. These are noted by the number of LOCE deflections, NDLOCE, and as with the angle of attack the delta LOCE, DLOCE, does not show the angle but rather which deflection it is. For example 1 is the first deflection angle input in the for005.dat the 2 is the second angle and so on. As before the data is labeled the same as the information in the datcom.out and for006.dat files. Remember the AMHT is varied by declaring multiple cases and changing the incidence angle of the HT so to check this multiple Digital DATCOM models will need to be made for each HT incidence angle with all the elevator deflections.

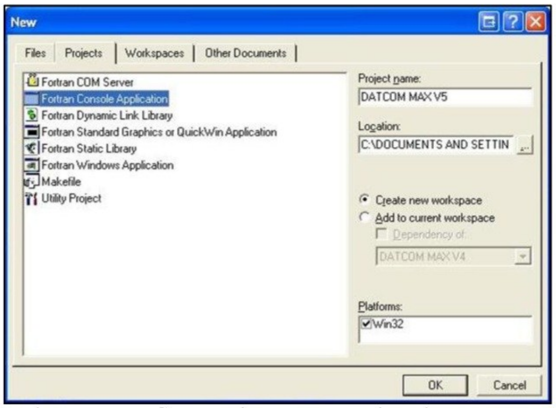
5.2 VALIDATION

Validation is the comparison of DATCOM MAX output against experimental aerodynamic data. Cross checking all available output from DATCOM MAX is ideal but not always possible. When not possible it is up to the user's experience to judge the "correctness" of the results. This process is entire dependent upon the type and amount of data available.

6 HOW TO BUILD A NEW VERSION OF DATCOM MAX

This tutorial is for Compaq Visual Fortran Professional Edition 6.6.a and is used on a Windows XP Professional Version 2002 Service Pack 3.

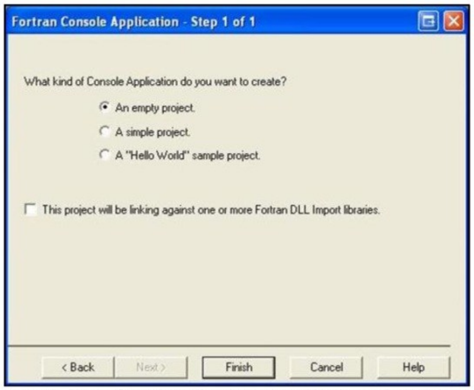
First things first and that is to open Compaq Visual Fortran and open a new project. Do this by clicking File → New then on the opened dialog box, shown in Figure 15, go to "Projects", type in the desired project name, while making sure the project is set to "Fortran Console Application".



Project name: DATCOM MAX V5
Location: C:\DOCUMENTS AND SETTIN
● Create new workspace
○ Add to current workspace
☐ Dependency of: DATCOM MAX V4
Platforms: ☑ Win32

Figure 15 - New Compaq Visual Fortran project window part 1.

After making sure the settings are the same as in Figure 15 click "OK" and a couple new windows will pop up after each other. Nothing should be changed and make sure the settings are the same as in Figure 16 and click "OK" then Figure 17 and click "OK" again.



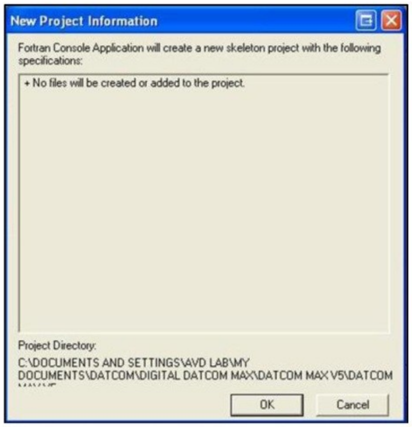
Fortran Console Application - Step 1 of 1

What kind of Console Application do you want to create?

- ● An empty project.
- ○ A simple project.
- ○ A "Hello World" sample project.

☐ This project will be linking against one or more Fortran DLL Import libraries.

Figure 16 - New Compaq Visual Fortran Project window part 2.



New Project Information

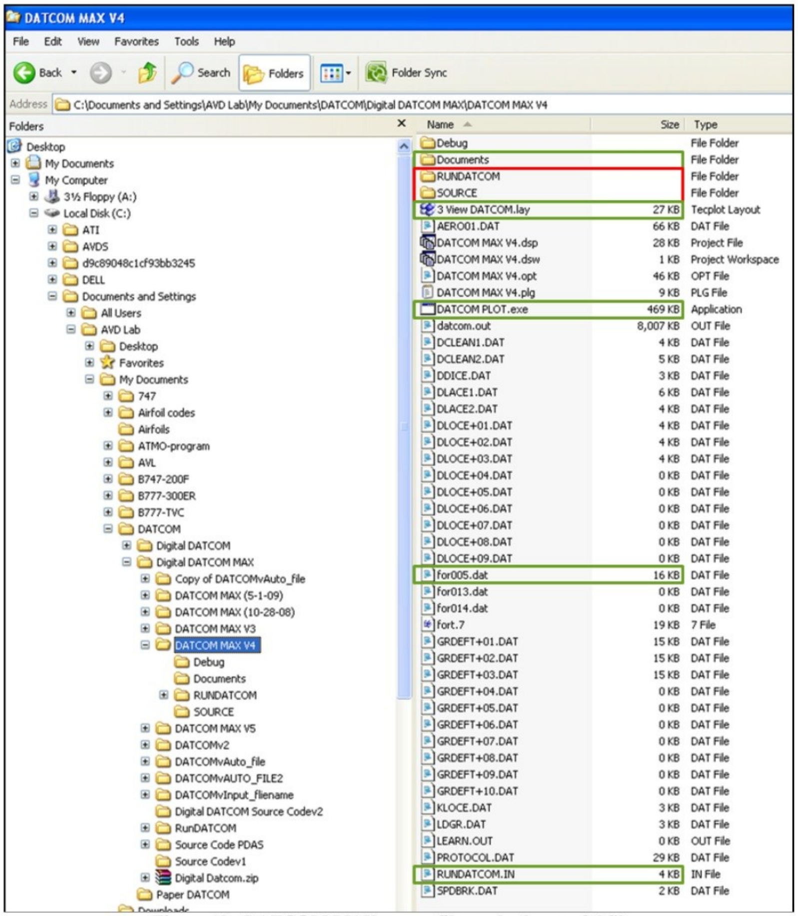
Fortran Console Application will create a new skeleton project with the following specifications:

+ No files will be created or added to the project.

Project Directory:
C:\DOCUMENTS AND SETTINGS\AVD LAB\MY DOCUMENTS\DATCOM\DIGITAL DATCOM MAX\DATCOM MAX V5\DATCOM

Figure 17 - New Compaq Visual Fortran Project window part 3.

Now an empty project is created with only two files in the folder location specified. These files are the name of the project with ".dsp" and ".dsw". Click on the ".dsw" to open the project if not already open. Now the source files need to be added to the empty project. To do this two steps are needed. First copy the source files from the previous version to the location of the new version. These folders are RUNDATCOM and SOURCE shown in Figure 18 outlined in red. Outlined in green are other useful files that should also be copied as well.



C:\Documents and Settings\AVD Lab\My Documents\DATCOM\Digital DATCOM MAX\DATCOM MAX V4

Name	Size	Type
Debug		File Folder
Documents		File Folder
RUNDATCOM		File Folder
SOURCE		File Folder
3 View DATCOM.lay	27 KB	Tecplot Layout
AERO01.DAT	66 KB	DAT File
DATCOM MAX V4.dsp	28 KB	Project File
DATCOM MAX V4.dsw	1 KB	Project Workspace
DATCOM MAX V4.opt	46 KB	OPT File
DATCOM MAX V4.plg	9 KB	PLG File
DATCOM PLOT.exe	469 KB	Application
datcom.out	8,007 KB	OUT File
DCLEAN1.DAT	4 KB	DAT File
DCLEAN2.DAT	5 KB	DAT File
DDICE.DAT	3 KB	DAT File
DLACE1.DAT	6 KB	DAT File
DLACE2.DAT	4 KB	DAT File
DLOCE+01.DAT	4 KB	DAT File
DLOCE+02.DAT	4 KB	DAT File
DLOCE+03.DAT	4 KB	DAT File
DLOCE+04.DAT	0 KB	DAT File
DLOCE+05.DAT	0 KB	DAT File
DLOCE+06.DAT	0 KB	DAT File
DLOCE+07.DAT	0 KB	DAT File
DLOCE+08.DAT	0 KB	DAT File
DLOCE+09.DAT	0 KB	DAT File
for005.dat	16 KB	DAT File
for013.dat	0 KB	DAT File
for014.dat	0 KB	DAT File
fort.7	19 KB	7 File
GRDEFT+01.DAT	15 KB	DAT File
GRDEFT+02.DAT	15 KB	DAT File
GRDEFT+03.DAT	15 KB	DAT File
GRDEFT+04.DAT	0 KB	DAT File
GRDEFT+05.DAT	0 KB	DAT File
GRDEFT+06.DAT	0 KB	DAT File
GRDEFT+07.DAT	0 KB	DAT File
GRDEFT+08.DAT	0 KB	DAT File
GRDEFT+09.DAT	0 KB	DAT File
GRDEFT+10.DAT	0 KB	DAT File
KLOCE.DAT	3 KB	DAT File
LDGR.DAT	3 KB	DAT File
LEARN.OUT	0 KB	OUT File
PROTOCOL.DAT	29 KB	DAT File
RUNDATCOM.IN	4 KB	IN File
SPDBRK.DAT	2 KB	DAT File

Figure 18 - DATCOM MAX source files and other useful files.

The second step after the files have been copied over to the project file is to link these file with the project. To do this open up the project and delete the current files under the project usually labeled as "Source Files", "Header Files", and "Resource Files". After that right click on the project and select "New Folder" shown in Figure 19.

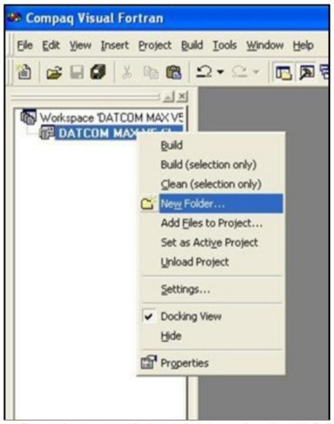
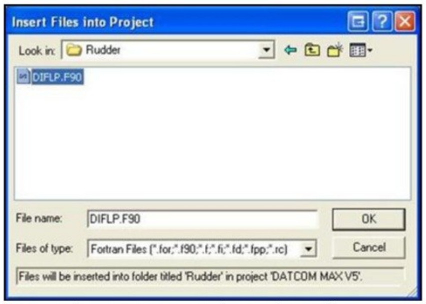


Figure 19 - Creating new linked folders for DATCOM MAX.

Created three folders named “SOURCE”, “RUNDATCOM”, and under the “RUNDATCOM” folder “Rudder”. These are shown in Figure 20.

Figure 20 - Linking files to DATCOM MAX project.

These are the same name as the folder copied over to the project file. Now these files must be linked to each other. To do this right click on each folder in the Compaq Visual Fortran project and click “Add Files to Folder…”, shown in Figure 20. The file to be added for Rudder is shown in Figure 21.



Look in: Rudder

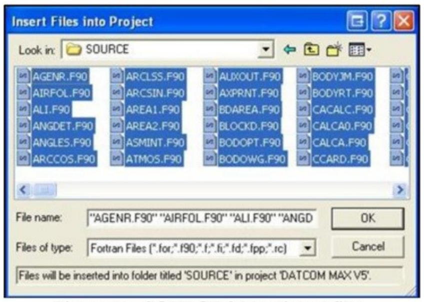
File name: DIFLP.F90

Files of type: Fortran Files (*.for;*.f90;*.f;*.fi;*.fd;*.fpp;*.rc)

Files will be inserted into folder titled 'Rudder' in project 'DATCOM MAX V5'.

Figure 21 - Rudder folder linked files.

Do this for the “SOURCE” and “RUNDATCOM” and select all files contained in those folders when linking, shown in Figure 22 and Figure 23.



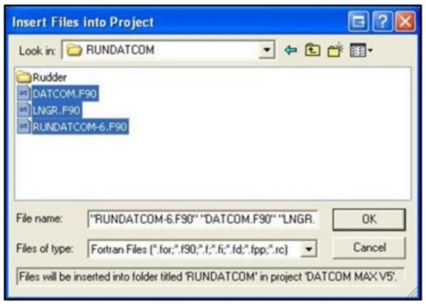
Look in: SOURCE

File name: "AGENR.F90" "AIRFOL.F90" "ALI.F90" "ANGD

Files of type: Fortran Files (*.for;*.f90;*.f;*.fi;*.fd;*.fpp;*.rc)

Files will be inserted into folder titled 'SOURCE' in project 'DATCOM MAX V5'.

Figure 22 - SOURCE folder linked files.



Look in: RUNDATCOM

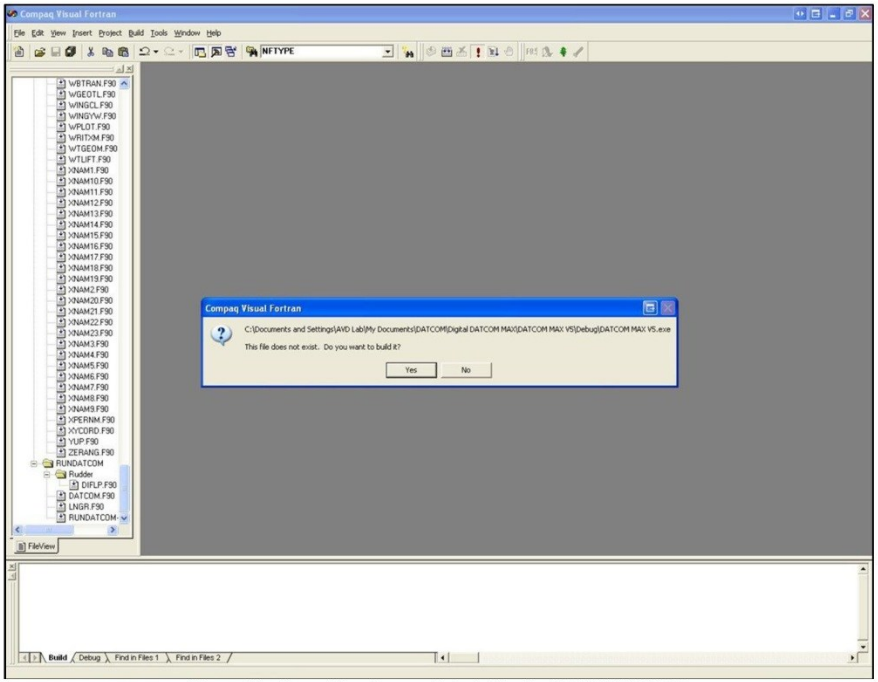
File name: "RUNDATCOM-6.F90" "DATCOM.F90" "LNGR.

Files of type: Fortran Files (*.for;*.f90;*.f;*.fi;*.fd;*.fpp;*.rc)

Files will be inserted into folder titled 'RUNDATCOM' in project 'DATCOM MAX V5'.

Figure 23 - RUNDATCOM folder link files .

Now the setup is finished and the new version of DATCOM MAX is ready to be compiled. To compile and run the program click on the red exclamation point in the top toolbar. A notification window will appear as seen in Figure 24 and click ok.



C:\Documents and Settings\AVD Lab\My Documents\DATCOM\Digital DATCOM MAX\DATCOM MAX V5\Debug\DATCOM MAX V5.exe

This file does not exist. Do you want to build it?

Figure 24 - Compiling the new linked files for DATCOM MAX.

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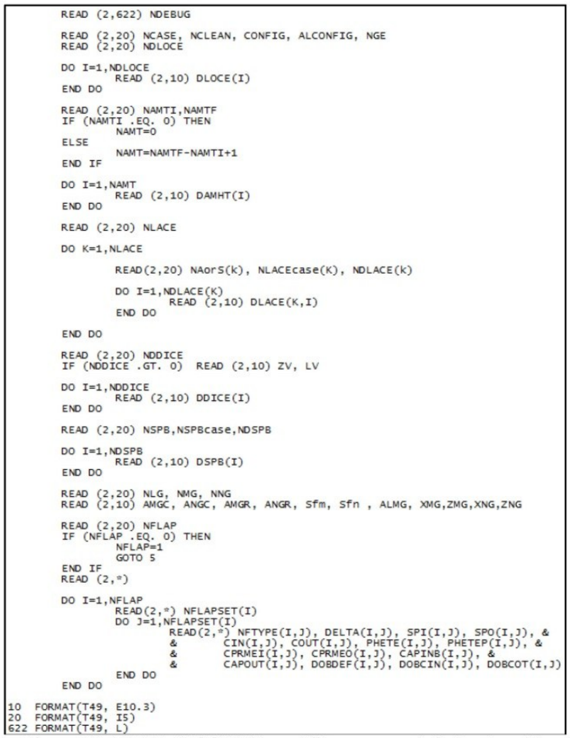
APPENDICES



```
        READ (2,622) NDEBUG

        READ (2,20) NCASE, NCLEAN, CONFIG, ALCONFIG, NGE
        READ (2,20) NDLOCE

        DO I=1,NDLOCE
                READ (2,10) DLOCE(I)
        END DO

        READ (2,20) NAMTI,NAMTF
        IF (NAMTI .EQ. 0) THEN
                NAMT=0
        ELSE
                NAMT=NAMTF-NAMTI+1
        END IF

        DO I=1,NAMT
                READ (2,10) DAMHT(I)
        END DO

        READ (2,20) NLACE

        DO K=1,NLACE

                READ(2,20) NAorS(k), NLACEcase(K), NDLACE(k)

                DO I=1,NDLACE(K)
                        READ (2,10) DLACE(K,I)
                END DO

        END DO

        READ (2,20) NDDICE
        IF (NDDICE .GT. 0)  READ (2,10) ZV, LV

        DO I=1,NDDICE
                READ (2,10) DDICE(I)
        END DO

        READ (2,20) NSPB,NSPBcase,NDSPB

        DO I=1,NDSPB
                READ (2,10) DSPB(I)
        END DO

        READ (2,20) NLG, NMG, NNG
        READ (2,10) AMGC, ANGC, AMGR, ANGR, Sfm, Sfn , ALMG, XMG,ZMG,XNG,ZNG

        READ (2,20) NFLAP
        IF (NFLAP .EQ. 0) THEN
                NFLAP=1
                GOTO 5
        END IF
        READ (2,*)

        DO I=1,NFLAP
                READ(2,*) NFLAPSET(I)
                DO J=1,NFLAPSET(I)
                        READ(2,*) NFTYPE(I,J), DELTA(I,J), SPI(I,J), SPO(I,J), &
                        &       CIN(I,J), COUT(I,J), PHETE(I,J), PHETEP(I,J), &
                        &       CPRMEI(I,J), CPRMEO(I,J), CAPINB(I,J), &
                        &       CAPOUT(I,J), DOBDEF(I,J), DOBCIN(I,J), DOBCOT(I,J)
                END DO
        END DO

10  FORMAT(T49, E10.3)
20  FORMAT(T49, I5)
622 FORMAT(T49, L)
```

Figure 25 - RUNDATCOM.IN read file source code in Fortran 90.

Table 2 - B747-200F model references.

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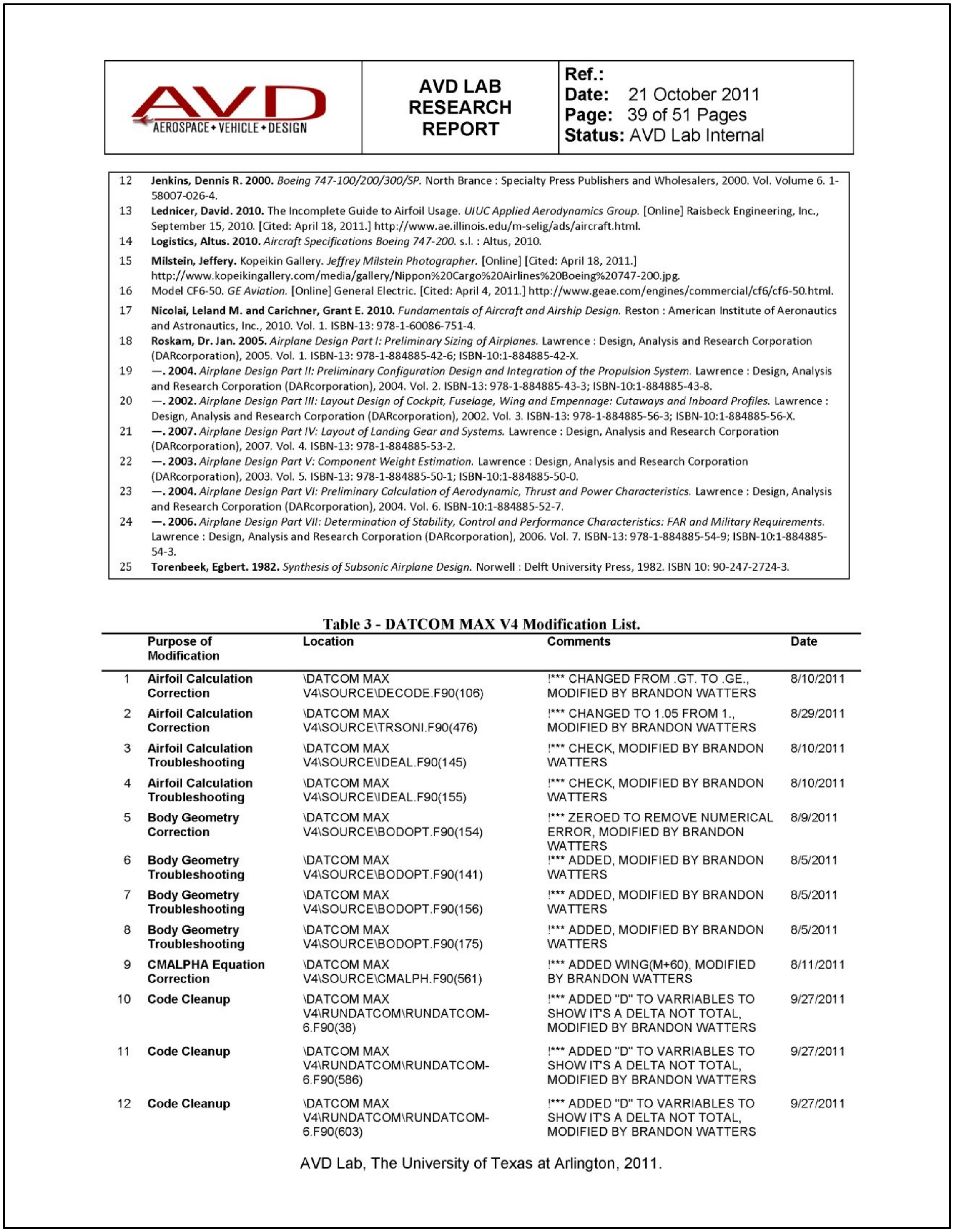

AEROSPACE ✦ VEHICLE ✦ DESIGN

AVD LAB RESEARCH REPORT

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Date: 21 October 2011
Page: 39 of 51 Pages
Status: AVD Lab Internal

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Table 3 - DATCOM MAX V4 Modification List.

	Purpose of Modification	Location	Comments	Date
1	**Airfoil Calculation Correction**	\DATCOM MAX V4\SOURCE\DECODE.F90(106)	!*** CHANGED FROM .GT. TO .GE., MODIFIED BY BRANDON WATTERS	8/10/2011
2	**Airfoil Calculation Correction**	\DATCOM MAX V4\SOURCE\TRSONI.F90(476)	!*** CHANGED TO 1.05 FROM 1., MODIFIED BY BRANDON WATTERS	8/29/2011
3	**Airfoil Calculation Troubleshooting**	\DATCOM MAX V4\SOURCE\IDEAL.F90(145)	!*** CHECK, MODIFIED BY BRANDON WATTERS	8/10/2011
4	**Airfoil Calculation Troubleshooting**	\DATCOM MAX V4\SOURCE\IDEAL.F90(155)	!*** CHECK, MODIFIED BY BRANDON WATTERS	8/10/2011
5	**Body Geometry Correction**	\DATCOM MAX V4\SOURCE\BODOPT.F90(154)	!*** ZEROED TO REMOVE NUMERICAL ERROR, MODIFIED BY BRANDON WATTERS	8/9/2011
6	**Body Geometry Troubleshooting**	\DATCOM MAX V4\SOURCE\BODOPT.F90(141)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/5/2011
7	**Body Geometry Troubleshooting**	\DATCOM MAX V4\SOURCE\BODOPT.F90(156)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/5/2011
8	**Body Geometry Troubleshooting**	\DATCOM MAX V4\SOURCE\BODOPT.F90(175)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/5/2011
9	**CMALPHA Equation Correction**	\DATCOM MAX V4\SOURCE\CMALPH.F90(561)	!*** ADDED WING(M+60), MODIFIED BY BRANDON WATTERS	8/11/2011
10	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(38)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
11	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(586)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
12	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(603)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011

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13	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(647)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
14	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(662)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
15	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(875)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
16	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(884)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
17	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(910)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
18	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(922)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
19	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(953)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
20	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1017)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
21	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1053)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
22	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1083)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
23	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1117)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
24	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1151)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
25	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1187)	!*** ADDED "D" TO VARRIABLES TO SHOW IT'S A DELTA NOT TOTAL, MODIFIED BY BRANDON WATTERS	9/27/2011
26	**Code Cleanup**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(269)	!*** ADDED, MODIFIED BY GARY COLEMAN, ASSUMED BY BRANDON WATTERS	8/15/2011
27	**Code Cleanup**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(389)	!*** ADDED, MODIFIED BY GARY COLEMAN, ASSUMED BY BRANDON WATTERS	8/15/2011
28	**Code Cleanup**	\DATCOM MAX V4\SOURCE\M11O13.F90(60)	!*** ADDED, MODIFIED BY GARY COLEMAN, ASSUMED BY BRANDON WATTERS	8/15/2011
29	**Code Cleanup**	\DATCOM MAX V4\SOURCE\LATFLP.F90(530)	!*** MODIFIED BY GARY COLMAN AND AMIT OZA? BRANDON WATTER'S ASSUMPTION	N/A
30	**Code Cleanup**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(231)	!*** REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
31	**Code Cleanup**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(409)	!*** REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
32	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(54)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011

33	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\LNGR.F90(26)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
34	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(50)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
35	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\Rudder\DIFLP.F90(21)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
36	**Code Cleanup**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(24)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
37	**Code Cleanup**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(31)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
38	**Code Cleanup**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(24)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
39	**Code Cleanup**	\DATCOM MAX V4\SOURCE\M11O13.F90(18)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
40	**Code Cleanup**	\DATCOM MAX V4\SOURCE\MAIN02.F90(15)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
41	**Code Cleanup**	\DATCOM MAX V4\SOURCE\MAIN05.F90(24)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
42	**Code Cleanup**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(43)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
43	**Code Cleanup**	\DATCOM MAX V4\SOURCE\MAIN01.F90(68)	!*** VARIABLES REMOVED BECAUSE NOT USED AND MEMORY HOG, MODIFIED BY BRANDON WATTERS	9/28/2011
44	**Code Cleanup**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(122)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
45	**Code Information Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(133)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/24/2011
46	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1257)	!*** ADDED 622, MODIFIED BY BRANDON WATTERS	8/26/2011
47	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(198)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
48	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(245)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
49	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(259)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
50	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(265)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
51	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(274)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
52	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(289)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011

53	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(301)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
54	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(318)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
55	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(334)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
56	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(351)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
57	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(404)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
58	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(458)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
59	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(465)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
60	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(476)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
61	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(214)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
62	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(248)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
63	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(259)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
64	**Debug Mode**	\DATCOM MAX V4\SOURCE\CMALPH.F90(342)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
65	**Debug Mode**	\DATCOM MAX V4\SOURCE\CMALPH.F90(584)	!*** ADDED DEBUG MODE, MODIFIED BY BRANDON WATTERS	8/26/2011
66	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(42)	!*** ADDED NCLEAN, NDEBUG, & TIME'S, MODIFIED BY BRANDON WATTERS	8/4/2011
67	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(41)	!*** ADDED NDEBUG, MODIFIED BY BRANDON WATTERS	8/26/2011
68	**Debug Mode**	\DATCOM MAX V4\SOURCE\CMALPH.F90(5)	!*** ADDED NDEBUG, MODIFIED BY BRANDON WATTERS	8/26/2011
69	**Debug Mode**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(51)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/26/2011
70	**Debug Mode**	\DATCOM MAX V4\SOURCE\CMALPH.F90(11)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/26/2011
71	**Debug Mode**	\DATCOM MAX V4\SOURCE\MAIN01.F90(65)	!*** ADDED, MODIFIED BY BRANDON WATTERS	9/27/2011
72	**Debug Mode**	\DATCOM MAX V4\SOURCE\MAIN05.F90(21)	!*** ADDED, MODIFIED BY BRANDON WATTERS	9/27/2011
73	**Derivatives Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(630)	!*** ADDED WRITE, MODIFIED BY BRANDON WATTERS	9/1/2011

74	**DICE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(744)	!*** ADDED WRITE'S AND EXPANDED IF STATEMENT, MODIFIED BY BRANDON WATTERS	8/16/2011
75	**Double Slotted Flaps**	\DATCOM MAX V4\SOURCE\MAIN05.F90(95)	!*** ADDED DOUBLE SLOTTED FLAPS VARIABLES, MODIFIED BY BRANDON WATTERS	7/7/2011
76	**Double Slotted Flaps**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(240)	!*** DOUBLE SLOTTED FALPS, MODIFIED BY BRANDON WATTERS	7/7/2011
77	**Double Slotted Flaps**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(85)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
78	**Double Slotted Flaps Execution**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(518)	!*** CHANGED K COUNTER, MODIFIED BY BRANDON WATTERS	7/7/2011
79	**Double Slotted Flaps Troubleshooting**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(672)	!*** ADDED, MODIFIED BY BRANDON WATTERS	7/7/2011
80	**Double Slotted Flaps Troubleshooting**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(679)	!*** ADDED, MODIFIED BY BRANDON WATTERS	7/7/2011
81	**Double Slotted Flaps Troubleshooting**	\DATCOM MAX V4\SOURCE\WBAERO.F90(58)	!*** ADDED, MODIFIED BY BRANDON WATTERS	7/19/2011
82	**Double Slotted Flaps Troubleshooting**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(723)	!*** ADDED, MODIFIED BY BRANDON WATTERS	7/28/2011
83	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(381)	!*** ADDED IF STATEMENT, MODIFIED BY BRANDON WATTERS	9/1/2011
84	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(55)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
85	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(66)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
86	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\LNGR.F90(27)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
87	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\LNGR.F90(38)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
88	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(51)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
89	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(62)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
90	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\Rudder\DIFLP.F90(22)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
91	**General Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\Rudder\DIFLP.F90(33)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
92	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
93	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
94	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(32)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
95	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(43)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
96	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
97	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011

98	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(19)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
99	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(30)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
100	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(69)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
101	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(80)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
102	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(16)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
103	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(27)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
104	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
105	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
106	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(44)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
107	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(55)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/4/2011
108	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(61)	!*** ADDED NCLEAN, MODIFIED BY BRANDON WATTERS	8/4/2011
109	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(15)	!*** ADDED, MODIFIED BY BRANDON WATTERS	7/27/2011
110	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(40)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/23/2011
111	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(77)	!*** REPLACED IF STATEMENT, MODIFIED BY BRANDON WATTERS	8/3/2011
112	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(137)	!*** REPLACED IF STATEMENT, MODIFIED BY BRANDON WATTERS	8/23/2011
113	**General Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(342)	!*** REPLACED IF STATEMENT, MODIFIED BY BRANDON WATTERS	8/23/2011
114	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(37)	!*** ADDED DIMENSIONS, MODIFIED BY BRANDON WATTERS	9/29/2011
115	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(602)	!*** ADDED DIMENSIONS, MODIFIED BY BRANDON WATTERS	9/29/2011
116	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(634)	!*** ADDED DIMENSIONS, MODIFIED BY BRANDON WATTERS	9/29/2011
117	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(857)	!*** ADDED DIMENSIONS, MODIFIED BY BRANDON WATTERS	9/29/2011
118	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(165)	!*** ADDED DUE TO FLAP BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/29/2011
119	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(91)	!*** ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
120	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(44)	!*** ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
121	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(41)	!*** ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
122	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(78)	!*** BOOKKEEPING OF CORRECT FLAP DEFLECTIONS, MODIFIED BY	9/29/2011

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123	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(80)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
124	**Ground Effect Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(581)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
125	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(1)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
126	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(9)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
127	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(55)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
128	**Ground Effect Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(63)	!*** VARRIABLES ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
129	**Ground Effect Execution**	\DATCOM MAX V4\SOURCE\MAIN02.F90(52)	!*** 1040 AND 1030 ADDED FOR GRDEFF BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
130	**Ground Effect Execution**	\DATCOM MAX V4\SOURCE\MAIN02.F90(55)	!*** CHANGED DUE TO BOOKKEEPING, MODIFIED BY BRANDON WATTERS	9/28/2011
131	**Ground Effect Execution**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(353)	!*** MODIFIED DUE TO BOOKKEEPING OF D(CL)FLAPS STORAGE CHANGED, MODIFIED BY BRANDON WATTERS	9/26/2011
132	**Ground Effect Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1214)	!*** ADDED CLOSE COMMAND FOR ADDED FILES, MODIFIED BY BRANDON WATTERS	10/10/2011
133	**Ground Effect Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(112)	!*** CHANGED GRDEFT & DLOCE FILE NAMES AND ADDED SOME, MODIFIED BY BRANDON WATTERS	10/10/2011
134	**Ground Effect Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(640)	!*** CORRECTED LOOP ORDER, MODIFIED BY BRANDON WATTERS	8/23/2011
135	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(380)	!*** ADDED TO CHECK ALPHWG(J), MODIFIED BY BRANDON WATTERS	8/18/2011
136	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(430)	!*** ADDED TO CHECK CLWB, MODIFIED BY BRANDON WATTERS	8/18/2011
137	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(365)	!*** ADDED TO CHECK DALPHA(J), MODIFIED BY BRANDON WATTERS	8/18/2011
138	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(449)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/18/2011
139	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(464)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/18/2011
140	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(489)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/18/2011
141	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(504)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/18/2011
142	**Ground Effect Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(509)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/18/2011
143	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(370)	!*** ADDED BODYOUT, MODIFIED BY BRANDON WATTERS	9/1/2011
144	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(55)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011

145	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(66)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
146	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\LNGR.F90(27)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
147	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\LNGR.F90(38)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
148	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(51)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
149	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(62)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
150	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\Rudder\DIFLP.F90(22)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
151	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\Rudder\DIFLP.F90(33)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
152	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
153	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
154	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(32)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
155	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(43)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
156	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
157	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
158	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(19)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
159	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\M11O13.F90(30)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
160	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(69)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
161	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(80)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
162	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(16)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
163	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(27)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
164	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(25)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
165	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(36)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
166	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(44)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
167	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\OUTPT2.F90(55)	!*** ADDED NCLEAN & NDLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
168	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(100)	!*** ADDED PLACEHOLDERS, MODIFIED BY BRANDON WATTERS	8/23/2011
169	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\DRAGFP.F90(30)	!*** ADDED, MODIED BY BRANDON WATTERS	8/31/2011
170	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\DRAGFP.F90(36)	!*** ADDED, MODIED BY BRANDON WATTERS	8/31/2011

171	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(10)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/23/2011
172	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(7)	!*** ADDED, MODIFIED BY BRANDON WATTERS	9/1/2011
173	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(223)	!*** IF STATEMENT CHANGED, MODIFIED BY BRANDON WATTERS	8/4/2011
174	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(80)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
175	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(85)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
176	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
177	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(57)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
178	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
179	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(94)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
180	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(53)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/23/2011
181	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(80)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
182	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(85)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
183	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
184	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(57)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
185	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
186	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(94)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
187	**LOCE Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(53)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	9/1/2011
188	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(388)	!*** REPLACED DCDLOCE DCLLOCE DCMLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
189	**LOCE Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(417)	!*** REPLACED DCDLOCE DCLLOCE DCMLOCE, MODIFIED BY BRANDON WATTERS	8/23/2011
190	**LOCE Execution**	\DATCOM MAX V4\SOURCE\MAIN05.F90(18)	!*** ADDED AND DO NOT USE I, MODIFIED BY BRANDON WATTERS	9/1/2011
191	**LOCE Execution**	\DATCOM MAX V4\SOURCE\DRAGFP.F90(105)	!*** ADDED HTPL IF STATEMENT, MODIFIED BY BRANDON WATTERS	8/31/2011
192	**LOCE Execution**	\DATCOM MAX V4\SOURCE\MAIN05.F90(160)	!*** GRAB HTPL WITH ELEVATOR DEFLECTIONS OUTPUT, MODIFIED BY BRANDON WATTERS	8/23/2011
193	**LOCE Execution**	\DATCOM MAX V4\SOURCE\MAIN05.F90(160)	!*** GRAB HTPL WITH ELEVATOR DEFLECTIONS OUTPUT, MODIFIED BY BRANDON WATTERS	9/1/2011

194	**LOCE Execution**	\DATCOM MAX V4\SOURCE\MAIN05.F90(160)	!*** GRAB HTPL WITH ELEVATOR DEFLECTIONS OUTPUT, MODIFIED BY BRANDON WATTERS	9/27/2011
195	**LOCE Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(718)	!*** ADDED MACH LOCATION, MODIFIED BY BRANDON WATTERS	9/1/2011
196	**LOCE Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(684)	!*** ADDED MACH LOOP, MODIFIED BY BRANDON WATTERS	8/27/2011
197	**LOCE Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(704)	!*** ADDED WRITE, MODIFIED BY BRANDON WATTERS	9/1/2011
198	**LOCE Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(679)	!*** CORRECTED LOOP, MODIFIED BY BRANDON WATTERS	9/1/2011
199	**Method Modification Removed**	\DATCOM MAX V4\SOURCE\DRAGFP.F90(202)	!*** -CD(J) UNCOMMENTED, MODIFIED BY BRANDON WATTERS	8/4/2011
200	**Method Modification Removed**	\DATCOM MAX V4\SOURCE\CMALPH.F90(364)	!*** QUICK FIX TAKEN OUT, MODIFIED BY BRANDON WATTERS	7/7/2011
201	**Program Run Time**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(42)	!*** ADDED NCLEAN, NDEBUG, & TIME'S, MODIFIED BY BRANDON WATTERS	8/26/2011
202	**Program Run Time**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(94)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/26/2011
203	**Program Run Time**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1204)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/26/2011
204	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(212)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
205	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(249)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
206	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(262)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
207	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(268)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
208	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(277)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
209	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(292)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
210	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(306)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
211	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(321)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
212	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(337)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011

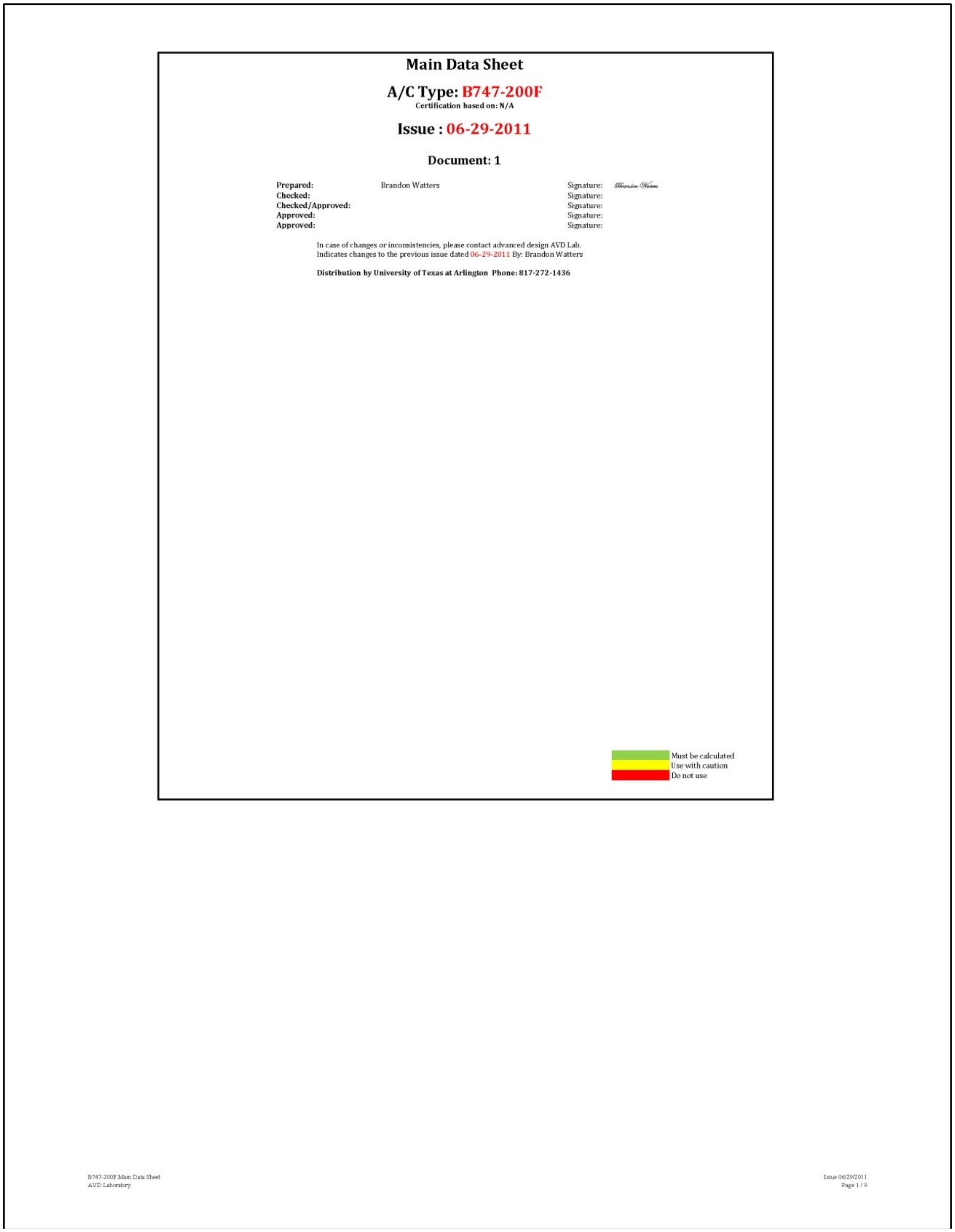
213	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(355)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
214	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(407)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
215	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(461)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
216	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(468)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
217	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(479)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
218	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(97)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
219	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(139)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
220	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(217)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
221	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(251)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
222	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(263)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
223	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1211)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
224	**Protocol Output**	\DATCOM MAX V4\SOURCE\CMALPH.F90(345)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
225	**Protocol Output**	\DATCOM MAX V4\SOURCE\CMALPH.F90(587)	!*** ADDED TO SAVE COMMAND PROMPT OUTPUT, MODIFIED BY BRANDON WATTERS	8/24/2011
226	**Protocol Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(76)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/26/2011
227	**Speed Brake Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(767)	!*** MOMENT ADDED AND LIFT AND DRAG LOCATIONS SWITCHED, MODIFIED BY BRANDON WATTERS	8/16/2011
228	**Speed Brake Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1152)	!*** MOMENT ADDED AND LIFT AND DRAG LOCATIONS SWITCHED, MODIFIED BY BRANDON WATTERS	8/16/2011
229	**Speed Brake Output**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(1161)	!*** MOMENT ADDED AND LIFT AND DRAG LOCATIONS SWITCHED, MODIFIED BY BRANDON WATTERS	8/16/2011
230	**Spoiler Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(546)	!*** COMMENTED OUT TO CORRECT SPOILER DATA, MODIFIED BY BRANDON WATTERS	8/15/2011
231	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(100)	!*** ADDED PLACEHOLDERS, MODIFIED BY BRANDON WATTERS	8/4/2011

232	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN02.F90(9)	!*** ADDED, MODIFIED BY BRANDON WATTERS	9/28/2011
233	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(295)	!*** DWCD ADDED, MODIFIED BY BRANDON WATTERS	8/31/2011
234	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(320)	!*** DWCD MODIFIED, MODIFIED BY BRANDON WATTERS	8/31/2011
235	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(393)	!*** DWCD NCLEAN CHANGED TO IFS, MODIFIED BY BRANDON WATTERS	8/31/2011
236	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(422)	!*** DWCD NCLEAN CHANGED TO IFS, MODIFIED BY BRANDON WATTERS	8/31/2011
237	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(422)	!*** DWCD NCLEAN CHANGED TO IFS, MODIFIED BY BRANDON WATTERS	9/1/2011
238	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(297)	!*** DWCL ADDED, MODIFIED BY BRANDON WATTERS	8/31/2011
239	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(322)	!*** DWCL MODIFIED, MODIFIED BY BRANDON WATTERS	8/31/2011
240	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(299)	!*** DWCM ADDED, MODIFIED BY BRANDON WATTERS	8/31/2011
241	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\RUNDATCOM-6.F90(324)	!*** DWCM MODIFIED, MODIFIED BY BRANDON WATTERS	8/31/2011
242	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(262)	!*** DW'S CHANGED FROM CASECOUNT TO IFS LOCATIONS, MODIFIED BY BRANDON WATTERS	8/31/2011
243	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(262)	!*** DW'S CHANGED FROM CASECOUNT TO IFS LOCATIONS, MODIFIED BY BRANDON WATTERS	9/27/2011
244	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\RUNDATCOM\DATCOM.F90(80)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
245	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
246	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(57)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
247	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\LIFTFP.F90(50)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
248	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN01.F90(94)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
249	**SYMFP Delta Bookkeeping**	\DATCOM MAX V4\SOURCE\MAIN05.F90(53)	!*** MODIFIED DWCL DWCM DWCD DHTCL DHTCM DHTCD, MODIFIED BY BRANDON WATTERS	8/4/2011
250	**SYMFP Delta Calculation Correction**	\DATCOM MAX V4\SOURCE\WBCM.F90(148)	!*** CORRECTED BODY-WING CM FORMULA, MODIFIED BY BRANDON WATTERS	7/25/2011
251	**SYMFP Delta Execution**	\DATCOM MAX V4\SOURCE\MAIN01.F90(233)	!*** GRAB FLAP DELTA OUTPUT, MODIFIED BY BRANDON WATTERS	8/4/2011
252	**SYMFP Delta Execution**	\DATCOM MAX V4\SOURCE\MAIN01.F90(187)	!*** REMOVED, MODIFIED BY BRANDON WATTERS	8/3/2011

253	**SYMFP Delta Execution**	\DATCOM MAX V4\SOURCE\MAIN05.F90(131)	!*** REMOVED, MODIFIED BY BRANDON WATTERS	8/3/2011
254	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN05.F90(145)	!*** ADDED BY BRANDON WATTERS	7/12/2011
255	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN00.F90(176)	!*** ADDED BY BRANDON WATTERS	8/2/2011
256	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN00.F90(199)	!*** ADDED BY BRANDON WATTERS	8/2/2011
257	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN00.F90(122)	!*** ADDED CHECK, MODIFIED BY BRANDON WATTERS	7/26/2011
258	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN01.F90(148)	!*** ADDED CHECK, MODIFIED BY BRANDON WATTERS	7/26/2011
259	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN05.F90(70)	!*** ADDED CHECK, MODIFIED BY BRANDON WATTERS	7/26/2011
260	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\GRDEFF.F90(160)	!*** ADDED TO CHECK BW(J+100), MODIFIED BY BRANDON WATTERS	8/18/2011
261	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\WBAERO.F90(102)	!*** ADDED TO CHECK BW(J+100), MODIFIED BY BRANDON WATTERS	8/18/2011
262	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN05.F90(114)	!*** ADDED, MODIFIED BY BRANDON WATTERS	8/4/2011
263	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\FLAPCM.F90(474)	!*** CHECK, MODIFIED BY BRANDON WATTERS	7/28/2011
264	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN01.F90(205)	!*** DWCL(II) ADDED, MODIFIED BY BRANDON WATTERS	7/14/2011
265	**SYMFP Delta Troubleshooting**	\DATCOM MAX V4\SOURCE\MAIN01.F90(213)	!*** DWCM(II) REMOVED, MODIFIED BY BRANDON WATTERS	7/14/2011

APPENDIX B

B747-200F MAIN DATA SHEET



Main Data Sheet

A/C Type: B747-200F

Certification based on: N/A

Issue : 06-29-2011

Document: 1

Prepared:	Brandon Watters	Signature:	Brandon Watters
Checked:		Signature:	
Checked/Approved:		Signature:	
Approved:		Signature:	
Approved:		Signature:	

In case of changes or inconsistencies, please contact advanced design AVD Lab.
Indicates changes to the previous issue dated 06-29-2011 By: Brandon Watters

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🟩	Must be calculated
🟨	Use with caution
🟥	Do not use

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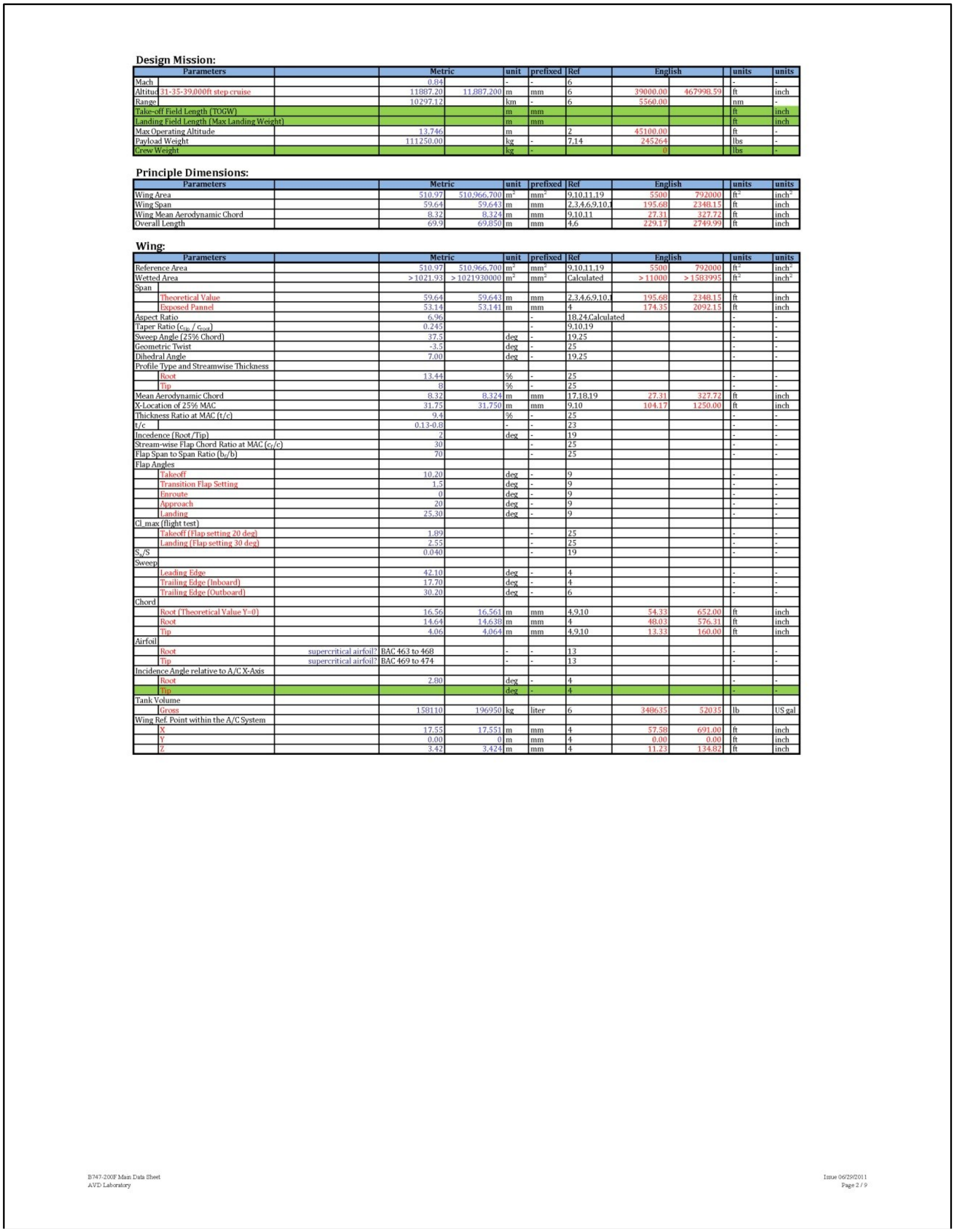

Design Mission:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Mach			0.84		-	-	6			-	-
Altitud	31-35-39,000ft step cruise		11887.20	11,887,200	m	mm	6	39000.00	467998.59	ft	inch
Range			10297.12		km	-	6	5560.00		nm	-
Take-off Field Length (TOGW)					m	mm				ft	inch
Landing Field Length (Max Landing Weight)					m	mm				ft	inch
Max Operating Altitude			13,746		m		2	45100.00		ft	-
Payload Weight			111250.00		kg	-	7,14	245264		lbs	-
Crew Weight					kg	-		0		lbs	-

Principle Dimensions:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Wing Area			510.97	510,966,700	m^2	mm^2	9,10,11,19	5500	792000	ft^2	$inch^2$
Wing Span			59.64	59,643	m	mm	2,3,4,6,9,10,1	195.68	2348.15	ft	inch
Wing Mean Aerodynamic Chord			8.32	8,324	m	mm	9,10,11	27.31	327.72	ft	inch
Overall Length			69.9	69,850	m	mm	4,6	229.17	2749.99	ft	inch

Wing:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Reference Area			510.97	510,966,700	m^2	mm^2	9,10,11,19	5500	792000	ft^2	$inch^2$
Wetted Area			>1021.93	>1021930000	m^2	mm^2	Calculated	>11000	>1583995	ft^2	$inch^2$
Span											
	Theoretical Value		59.64	59,643	m	mm	2,3,4,6,9,10,1	195.68	2348.15	ft	inch
	Exposed Pannel		53.14	53,141	m	mm	4	174.35	2092.15	ft	inch
Aspect Ratio			6.96			-	18,24,Calculated			-	-
Taper Ratio (c_{tip} / c_{root})			0.245			-	9,10,19			-	-
Sweep Angle (25% Chord)			37.5		deg	-	19,25			-	-
Geometric Twist			-3.5		deg	-	25			-	-
Dihedral Angle			7.00		deg	-	19,25			-	-
Profile Type and Streamwise Thickness											
	Root		13.44		%	-	25			-	-
	Tip		8		%	-	25			-	-
Mean Aerodynamic Chord			8.32	8,324	m	mm	17,18,19	27.31	327.72	ft	inch
X-Location of 25% MAC			31.75	31,750	m	mm	9,10	104.17	1250.00	ft	inch
Thickness Ratio at MAC (t/c)			9.4		%	-	25			-	-
t/c			0.13-0.8		-	-	23			-	-
Incedence (Root/Tip)			2		deg	-	19			-	-
Stream-wise Flap Chord Ratio at MAC (c_f/c)			30			-	25			-	-
Flap Span to Span Ratio (b_f/b)			70			-	25			-	-
Flap Angles											
	Takeoff		10,20		deg	-	9			-	-
	Transition Flap Setting		1,5		deg	-	9			-	-
	Enroute		0		deg	-	9			-	-
	Approach		20		deg	-	9			-	-
	Landing		25,30		deg	-	9			-	-
Cl_max (flight test)											
	Takeoff (Flap setting 20 deg)		1.89			-	25			-	-
	Landing (Flap setting 30 deg)		2.55			-	25			-	-
S_a/S			0.040			-	19			-	-
Sweep											
	Leading Edge		42.10		deg	-	4			-	-
	Trailing Edge (Inboard)		17.70		deg	-	4			-	-
	Trailing Edge (Outboard)		30.20		deg	-	6			-	-
Chord											
	Root (Theoretical Value Y=0)		16.56	16,561	m	mm	4,9,10	54.33	652.00	ft	inch
	Root		14.64	14,638	m	mm	4	48.03	576.31	ft	inch
	Tip		4.06	4,064	m	mm	4,9,10	13.33	160.00	ft	inch
Airfoil											
	Root	supercritical airfoil?	BAC 463 to 468		-	-	13			-	-
	Tip	supercritical airfoil?	BAC 469 to 474		-	-	13			-	-
Incidence Angle relative to A/C X-Axis											
	Root		2.80		deg	-	4			-	-
	Tip				deg	-	4			-	-
Tank Volume											
	Gross		158110	196950	kg	liter	6	348635	52035	lb	US gal
Wing Ref. Point within the A/C System											
	X		17.55	17,551	m	mm	4	57.58	691.00	ft	inch
	Y		0.00	0	m	mm	4	0.00	0.00	ft	inch
	Z		3.42	3,424	m	mm	4	11.23	134.82	ft	inch

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Aileron:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Inboard Wing:												
Chord					m	mm	4				ft	inch
Surface Area			3.32	3,320,000	m^2	mm^2	4	35.74	5146.01		ft^2	inch^2
Maximum Displacement												
	up		20		deg	-	9				-	-
	down		20		deg	-	9				-	-
Normal Operation Rate												
	up		45		deg/s	-	9				-	-
	down		40		deg/s	-	9				-	-
One Hydraulic System Failure Rate												
	up		35		deg/s	-	9				-	-
	down		27		deg/s	-	9				-	-
Span fraction b/2												
	Root		0.38			-	19				-	-
	Tip		0.44			-	19				-	-
Chord fraction c_w												
	Root		0.17			-	19				-	-
	Tip		0.25			-	19				-	-
Chord												
	Root		1.59	1,590	m	mm	4	5.22	62.59		ft	inch
	Tip		2.16	2,159	m	mm	4	7.08	85.00		ft	inch
Span Location from Centerline												
	Root		11.33	11,332	m	mm	4,Calculated	37.18	446.15		ft	inch
	Tip		13.12	13,122	m	mm	4,Calculated	43.05	516.59		ft	inch
Outboard Wing:												
Chord					m	mm	4				ft	inch
Surface Area			6.93	6,930,000	m^2	mm^2	4	74.59	10741.52		ft^2	inch^2
Maximum Displacement												
	up		25		deg	-	9				-	-
	down		15		deg	-	9				-	-
Normal Operation Rate												
	up		55		deg/s	-	9				-	-
	down		45		deg/s	-	9				-	-
One Hydraulic System Failure Rate												
	up		45		deg/s	-	9				-	-
	down		22		deg/s	-	9				-	-
Span fraction b/2												
	in		0.70			-	19				-	-
	out		0.95			-	19				-	-
Chord fraction c_w												
	Root		0.11			-	19				-	-
	Tip		0.17			-	19				-	-
Chord												
	Root		1.21	1,214	m	mm	4	3.98	47.81		ft	inch
	Tip		0.88	878	m	mm	4	2.88	34.56		ft	inch
Span Location from Centerline												
	Root		20.88	20,875	m	mm	4,Calculated	68.49	821.85		ft	inch
	Tip		28.33	28,331	m	mm	4,Calculated	92.95	1115.37		ft	inch

Spoilers:

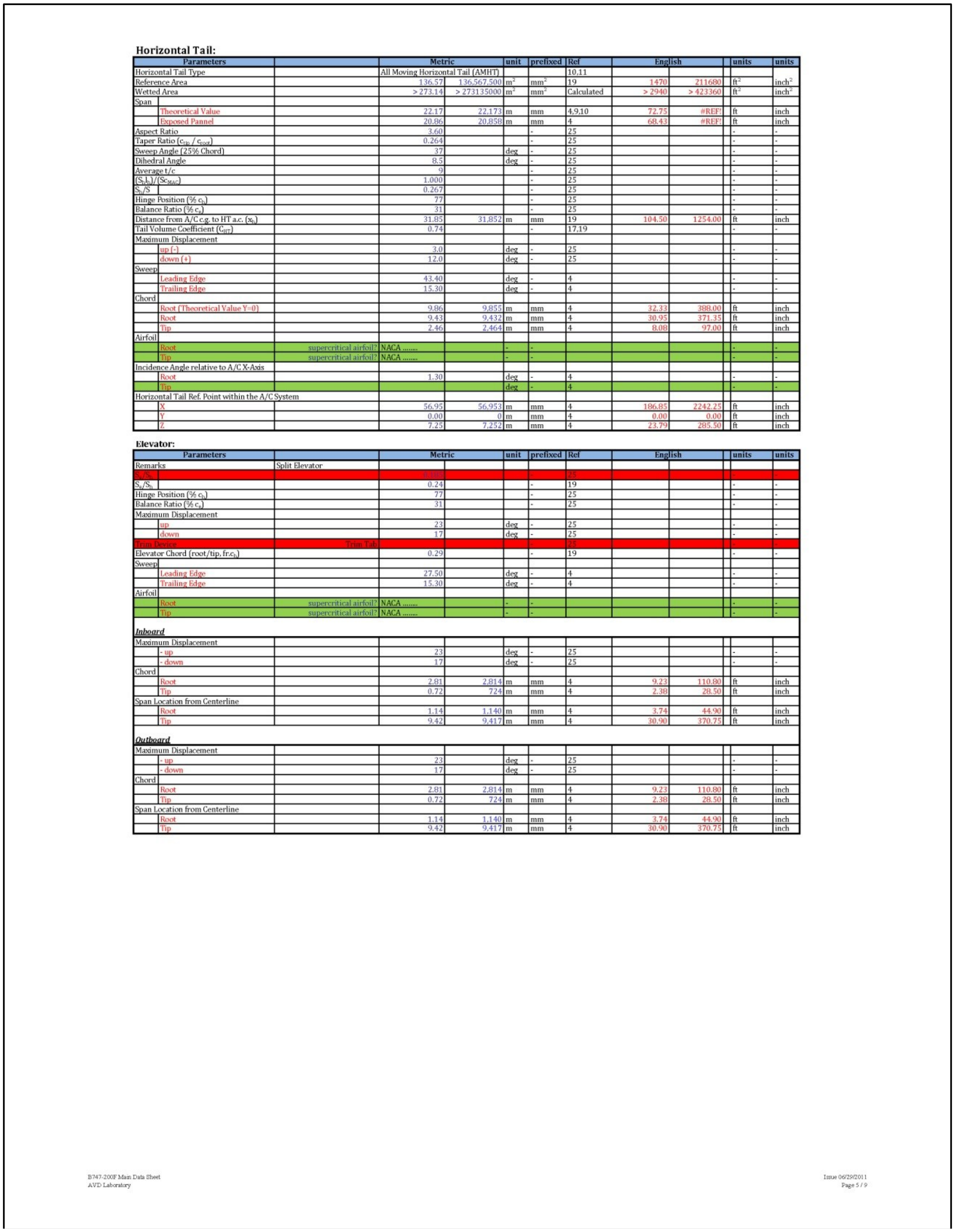
Parameters			Metric		unit	prefixed	Ref	English			units	units
Panels 1,2,3,4,9,10,11,12:												
Chord			1.34	1,337	m	mm	4	4.39	52.64		ft	inch
Surface Area			2.09	2,090,000	m^2	mm^2	4	22.50	3239.51		ft^2	inch^2
Maximum Displacement			45		deg	-	9				-	-
Normal Operation Rate			75		deg/s	-	9				-	-
Span Location fraction b/2												
	Root		0.46			-	19				-	-
	Tip		0.67			-	19				-	-
Chord fraction c_w												
	Root		0.12			-	19				-	-
	Tip		0.16			-	19				-	-
Chord of wing												
	Root		8.67	8,669	m	mm	4	28.44	341.30		ft	inch
	Tip		6.60	6,604	m	mm	4	21.67	260.00		ft	inch
Hinge Location fr. c_w												
	Root		0.71			-	19				-	-
	Tip		0.71			-	19				-	-
Hinge Location from L.E.												
	Root		6.12	6,122	m	mm	4	20.08	241.00		ft	inch
	Tip		4.57	4,566	m	mm	4	14.98	179.75		ft	inch
Span Location from Centerline												
	Root		13.72	13,718	m	mm	4,Calculated	45.01	540.08		ft	inch
	Tip		19.98	19,980	m	mm	4,Calculated	65.55	786.63		ft	inch
Panels 5,8:												
Chord			1.47	1,465	m	mm	4	4.81	57.68		ft	inch
Surface Area			3.15	3,150,000	m^2	mm^2	4	33.91	4882.51		ft^2	inch^2
Maximum Displacement			20		deg	-	9				-	-
Normal Operation Rate			75		deg/s	-	9				-	-
Chord of wing												
	Root		11.66	11,659	m	mm	4	38.25	459.00		ft	inch
	Tip		10.41	10,406	m	mm	4	34.14	409.66		ft	inch
Hinge Location from L.E.												
	Root		8.67	8,674	m	mm	4	28.46	341.50		ft	inch
	Tip		7.42	7,417	m	mm	4	24.33	292.00		ft	inch
Span Location from Centerline												
	Root		8.34	8,338	m	mm	4	27.35	328.25		ft	inch
	Tip		10.47	10,471	m	mm	4	34.35	412.25		ft	inch

Air Brake:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Panels 6,7: (Speedbreaks Only)												
Chord			1.47	1,465	m	mm	4	4.81	57.68		ft	inch
Surface Area			3.15	3,150,000	m^2	mm^2	4	33.91	4882.51		ft^2	inch^2
Maximum Displacement			20		deg	-	9				-	-
Normal Operation Rate			25		deg/s	-	9				-	-
Span Location from Centerline												
	Root		6.15	6,150	m	mm	4	20.18	242.13		ft	inch
	Tip		8.34	8,338	m	mm	4	27.35	328.25		ft	inch

High Lift Devices:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Trailing Edge												
Inboard Wing:												
Flap type			Triple Slotted				9,10					
Flap Chord (Retracted)												
	Root		1.52	1,517	m	mm	4	4.98	59.71		ft	inch
	Tip		1.52	1,517	m	mm	4	4.98	59.71		ft	inch
Wing Chord (Retracted)												
	Root		14.64	14,638	m	mm	15	48.03	576.31		ft	inch
	Tip		9.90	9,896	m	mm	15	32.47	389.59		ft	inch
Wing Chord (Extended)												
	Root				m	mm	15				ft	inch
	Tip				m	mm	15				ft	inch
C1 Chord												
	Root				m	mm	4				ft	inch
	Tip		0.6594	659	m	mm	4	2.16	25.96		ft	inch
C2 Chord												
	Root		1.7340	1,734	m	mm	4	5.69	68.27		ft	inch
	Tip		1.9782	1,978	m	mm	4	6.49	77.88		ft	inch
C3 Chord												
	Root		1.1300	1,130	m	mm	4	3.71	44.49		ft	inch
	Tip		1.1181	1,118	m	mm	4	3.67	44.02		ft	inch
Span Location from Centerline												
	Root		3.25	3,251	m	mm	4	10.67	128.00		ft	inch
	Tip		11.33	11,332	m	mm	4	37.18	446.15		ft	inch
Surface Area			116.81	116,806,988	m^2	mm^2	4,Calculated	1257.30	181051.18		ft^2	$inch^2$
Detents		Max	0,10,20,25,30	30	deg	deg	4,9,10				-	-
C3 Detents		Max	0,15,30,37.5,45	45	deg	deg	4				-	-
Outboard Wing:												
Flap type			Triple Slotted				9,10					
Flap Chord (Retracted)												
	Root		1.25	1,251	m	mm	4	4.10	49.25		ft	inch
	Tip		0.64	636	m	mm	4	2.09	25.03		ft	inch
Wing Chord (Retracted)												
	Root		8.85	8,851	m	mm	4	29.04	348.46		ft	inch
	Tip		4.43	4,433	m	mm	4	14.54	174.53		ft	inch
Wing Chord (Extended)												
	Root				m	mm	4				ft	inch
	Tip				m	mm	4				ft	inch
C1 Chord												
	Root				m	mm	4				ft	inch
	Tip		0.3249	325	m	mm	4	1.07	12.79		ft	inch
C2 Chord												
	Root		1.3730	1,373	m	mm	4	4.50	54.05		ft	inch
	Tip		1.1744	1,174	m	mm	4	3.85	46.24		ft	inch
C3 Chord												
	Root		0.9925	993	m	mm	4	3.26	39.07		ft	inch
	Tip		0.6292	629	m	mm	4	2.06	24.77		ft	inch
Span Location from Centerline												
	Root		13.12	13,122	m	mm	4	43.05	516.59		ft	inch
	Tip		20.90	20,898	m	mm	4	68.56	822.75		ft	inch
Surface Area			62.49	62,491,227	m^2	mm^2	4,Calculated	672.65	96861.59		ft^2	$inch^2$
Detents			0,10,20,25,30		deg	-	9,10				-	-
C3 Detents		Max	0,15,30,37.5,45	45	deg	deg	4				-	-
Leading Edge												
Inboard Wing:												
Flap type			Krueger standard unslotted				9,10					
Flap Chord (Retracted)												
	Root		0.81	813	m	mm	4	2.67	32.02		ft	inch
	Tip		0.81	813	m	mm	4	2.67	32.02		ft	inch
Wing Chord (Retracted)												
	Root		13.09	13,087	m	mm	4	42.94	515.25		ft	inch
	Tip				m	mm	4				ft	inch
Span Location from Centerline												
	Root		5.92	5,925	m	mm	4	19.44	233.25		ft	inch
	Tip		20.36	20,365	m	mm	4	66.81	801.75		ft	inch
Outboard of Inboard Nacelles:												
Flap type			Krueger variable cambered and slotted				9,10					
Flap Chord (Retracted)												
	Root		0.81	813	m	mm	4	2.67	32.00		ft	inch
	Tip		0.81	813	m	mm	4	2.67	32.00		ft	inch
Wing Chord (Retracted)												
	Root				m	mm	4				ft	inch
	Tip		4.23	4,232	m	mm	4	13.89	166.63		ft	inch
Span Location from Centerline												
	Root		22.09	22,092	m	mm	4	72.48	869.75		ft	inch
	Tip		29.15	29,152	m	mm	4	95.64	1147.72		ft	inch



Horizontal Tail:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Horizontal Tail Type			All Moving Horizontal Tail (AMHT)				10,11				
Reference Area			136.57	136,567,500	m^2	mm^2	19	1470	211680	ft^2	$inch^2$
Wetted Area			> 273.14	> 273135000	m^2	mm^2	Calculated	> 2940	> 423360	ft^2	$inch^2$
Span											
	Theoretical Value		22.17	22,173	m	mm	4,9,10	72.75	#REF!	ft	inch
	Exposed Pannel		20.86	20,858	m	mm	4	68.43	#REF!	ft	inch
Aspect Ratio			3.60			-	25			-	-
Taper Ratio (c_{tip} / c_{root})			0.264			-	25			-	-
Sweep Angle (25% Chord)			37		deg	-	25			-	-
Dihedral Angle			8.5		deg	-	25			-	-
Average t/c			9			-	25			-	-
$(S_h l_h)/(Sc_{MAC})$			1.000			-	25			-	-
S_h/S			0.267			-	25			-	-
Hinge Position (% c_h)			77			-	25			-	-
Balance Ratio (% c_e)			31			-	25			-	-
Distance from A/C c.g. to HT a.c. (x_h)			31.85	31,852	m	mm	19	104.50	1254.00	ft	inch
Tail Volume Coefficient (C_{HT})			0.74			-	17,19			-	-
Maximum Displacement											
	up (-)		3.0		deg	-	25			-	-
	down (+)		12.0		deg	-	25			-	-
Sweep											
	Leading Edge		43.40		deg	-	4			-	-
	Trailing Edge		15.30		deg	-	4			-	-
Chord											
	Root (Theoretical Value Y=0)		9.86	9,855	m	mm	4	32.33	388.00	ft	inch
	Root		9.43	9,432	m	mm	4	30.95	371.35	ft	inch
	Tip		2.46	2,464	m	mm	4	8.08	97.00	ft	inch
Airfoil											
	Root	supercritical airfoil?	NACA ……..		-	-				-	-
	Tip	supercritical airfoil?	NACA ……..		-	-				-	-
Incidence Angle relative to A/C X-Axis											
	Root		1.30		deg	-	4			-	-
	Tip				deg	-	4			-	-
Horizontal Tail Ref. Point within the A/C System											
	X		56.95	56,953	m	mm	4	186.85	2242.25	ft	inch
	Y		0.00	0	m	mm	4	0.00	0.00	ft	inch
	Z		7.25	7,252	m	mm	4	23.79	285.50	ft	inch

Elevator:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Remarks		Split Elevator									
S_a/S_h			0.185			-	25			-	-
S_e/S_h			0.24			-	19			-	-
Hinge Position (% c_h)			77			-	25			-	-
Balance Ratio (% c_e)			31			-	25			-	-
Maximum Displacement											
	up		23		deg	-	25			-	-
	down		17		deg	-	25			-	-
Trim Device		Trim Tab				-	25			-	-
Elevator Chord (root/tip, fr.c_h)			0.29			-	19			-	-
Sweep											
	Leading Edge		27.50		deg	-	4			-	-
	Trailing Edge		15.30		deg	-	4			-	-
Airfoil											
	Root	supercritical airfoil?	NACA ……..		-	-				-	-
	Tip	supercritical airfoil?	NACA ……..		-	-				-	-
Inboard											
Maximum Displacement											
	- up		23		deg	-	25			-	-
	- down		17		deg	-	25			-	-
Chord											
	Root		2.81	2,814	m	mm	4	9.23	110.80	ft	inch
	Tip		0.72	724	m	mm	4	2.38	28.50	ft	inch
Span Location from Centerline											
	Root		1.14	1,140	m	mm	4	3.74	44.90	ft	inch
	Tip		9.42	9,417	m	mm	4	30.90	370.75	ft	inch
Outboard											
Maximum Displacement											
	- up		23		deg	-	25			-	-
	- down		17		deg	-	25			-	-
Chord											
	Root		2.81	2,814	m	mm	4	9.23	110.80	ft	inch
	Tip		0.72	724	m	mm	4	2.38	28.50	ft	inch
Span Location from Centerline											
	Root		1.14	1,140	m	mm	4	3.74	44.90	ft	inch
	Tip		9.42	9,417	m	mm	4	30.90	370.75	ft	inch

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Vertical Tail:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Reference Area			77.11	77,109,520	m^2	mm^2	19	830	119520	ft^2	$inch^2$
Wetted Area			> 154.219	> 154219040	m^2	mm^2	Calculated	> 1660	> 239040	ft^2	$inch^2$
Span											
	Theoretical Value		13.38	13,383	m	mm	4,Calculated	43.91	526.87	ft	inch
	Exposed Pannel		9.80	9,804	m	mm	4,9,10	32.17	386.00	ft	inch
Aspect Ratio			1.25			-	Calculated			-	-
Aspect Ratio			1.30			-	25			-	-
Taper Ratio (c_{tip} / c_{root})			0.340			-	Calculated			-	-
Sweep Angle (25% Chord)			44		deg	-	25			-	-
Average t/c						-	4			-	-
$(S_v l_v)/(Sb)$			0.0990			-	25			-	-
S_v/S			0.196			-	25			-	-
Hinge Position (% c_v)			77			-	25			-	-
Balance Ratio (% c_r)			42			-	25			-	-
Distance from A/C c.g. to HT a.c. (x_v)			31.09	31,090	m	mm	19	102.00	1224.00	ft	inch
Tail Volume Coefficient (C_{HT})			0.079			-	17,19			-	-
Z Distance from Zcg to A.C.			8.80	8,803	m	mm	4,Calculated	28.8822	346.59	ft	inch
X Distance from Xcg to A.C.			30.44	30,436	m	mm	4,Calculated	99.8554	1198.26	ft	inch
Sweep											
	Leading Edge		50.10		deg	-	4			-	-
	Trailing Edge		22.40		deg	-	4			-	-
Chord											
	Root		11.73	11,735	m	mm	4,9,10	38.50	462.00	ft	inch
	Tip		3.99	3,988	m	mm	4,9,10	13.08	157.00	ft	inch
Airfoil											
	Root	supercritical airfoil?	NACA		-	-				-	-
	Tip	supercritical airfoil?	NACA		-	-				-	-
Incidence Angle relative to A/C X-Axis											
	Root		0.00		deg	-	4			-	-
	Tip		0.00		deg	-	4			-	-
Vertical Tail Ref. Point within the A/C System											
	X		54.68	54,682	m	mm	4	179.40	2152.81	ft	inch
	Y		0.00	0	m	mm	4	0.00	0.00	ft	inch
	Z		8.99	8,992	m	mm	4	29.50	354.00	ft	inch

Rudder:

Parameters			Metric		unit	prefixed	Ref	English		units	units
Remarks		Split Rudder				-	25			-	-
S_r/S_h			0.173			-	25			-	-
S_r/S_h			0.30			-	19			-	-
Hinge Position (% c_v)			77			-	25			-	-
Balance Ratio (% c_r)			42			-	25			-	-
Rudder Chord (root/tip, fr.cv)			0.30			-	19			-	-
Inboard											
Chord											
	Root		3.52	3,518	m	mm	4	11.54	138.49	ft	inch
	Tip		2.84	2,845	m	mm	4	9.33	112.00	ft	inch
Span Location from Centerline											
	Root		9.20	9,202	m	mm	4	30.19	362.30	ft	inch
	Tip		12.02	12,022	m	mm	4	39.44	473.30	ft	inch
Surface Area			8.67	8,670,000	m^2	mm^2	4	93	13439	ft^2	$inch^2$
Maximum Displacement		±	25		deg	-	9,25			-	-
Normal Operation Rate			50		deg/s	-	9			-	-
One Hydraulic System Failure Rate			40		deg/s	-	9			-	-
Outboard											
Chord											
	Root		2.84	2,845	m	mm	4	9.33	112.00	ft	inch
	Tip		1.44	1,435	m	mm	4	4.71	56.50	ft	inch
Span Location from Centerline											
	Root		12.02	12,022	m	mm	4	39.44	473.30	ft	inch
	Tip		18.00	17,996	m	mm	4	59.04	708.50	ft	inch
Surface Area			12.58	12,580,000	m^2	mm^2	4	135	19499	ft^2	$inch^2$
Maximum Displacement		±	25		deg	-	9,25			-	-
Normal Operation Rate			50		deg/s	-	9			-	-
One Hydraulic System Failure Rate			40		deg/s	-	9			-	-

Fuselage:

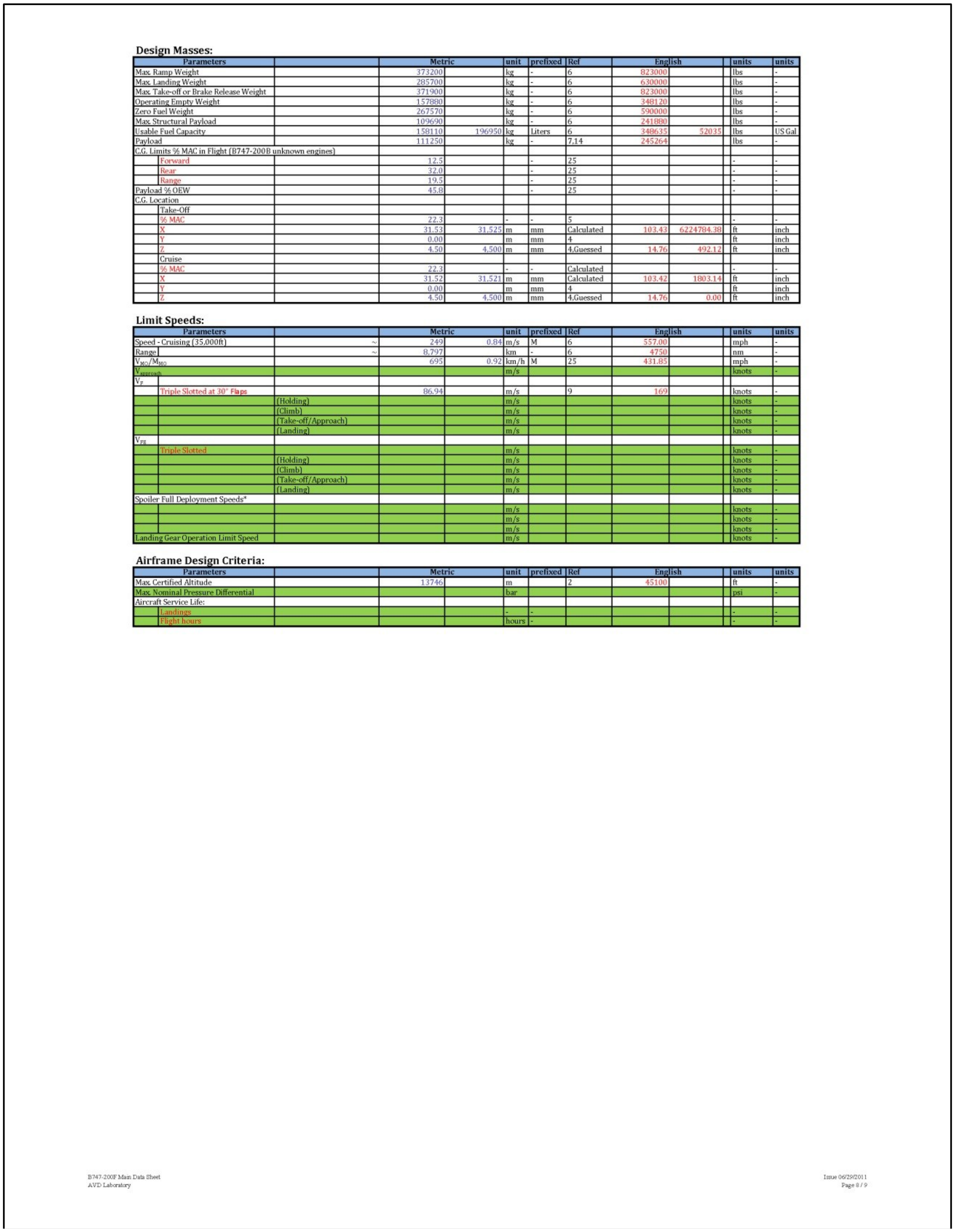
Parameters			Metric		unit	prefixed	Ref	English		units	units
Reference Length			68.63	68,631	m	mm	4	225.17	2701.99	ft	inch
Hight					m	mm	4			ft	inch
Width			6.50	6,502	m	mm	6,9,10	21.33	256.00	ft	inch
Planform Area					m^2	mm^2	4			ft^2	$inch^2$
Surface Wetted Area					m^2	mm^2	4			ft^2	$inch^2$
Max Cross-Section Area					m^2	mm^2	4			ft^2	$inch^2$
Load Volume			605.00	6.05E+11	m^3	mm^3	14	21365	36919365	ft^3	$inch^3$
Max. Main-Deck Cargo Volume-Paletized Cargo			522.00	5.22E+11	m^3	mm^3	6	18434	31854394	ft^3	$inch^3$
Max. Lower-Lobe Containerized Cargo Volume			150.00	1.5E+11	m^3	mm^3	6	5297	9153562	ft^3	$inch^3$
Max. Lower-Lobe Bulk Cargo Volume			23.00	23000000000	m^3	mm^3	6	812	1403546	ft^3	$inch^3$
Frame											
	Flange Length				m	mm				ft	inch
	Flange Thickness				m	mm				ft	inch
	Web Thickness				m	mm				ft	inch
Fuselage Ref. Point within the A/C System											
	X		0.00	0	m	mm	4	0.00	0.00	ft	inch
	Y		0.00	0	m	mm	4	0.00	0.00	ft	inch
	Z		5.63	5,629	m	mm	4	18.47	221.63	ft	inch
Design Eye Point (DEP)											
	X				m	mm				ft	inch
	Y	±			m	mm	±			ft	inch
	Z				m	mm				ft	inch

Landing Gear:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Size			1.2446 x 0.4826 - 0.508	1244.6 x 482.6 -	m	mm	21	333 - 1.666667	49 x 19-20		ft	inch
Ply Rating			32 TL		-	-	21				-	-
Lateral Distance Between Two Tires												
	Nose Gear		0.91	910	m	mm	6	2.99	35.83		ft	inch
	Wing Gear		1.12	1,120	m	mm	6	3.67	44.09		ft	inch
	Body Gear		1.12	1,120	m	mm	6	3.67	44.09		ft	inch
Longitudinal Distance Between Two Tires												
	Wing Gear		1.47	1,470	m	mm	6	4.82	57.87		ft	inch
	Body Gear		1.47	1,470	m	mm	6	4.82	57.87		ft	inch
Wheel base												
	Nose Gear to Wing Gear		24.07	24,070	m	mm	6	78.97	947.63		ft	inch
	Nose Gear to Body Gear		27.14	27,140	m	mm	6	89.04	1068.50		ft	inch
Wheel track												
	Wing Gear		11.00	11,000	m	mm	6	36.09	433.07		ft	inch
	Body Gear		3.84	3,840	m	mm	6	12.60	151.18		ft	inch
Distance Between Two Tires												
	MLG		1.12	1,120	m	mm	6	3.67	44.09		ft	inch
	NLG		0.91	910	m	mm	6	2.99	35.83		ft	inch
Inflation pressure			13.44		bar	-	21	195			psi	-
Frontal Area of Main Wheels			0.5808	580,780	m^2	mm^2	4	6.2515	900		ft^2	$inch^2$
Frontal Area of Nose Wheels			0.5808	580,780	m^2	mm^2	4	6.2515	900		ft^2	$inch^2$
Length of Main Landing Gear			2.60	2,599	m	mm	4	8.53	102.33		ft	inch
Reference point within the A/C System Main Gear 1												
	X		31.8008	31,801	m	mm	4	104.33	1252.00		ft	inch
	Y		-5.5066		m	mm	4				ft	inch
	Z		0.5334	533	m	mm	4	1.75	21.00		ft	inch
Reference point within the A/C System Main Gear 2												
	X		31.8008	31,801	m	mm	4	104.33	1252.00		ft	inch
	Y		5.5066	5,507	m	mm	4	18.07	216.79		ft	inch
	Z		0.5334	533	m	mm	4	1.75	21.00		ft	inch
Reference point within the A/C System Body Gear 1												
	X		34.8615	34,862	m	mm	4	114.38	1372.50		ft	inch
	Y		-1.9191		m	mm	4				ft	inch
	Z		0.5334	533	m	mm	4	1.75	21.00		ft	inch
Reference point within the A/C System Body Gear 2												
	X		34.8615	34,862	m	mm	4	114.38	1372.50		ft	inch
	Y		1.9191	1,919	m	mm	4	6.30	75.55		ft	inch
	Z		0.5334	533	m	mm	4	1.75	21.00		ft	inch
Reference point within the A/C System Nose Gear												
	X		7.7615	7,762	m	mm	4	25.46	305.57		ft	inch
	Y		0.0000	0	m	mm	4	0.00	0.00		ft	inch
	Z		0.7239	724	m	mm	4	2.38	28.50		ft	inch

Power Plant:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Manufacturer		General Electric	CF6-50E2									
Type		High Bypass Turbo-Fan										
Number of engines			4									
Take-off thrust												
	- normal	for one engine	233.53		kN	-	8	52500			lbf	-
	- APR	for one engine			kN	-					lbf	-
SFC*	Conversion Factor 28.325	at maximum thrust	04236-0.0109051		kg/kN	-	16	0.368-0.385			lb/lbf/h	-
Fan/Compressor Stages			1F/3LPC/14HPC		-	-	8,16				-	-
Low-Pressure Turbine / High-Pressure Turbine			4/2		-	-	8				-	-
Maximum Diameter			2.67	2,667	m	mm	8	8.75	105		ft	inch
Length			4.65	4,648	m	mm	8	15.25	183		ft	inch
Max Power at Sea Level			234		kN	-	8	52499.99			lbf	-
Overall Pressure Ratio at Max Power			30.40		-	-	8				-	-
Propulsion System weight						kg					lbs	
Bypass ratio			4.24 - 4.4		-	-	16				-	-
Dry Weight			4104		kg	-	1	9047			lbs	-
C.G. Locations												
	Station (engine only)	±2"	5.69	5,690	m	mm	1	18.67	224.00		ft	inch
	Waterline (engine only)	±1"	2.46	2,459	m	mm	1	8.07	96.80		ft	inch
Nacelle wetted area for total A/C					m^2	mm^2					ft^2	$inch^2$
Pylon wetted area for total A/C					m^2	mm^2					ft^2	$inch^2$
Nacelle Max Frontal Area					m^2	mm^2					ft^2	$inch^2$
Nacelle Outlet Diameter					m	mm					ft	inch
Nacelle Inlet Diameter					m	mm					ft	inch
Nacelle Max Length					m	mm					ft	inch
Nacelle Max Height					m	mm					ft	inch
Reference point within the A/C System (Ref. pt. engine = Fanref. plane / axis of rotation)												
	X ****				m	mm					ft inch	
	Y ****	±			m	mm	±				ft inch	
	Z ****				m	mm					ft inch	
Toe in angle		±				deg						
Engine incidence within the A/C System						deg						
No. of strakes per nacelle						-						
Ref. Area nacelle strake					m^2						ft^2	



Design Masses:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Max. Ramp Weight			373200		kg	-	6	823000			lbs	-
Max. Landing Weight			285700		kg	-	6	630000			lbs	-
Max. Take-off or Brake Release Weight			371900		kg	-	6	823000			lbs	-
Operating Empty Weight			157880		kg	-	6	348120			lbs	-
Zero Fuel Weight			267570		kg	-	6	590000			lbs	-
Max. Structural Payload			109690		kg	-	6	241880			lbs	-
Usable Fuel Capacity			158110	196950	kg	Liters	6	348635	52035		lbs	US Gal
Payload			111250		kg	-	7,14	245264			lbs	-
C.G. Limits % MAC in Flight (B747-200B unknown engines)												
	Forward		12.5			-	25				-	-
	Rear		32.0			-	25				-	-
	Range		19.5			-	25				-	-
Payload % OEW			45.8			-	25				-	-
C.G. Location												
	Take-Off											
	% MAC		22.3		-	-	5				-	-
	X		31.53	31,525	m	mm	Calculated	103.43	6224784.38		ft	inch
	Y		0.00		m	mm	4				ft	inch
	Z		4.50	4,500	m	mm	4,Guessed	14.76	492.12		ft	inch
	Cruise											
	% MAC		22.3		-	-	Calculated				-	-
	X		31.52	31,521	m	mm	Calculated	103.42	1803.14		ft	inch
	Y		0.00		m	mm	4				ft	inch
	Z		4.50	4,500	m	mm	4,Guessed	14.76	0.00		ft	inch

Limit Speeds:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Speed - Cruising (35,000ft)		~	249	0.84	m/s	M	6	557.00			mph	-
Range		~	8,797		km	-	6	4750			nm	-
V_{MO}/M_{MO}			695	0.92	km/h	M	25	431.85			mph	-
$V_{approach}$					m/s						knots	-
V_F												
	Triple Slotted at 30° Flaps		86.94		m/s		9	169			knots	-
		(Holding)			m/s						knots	-
		(Climb)			m/s						knots	-
		(Take-off/Approach)			m/s						knots	-
		(Landing)			m/s						knots	-
V_{FE}												
	Triple Slotted				m/s						knots	-
		(Holding)			m/s						knots	-
		(Climb)			m/s						knots	-
		(Take-off/Approach)			m/s						knots	-
		(Landing)			m/s						knots	-
Spoiler Full Deployment Speeds*												
					m/s						knots	-
					m/s						knots	-
					m/s						knots	-
Landing Gear Operation Limit Speed					m/s						knots	-

Airframe Design Criteria:

Parameters			Metric		unit	prefixed	Ref	English			units	units
Max. Certified Altitude			13746		m		2	45100			ft	-
Max. Nominal Pressure Differential					bar						psi	-
Aircraft Service Life:												
	Landings				-	-					-	-
	Flight hours				hours	-					-	-

List of attached drawings

1 Principle Dimensions - 3 View; 747-200.dxf

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APPENDIX C

B747-200F DIGITAL DATCOM MODELS

WB-Clean

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DIM M

BUILD

DUMP CASE

PART

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   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$

 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$

 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,

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SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
CASEID B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=0.0 SYMFLP = Elevator)
DAMP
SAVE
```

WB-Ailerons

```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
        3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
        8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
        2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
        0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
        0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
        0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
        0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
        -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
```

```
      -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
      0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
      0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
      0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
      0.0048805,0.0034155,0.0018800,0.0002700,
   THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
      0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
      0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
      0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
      0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $ASYFLP STYPE=4.0, NDELTA=9.0, SPANFI=11.3322, SPANFO=13.1215,
   DELTAL=-20.0,-15.0,-10.0,-5.0,0.0,5.0,10.0,15.0,20.0,
   DELTAR=20.0,15.0,10.0,5.0,0.0,-5.0,-10.0,-15.0,-20.0,
   CHRDFI=1.5897, CHRDFO=2.1590$
CASEID W/Aileron Configuration, B747-200F (ASYFLP = Ailerons)
DAMP
```

WB-LE Flaps

```
DIM M

BUILD

DUMP CASE

PART

 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,

   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,

   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$

 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$

 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,

   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,

        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,

   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,

        3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,

   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,

        8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,

   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,

        2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$

 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,

   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,

        0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,

        0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,

        0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,

   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,

        0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,

        -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
```

```
      -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
      0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
      0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
      0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
      0.0048805,0.0034155,0.0018800,0.0002700,
   THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
      0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
      0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
      0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
      0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $SYMFLP FTYPE=8.0, NDELTA=2.0, DELTA=25.0,30.0, SPANFI=5.9246,
   SPANFO=29.1522, CHRDFI=0.8133, CHRDFO=0.8128, CPRMEI=13.9007,
CPRMEO=5.0451$
CASEID W/TE Flaps Configuration, B747-200F (SYMFLP = Krueger)
DAMP
```

WB-TE Flaps

```
DIM M

BUILD

DUMP CASE

PART

 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,

  NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,

  NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$

 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$

 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,

  X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,

      23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,

  R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,

      3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,

  ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,

      8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,

  ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,

      2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$

 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,

  XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,

      0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,

      0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,

      0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,

  MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,

      0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,

      -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
```

```
     -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
     0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
     0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
     0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
     0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
     0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
     0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
     0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
     0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
     0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
     0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
     0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $SYMFLP FTYPE=3.0, NDELTA=1.0, DELTA=30.0, SPANFI=3.2512,
  SPANFO=20.8979, CHRDFI=1.5166, CHRDFO=0.6358, PHETE=0.0012283,
  PHETEP=0.0014263, CPRMEI=16.0987, CPRMEO=5.6637$
CASEID W/TE Flaps Configuration, B747-200F (SYMFLP = FOWLER FLAPS)
DAMP
```

WB-Spoilers

```
DIM M

BUILD

DUMP CASE

PART

 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,

   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,

   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$

 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$

 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,

   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,

        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,

   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,

        3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,

   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,

        8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,

   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,

        2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$

 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,

   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,

        0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,

        0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,

        0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,

   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,

        0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,

        -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
```

```
      -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
      0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
      0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
      0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
      0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
      0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
      0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
      0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
      0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $ASYFLP STYPE=1.0, NDELTA=5.0, SPANFI=13.7179, SPANFO=19.9805,
  CHRDFI=1.3371, CHRDFO=1.3371,
  DELTAS=0.0,0.0453175,0.0739976,0.1004294,0.1238097,
  XSOC=0.8748379,0.8688718,0.8584331,0.8431727,0.8235543,
  XSPRME=0.6997446,
  HSOC=0.0153960,0.0607135,0.0893936,0.1158254,0.1392057$
CASEID W/Spoiler Configuration, B747-200F (ASYFLP = Spoilers)
DAMP
```

WB-Speed Brakes

```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
  NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
  NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
  X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
      23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
  R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
      3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
  ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
      8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
  ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
      2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
  XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
      0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
      0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
      0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
  MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
      0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
      -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
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```
     -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
     0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
     0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
     0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
     0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
     0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
     0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
     0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
     0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
     0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
     0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
     0.0013600$
 $WGPLNF    CHRDTP=4.064,    SSPNE=26.5704,    SSPN=29.8216,    CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $SYMFLP FTYPE=5.0, NDELTA=2.0,
  DELTA=10.0,20.0,
  PHETE=0.000634278, PHETEP=0.000482512, CHRDFI=1.4650, CHRDFO=1.4650,
  SPANFI=6.1500, SPANFO=8.3376$
CASEID W/Speed Brakes, B747-200F (Case 6, Speed brakes modeled as a split flap)
DAMP
```

WBHV-Clean

```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
        ZH=6.8961, ALIH=0.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
        3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
        8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
        2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
        0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
        0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
        0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
        0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
```

```
     -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
     -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
     0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
     0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
     0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
     0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
     0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
     0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
     0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
     0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
     0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
     0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
     0.0013600$
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6-64A010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
  SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6-63A008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
  SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
CASEID B/W/HT/VT, B747-200F (CLEAN)
DAMP
SAVE
```

WBHV-Elevator

```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
  NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
  NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
      ZH=6.8961, ALIH=0.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
  X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
      23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
  R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
      3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
  ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
      8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
  ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
      2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
  XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
      0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
      0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
      0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
  MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
      0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
```

```
    -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
    -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
    0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
    0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
    0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
    0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
    0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
    0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
    0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
    0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
    0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
    0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
    0.0013600$
 $WGPLNF   CHRDTP=4.064,   SSPNE=26.5704,   SSPN=29.8216,   CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6-64A010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
  SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6-63A008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
  SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
  DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
  PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
```

```
   SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (CLEAN ALIH=0.0 SYMFLP = Elevator)
DAMP
SAVE
```

WBHV-AMHT+e

```
DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
  NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
  NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
      ZH=6.8961, ALIH=15.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
  X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
      23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
  R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
      3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
  ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
      8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
  ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
      2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
  XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
      0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
      0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
      0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
  MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
      0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
```

```
     -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
     -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
     0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
     0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
     0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
     0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
     0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
     0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
     0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
     0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
     0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
     0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
     0.0013600$
 $WGPLNF    CHRDTP=4.064,    SSPNE=26.5704,    SSPN=29.8216,    CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6-64A010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
  SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6-63A008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
  SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
  DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
  PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
```

```
   SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (CLEAN ALIH=0.0 SYMFLP = Elevator)
DAMP
SAVE
```

APPENDIX D

B747-200F DATCOM MAX MODEL

for005.dat

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DIM M
BUILD
DUMP CASE
PART
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
        ZH=6.8961, ALIH=15.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
        3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
   ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
        8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
   ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
        2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
 $WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
   XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
        0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
        0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
        0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
   MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
        0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
```

```
      -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
      -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
      0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
      0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
      0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
      0.0048805,0.0034155,0.0018800,0.0002700,
  THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
      0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
      0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
      0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
      0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
 $WGPLNF     CHRDTP=4.064,     SSPNE=26.5704,     SSPN=29.8216,     CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6-64A010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
  SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6-63A008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
  SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
  DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
  PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
```

```
  SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 1, CLEAN ALIH=15.0 SYMFLP = Elevator)
DAMP
SAVE
NEXT CASE
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
      ZH=6.8961, ALIH=10.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
  DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
  PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
  SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 2, ALIH=10.0 SYMFLP = Elevator)
DAMP
SAVE
NEXT CASE
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
      ZH=6.8961, ALIH=5.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
  DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
  PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
  SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 3, ALIH=5.0 SYMFLP = Elevator)
DAMP
SAVE
NEXT CASE
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
```

```
        ZH=6.8961, ALIH=0.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
   DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
   PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
   SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 4, ALIH=0.0 SYMFLP = Elevator)
DAMP
SAVE
NEXT CASE
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
        ZH=6.8961, ALIH=-5.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $SYMFLP FTYPE=1.0, NDELTA=9.0,
   DELTA=-23.0,-20.0,-15.0,-5.0,0.0,5.0,10.0,15.0,17.0,
   PHETE=0.0005077, PHETEP=0.0003827, CHRDFI=2.8144, CHRDFO=0.7239,
   SPANFI=1.1404, SPANFO=9.4171$
CASEID B/W/HT/VT, B747-200F (Case 5, ALIH=-5.0 SYMFLP = Elevator)
DAMP
NEXT CASE
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
        23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
```

```
    3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
 ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
    8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
 ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
    2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
$WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
 XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
    0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
    0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
    0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
 MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
    0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
    -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
    -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
    0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
    0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
    0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
    0.0048805,0.0034155,0.0018800,0.0002700,
 THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
    0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
    0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
    0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
    0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
    0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
    0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
    0.0013600$
```

```
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
  CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $ASYFLP STYPE=4.0, NDELTA=9.0, SPANFI=11.3322, SPANFO=13.1215,
  DELTAL=-20.0,-15.0,-10.0,-5.0,0.0,5.0,10.0,15.0,20.0,
  DELTAR=20.0,15.0,10.0,5.0,0.0,-5.0,-10.0,-15.0,-20.0,
  CHRDFI=1.5897, CHRDFO=2.1590$
CASEID W/Aileron Configuration, B747-200F (Case 6, ASYFLP = Ailerons)
DAMP
SAVE
NEXT CASE
 $ASYFLP STYPE=1.0, NDELTA=5.0, SPANFI=13.7179, SPANFO=19.9805,
  CHRDFI=1.3371, CHRDFO=1.3371,
  DELTAS=0.0,0.0453175,0.0739976,0.1004294,0.1238097,
  XSOC=0.8748379,0.8688718,0.8584331,0.8431727,0.8235543,
  XSPRME=0.6997446,
  HSOC=0.0153960,0.0607135,0.0893936,0.1158254,0.1392057$
CASEID W/Spoiler Configuration, B747-200F (Case 7, ASYFLP = Spoilers)
DAMP
NEXT CASE
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
  NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
  NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8, XH=56.9532,
      ZH=6.8961, ALIH=0.0, XV=54.6816, ZV=8.9916, VERTUP=.TRUE.$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
```

```
 X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
    23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
 R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
    3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
 ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
    8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
 ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
    2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
$WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
 XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
    0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
    0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
    0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
 MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
    0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
    -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
    -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
    0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
    0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
    0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
    0.0048805,0.0034155,0.0018800,0.0002700,
 THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
    0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
    0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
    0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
    0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
```

```
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
 $WGPLNF    CHRDTP=4.064,    SSPNE=26.5704,    SSPN=29.8216,    CHRDR=14.0663,
SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
NACA-V-6A64-010
 $VTPLNF CHRDTP=3.9878, SSPNE=9.8044, SSPN=9.8044, CHRDR=11.7348,
   SAVSI=44.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-6A63-008
 $HTPLNF CHRDTP=2.4638, SSPNE=10.4288, SSPN=11.0865, CHRDR=9.8552,
   SAVSI=37.0, CHSTAT=0.25, DHDADI=8.5, TYPE=1.0$
 $ASYFLP STYPE=6.0, NDELTA=5.0, SPANFI=9.2024, SPANFO=17.9959,
   DELTAR=-25.0,-15.0,0.0,15.0,25.0, CHRDFI=3.5177, CHRDFO=1.4351$
CASEID B/W/HT/VT, B747-200F (Case 8, ASYFLP = Rudder)
DAMP
NEXT CASE
 $FLTCON NMACH=5.0, MACH=0.075,0.151,0.226,0.302,0.377,
   NALT=5.0, ALT=0.0,0.0,0.0,0.0,0.0,
   NALPHA=7.0, ALSCHD(1)=-5.0,0.0,5.0,10.0,15.0,20.0,25.0$
 $SYNTHS XCG=31.5211, ZCG=4.5, XW=18.27, ZW=2.7586, ALIW=2.8$
 $BODY NX=20.0, BNOSE=2.0, BTAIL=2.0, BLN=23.091, BLA=19.304, ITYPE=3.0,
   X(1)= 0.000,2.309,4.618,6.927,9.236,11.545,13.855,16.164,18.473,20.782,
      23.091,23.120,42.424,46.169,49.914,53.659,57.403,61.148,67.816,68.637,
   R(1)= 0.000,1.588,2.197,2.619,2.911,3.118,3.232,3.253,3.253,3.253,3.253,
      3.253,3.253,3.253,3.221,2.934,2.381,1.721,0.464,0.000,
```

```
 ZU(1)=5.629,7.468,8.769,9.881,10.030,10.043,9.957,9.798,9.585,9.322,8.995,
      8.995,8.995,8.995,9.006,9.103,9.052,9.014,9.185,8.144,
 ZL(1)=5.629,3.924,3.200,2.737,2.457,2.286,2.197,2.184,2.184,2.184,2.184,
      2.184,2.184,2.362,2.902,3.680,4.489,5.280,6.683,8.144$
$WGSCHR TCEFF=0.1, TYPEIN=2.0, NPTS=50.0,
 XCORD=0.0,0.0001,0.0002,0.0004,0.0008,0.0014,0.002,0.003,0.004,0.005,0.006,
      0.008,0.010,0.012,0.014,0.020,0.026,0.032,0.04,0.05,0.06,0.07,0.08,
      0.10,0.12,0.14,0.16,0.19,0.22,0.26,0.30,0.35,0.40,0.45,0.50,0.55,0.60,
      0.65,0.70,0.74,0.78,0.82,0.86,0.90,0.93,0.95,0.97,0.98,0.99,1.0,
 MEAN= 0.0000000,0.0000300,0.0000500,0.0000250,0.0000260,0.0000400,0.0000550,
      0.0000200,-0.0000045,-0.0000845,-0.0001345,-0.0002100,-0.0002840,
      -0.0003200,-0.0004195,-0.0006595,-0.0008000,-0.0009300,-0.0010345,
      -0.0010945,-0.0010945,-0.0010300,-0.0009245,-0.0006100,-0.0002095,
      0.0001955,0.0006050,0.0011755,0.0017150,0.0024500,0.0032505,0.0041905,
      0.0052705,0.0064705,0.0078755,0.0095150,0.0114105,0.0134455,0.0153960,
      0.0165255,0.0172760,0.0170555,0.0156655,0.0129350,0.0099805,0.0075850,
      0.0048805,0.0034155,0.0018800,0.0002700,
 THICK=0.0000000,0.0033000,0.0051000,0.0071300,0.0099500,0.0130600,0.0155300,
      0.0187400,0.0212290,0.0234290,0.0252890,0.0283800,0.0309500,0.0331200,
      0.0351790,0.0402390,0.0443200,0.0479600,0.0522290,0.0568910,0.0609890,
      0.0646400,0.0679290,0.0735600,0.0781790,0.0820310,0.0852300,0.0891690,
      0.0923300,0.0957000,0.0981210,0.1001410,0.1006990,0.0996990,0.0969310,
      0.0922100,0.0854390,0.0766890,0.0661500,0.0569710,0.0468300,0.0367490,
      0.0313310,0.0258700,0.0199610,0.0151700,0.0097610,0.0068310,0.0037600,
      0.0013600$
```

```
 $WGPLNF CHRDTP=4.064, SSPNE=26.5704, SSPN=29.8216, CHRDR=14.0663,
SAVSI=40.76,
   CHSTAT=0.0, TWISTA=-3.5, DHDADI=7.0, TYPE=1.0$
 $SYMFLP FTYPE=5.0, NDELTA=2.0,
   DELTA=10.0,20.0,
   PHETE=0.000634278, PHETEP=0.000482512, CHRDFI=1.4650, CHRDFO=1.4650,
   SPANFI=6.1500, SPANFO=8.3376$
CASEID B/W/HT/VT, B747-200F (Case 9, Speed brakes modeled as a split flap)
DAMP
```

RUNDATCOM.IN

```
NAME OF AERO OUTPUT FILE                  AERO01.DAT
DEBUG MODE (T=ON, F=OFF)                  F
TOTAL NUMBER OF CASES                    9
CASE NUMBER OF CLEAN CONFIGURATION                4
CONFIGURATION CODE(B=1, W=2,...,BWHV=11)          11
LOCE CONFIGURATION (1=e(NA), 2=AMHT, 3=AMHT+e)   3
Ground effect (0=no, 1=yes(ft), 2=yes(m))        0
NUMBER OF LOCE DEFLECTION                   9
LoCE DEFLECTIONS                     -23.0
                           -20.0
                           -15.0
                           -5.0
                           0.0
                           5.0
                           10.0
                           15.0
                           17.0
1ST AMHT CASE (read but not used if 1)           1
LAST AMHT CASE                      5
AMHT DEFLECTIONS                      15.0
                           10.0
                           5.0
                           0.0
                           -5.0
Number of LACE                    2
```

```
Alieron=1, Spoiler=2                    1

CASE NUMBER OF LACE RUN                          6

NUMBER OF LACE DEFLECITONS                         9

LACE DEFLECTIONS                             20.0

                                   15.0

                                   10.0

                                   5.0

                                   0.0

                                   -5.0

                                   -10.0

                                   -15.0

                                   -20.0

Alieron=1, Spoiler=2                    2

CASE NUMBER OF LACE RUN                          7

NUMBER OF LACE DEFLECITONS                         5

LACE DEFLECTIONS                             0.0

                                   15.0

                                   25.0

                                   35.0

                                   45.0

NUMBER OF DICE DEFLECITONS                         5

ZV (Z DISTANCE FROM XCG TO A.C. OF VT IN FT)     28.8822

LV (X DISTANCE FROM XCG TO A.C. OF VT IN FT)     99.8554

DICE DEFLECTIONS                            -25.0

                                   -15.0

                                   0.0
```

```
                              15.0
                              25.0
Speed Breaks (1=Yes, 0=No)                  1
Case Number of speed breaks                 9
Number of speed break deflection            2
Speed Break Deflection(s)                -10.0
                              -20.0
Landing Gear increments (1=yes, 0=no)         1
Number of main gear                     4
Number of nose gear                     1
Number of main gear wheel columns              4
Number of nose gear wheel columns              1
Number of main gear wheel rows              2
Number of nose gear wheel rows              1
Frontal area of main wheels (m^2)            0.5808
Frontal area of nose wheels (m^2)            0.5808
Length of main Landing gear (m)              2.5993
X Locaction of main landing gear (SI from Nose)  34.2519
Z Location of main landing gear (SI from Nose)   0.5334
X Location of the nose gear (SI from Nose)       10.1854
Z location of the nose gear (SI from Nose)       0.7239
number of flap settings                  7
FTYPE ALPHA bi    bo    Cfi    Cfo    PHETE    PHETEP    CPRMEI  CPRMEO CAPINB  CA-
POUT DOBDEF DOBCIN DOBCOT
0
1
```

```
8     30.0  5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0      0.0    0.0    0.0
0.0
1
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0      0.0    0.0
0.0    0.0
2
8     30.0  5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0      0.0    0.0    0.0
0.0
3     10.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0      0.0    0.0
0.0    0.0
2
8     30.0  5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0      0.0    0.0    0.0
0.0
3     20.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0      0.0    0.0
0.0    0.0
2
8     30.0  5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0      0.0    0.0    0.0
0.0
3     25.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0      0.0    0.0
0.0    0.0
2
8     30.0  5.9246 29.1522 0.8133 0.8128 0.0       0.0       13.9007 5.0451 0.0      0.0    0.0    0.0
0.0
3     30.0  3.2512 20.8979 1.5166 0.6358 0.0012283 0.0014263 16.0987 5.6637 0.0      0.0    0.0
0.0    0.0
```

APPENDIX E

B747-200F MODEL WING BACJ AIRFOIL COORDINATES

BOEING AIRFOIL J

50.	51.
0.000000	0.000000
0.000101	0.001680
0.000200	0.002600
0.000400	0.003590
0.000801	0.005001
0.001399	0.006570
0.002000	0.007820
0.003001	0.009390
0.004000	0.010610
0.005001	0.011630
0.006000	0.012510
0.008000	0.013980
0.010000	0.015191
0.012000	0.016240
0.014000	0.017170
0.019999	0.019460
0.026001	0.021360
0.032001	0.023050
0.040000	0.025080
0.050000	0.027351
0.060000	0.029400
0.069999	0.031290
0.080001	0.033040

0.100000	0.036170
0.120000	0.038880
0.140001	0.041211
0.160000	0.043220
0.190001	0.045760
0.220000	0.047880
0.260000	0.050300
0.300000	0.052311
0.350001	0.054261
0.400001	0.055620
0.449999	0.056320
0.499999	0.056341
0.549999	0.055620
0.599999	0.054130
0.649999	0.051790
0.700000	0.048471
0.740000	0.045011
0.780000	0.040691
0.819999	0.035430
0.859999	0.029190
0.900000	0.021990
0.929999	0.016020
0.950000	0.011830
0.969999	0.007521
0.979999	0.005340
0.990000	0.003150

1.000000	0.000950
0.000000	0.000000
0.000101	-0.001620
0.000200	-0.002500
0.000400	-0.003540
0.000801	-0.004949
0.001399	-0.006490
0.002000	-0.007710
0.003001	-0.009350
0.004000	-0.010619
0.005001	-0.011799
0.006000	-0.012779
0.008000	-0.014400
0.010000	-0.015759
0.012000	-0.016880
0.014000	-0.018009
0.019999	-0.020779
0.026001	-0.022960
0.032001	-0.024910
0.040000	-0.027149
0.050000	-0.029540
0.060000	-0.031589
0.069999	-0.033350
0.080001	-0.034889
0.100000	-0.037390
0.120000	-0.039299

0.140001	-0.040820
0.160000	-0.042010
0.190001	-0.043409
0.220000	-0.044450
0.260000	-0.045400
0.300000	-0.045810
0.350001	-0.045880
0.400001	-0.045079
0.449999	-0.043379
0.499999	-0.040590
0.549999	-0.036590
0.599999	-0.031309
0.649999	-0.024899
0.700000	-0.017679
0.740000	-0.011960
0.780000	-0.006139
0.819999	-0.001319
0.859999	0.002141
0.900000	0.003880
0.929999	0.003941
0.950000	0.003340
0.969999	0.002240
0.979999	0.001491
0.990000	0.000610
1.000000	-0.000410
1.000000	0.000950

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BIOGRAPHICAL INFORMATION

Brandon Watters's interest in design started at a young age without knowing it. He was born in 1987 in Fort Wayne Indiana. At age 5 he moved to Texas with his family where he has been ever since. Up to age 9 his favorite toys were LEGO's, K'NEX, Steel Tec, and Erector Set. At that age he began building and flying remote control (R/C) planes with his dad. Throughout high school at Trinity High School he continued to fly R/C planes while officiating and playing soccer. After being involved with R/C planes for years and flying to see family up north many times he became curious as to "Why do planes look the way they do?". Upon high school graduation it became clear to him that this curious question and drive to design things lead him to choose Aerospace Engineering for a college degree.

After the first two years of college at The University of Texas at Arlington (UTA), he yearned to put cameras on his planes. After joined and being involved with multiple engineering societies he soon discovered the Autonomous Vehicles Laboratory (AVL) at UTA. Here he used his experience with R/C planes and ambition to learn to design and build unmanned aerial aircraft (UAV). This was his first true introduction to design. After 2 years in AVL and winning multiple awards at the 2008 International AUVSI Student Unmanned Air Systems (UAS) Competition he entered his senior design class.

The senior design class introduced him to the Aerospace Vehicle Design (AVD) Laboratory. After graduating in 2009 with his B.S. degree he decided to pursue his Masters of Science in the AVD Lab at UTA. During his research he has contributed to industry contracts and served as the aerodynamics specialist for the AVD Laboratory. Most importantly though learning about the conceptual design process and "understanding why planes look the way they do".

His future plans are finding a job involving design of UAV's and enjoying his hobbies, which are scuba diving, snowboarding, wakeboarding, skydiving, motorcycling, and bicycling.