give a coefficient that has not dimensions, or dimensionless. A same procedure is used on the lift and drag equations to get Cl and Cd, for the coefficient of lift and coefficient of drag respectively. Much of what is needed for background on flight and flight dynamics, that is for data analysis, centers around these three coefficients: Cm, Cl, and Cd.

3-1: Cl, Cd, and Cm on seleted Aircraft.

It is necessary to look at some numbers for these three coefficients in order to get a feel for the coefficient of lift, the coefficient of drag, and the moments coefficient; even before we look at the equations. Dr. Robert C. Nelson[1] has made an excellent contribution in Appendix B in providing many detailed specs for specific aircraft, 14 specs for the C coefficients; but now we will only compare the three primary Cs of Cl, Cd, and Cmalpha for the following aircraft: the Jetstar business aircraft, the General Aviation Navion, the Convair 880[2],and the Boeing 747.

TABLE 1. Aerodynamic Coefficients for Aircraft.[a]

	Cl	Cd	Wing Area, S in square feet	Cmalpha
Convair 880	.68	.08	2000	-0.903
Boeing 747	1.11	.102	5500	-1.26
Jetstar Bussines Aircraft	.737	.095	542.5	-3.0
A-4D	.28[b]	.03	260	-0.38
Navion General Aviation Aircraft	.41[c]	.05	184	-.683
F-104	.735	.263	196.1	-.64
STOL transport[d]	1.5	.127	945	-0.78

a. Actually these coefficients, in order to simplify at this point in the book are for the longitudinal axis only, only at a speed of Mach .25, and only for sea level.

b. Those delta wings in those days did not provide as much lift, however it should be noted that the wings had only 260 square feet of area.

c. Much lower lift than Convair 880, 747, and Jetstar, but more lift than A4-D. But compare the wing areas.

1. FLIGHT STABILITY AND AUTOMATIC CONTROL.

d. We need one low speed tuboprop aircraft for comparison since another focus of this book will be on simulation with MATLAB of a transport aircraft and of the F-16. The closest spec FS&AC offers us of a jet like the F-16 is the A-4D, which is a ways back in history before the F-16; but some of the first elogated experiment flights at NASA on a UAV was on an A-4D offered to them by Naval Aviation.

1. You will come to expect low numbers like .68, .08, and -.903--all less than 1; andthe why of this will be discussed when we take a look at the equations.

2. It would make sense that the Aerodynamic Coefficients for the Boeing 747 would have higher numbers than for the Convair 880 since it is a much larger aircraft. The weight of the 747 is 636,600 pounds, and that of the Convair 880 was 126,000 pounds. And you notice that 2 of the coefficients for the 747 are above 1, Cl = 1.11 and Cmalpha = -1.26.

3. I guess that we are not surprised that the Jetstar has more lift than the 880 and less than the 747. If we respectively compare the surface area of the wings respectively of the Jetstar at 542.5 square feet, that of the 747 at 5,500 square feet, and that of the 880 at 2,000 square feet, that relationship is exactly what we would expect for the coefficients.

4. Wow {and not for Weight on Wheels}, look at the lift of the STOL transport aircraft, so we are not surprise to see a wing area of 945 square feet and a weight of only 40,000 pounds. The wing area of the transport aircraft we will simulate in MATLAB has a weight of 162,000 pounds and a wing area of 2170 square feet.

Please keep in mind that we an only provide in summary form a drop in the bucket of both basic aerodynamics and stability and control dynamics; that only which is required for TECHNICAL APPLICATIONS OF COMPUTERS, and in particular Data Analysis, and such is the way it should be lest we feebly try to compete with uncessarily with the experts like Anderson, and Stevens and Lewis. In other words, if you want a good, thorough book on Flight and Flight Mechanics read a book like the one by Anderson or on flight contol and simulation, read the one by Stevens and Lewis. {This chapter has tried to cull some of their essentials, by research while avoiding plagarism, combing those salient points of stability and control aerodynamics with many other recognized authori-

2. When Lockheed Martin at Fort Worth was still General Dynamics {in one of the dumbest moves in history the former astronaut Bill Anders sold GDFW to Lockheed even though it made over 50% of the profit for GD}, the Convair 880 made its last flight to Europe dropping off our F-16 teams at various bases to unground the F-16s. My team was dropped at Brussels to go to Beuvechan AFB; and as far as I know was the first to fly after the world-wide grounding.

ties, also with the practical applications in Flight Test Reports from the NASA Dryden and Langley servers.}

For the purpose of this book only and in this one chapter, we will do a little Systems Integration of our own, briefly integrating the two diverse subjects of flight Aerodynamics with that of Automatic Control, also in the Transport Aircraft MATLAB simulation, adding optimization. Actually the integration will be larger than that consisting of the bringing together in one chapter what has generally be called the disciples of and the title of books on flight mechanics, aerodynamics, the history of flight, automatic control, and flight test and simulation.[1] Ambitious yes; but that is far better than trying in one book on DATA ANALYSIS for Systems Integration to attempt an inclusion of even one complete chapter on these diverse but closely related subjects. Then except for a few "aerodynamic moments" in each chapter, we will have sufficient background to proceed into simulation, automatic control, and flight itself. The challenge of such integration will be assisted by a focus on those aspects of flight aerodynamics and automatic control that most easily lend themselves to data analysis. As a matter of fact, if a more scholarly and longer title were chosen for this chapter, it could be "Systems Integration of Flight Aerodynamics and Automatic Control for Simulation and Data Analysis". Never forget that when large flight simulators are

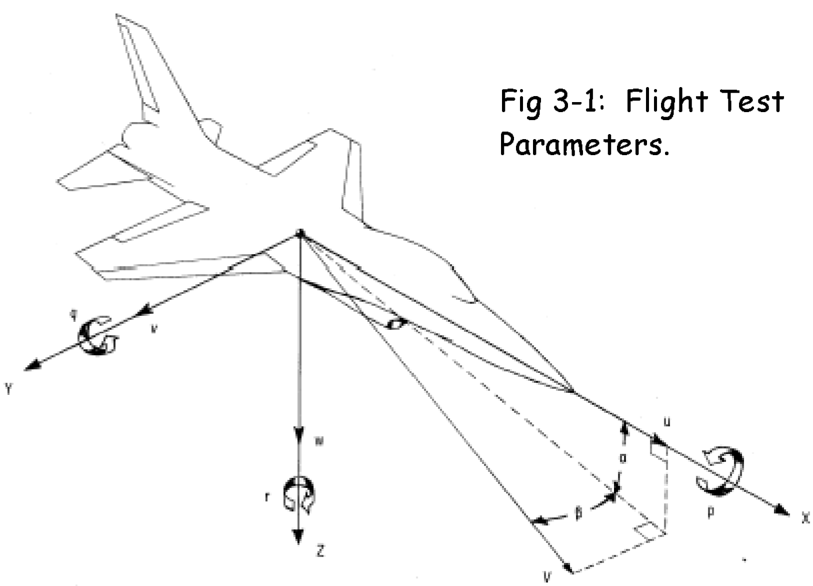

Fig 3-1: Flight Test Parameters.

1. For example Anderson on INTRODUCTION TO FLIGHT and Stevens and Lewis on AIRCRAFT CONTROL AND SIMULATION. Also FLIGHT DYNAMICS and THE AERODYNAMICS OF FLIGHT.

used like at NASA Dryden and Wright Patterson, the simulator comes first then the simulator data; and during actual flight test, that previously collected and analyzed data from the simulation both gives clues for flight test and gives another standard for comparison. {That is actual flight test data versus flight simulator data.} And in this day and time of fuel costs and the economic crunch, more and more aircraft and missile companies are turning to increased simulation for testing.

3-2: Steady State Flight with Principles of Stability and Control.

(NOTE: Sect 2.6, 3.6, and 3.7 of S&L and chp 7 of Anderson)

We pilots call this flight condition, "straight and level": in aerodynamics the more acceptable terminology is "Principles of Stability and Control." Airplane control, according to a recognized authority on Flight[1] is defined as:

Deflections of the flight control surfaces like the ailerons, elevators, and rudders to shift equilibrium positions {we will shortly come to the energy concept and equations for aircraft which is much like the basic kinetic energy versus potential energy concepts of physics, K.E. = 1/2 mv^2 and P.E. = h g}, or produce nonequilibrium accelerated motions called flight manuvers[2].

For purposes of data analysis, this entails a measurement of the deflections of these flight control surface, generally with transducers on motion sensors connected physically to those control surfaces; then the data collected in an onboard computer like in ATIS or the newer CAIS, then transmitted to ground for analysis by a special kind of radio signal called Telemetry. So ultimately designers, and the pilot learning to fly that particular aircraft, must decide what amount of deflection is required to do what is expected at that time, and beyond that how much force is required for that amount of deflection. Of course, technically we must have numbers of the deflection and for the force. Remember while the force in such small aircraft like the Piper Cherokee Arrow that most of us fly is almost directly on the control surfaces {that is directly and physically connected by a mechanical linkage}, the force in aircraft such as the F-16 and newer FBW (Flight By Wire) commercial aircraft is on a transducer. That proper

1. For enjoyable research and reading you can not beat John D. Anderson Jr's INTRODUCTION TO FLIGHT. In this easy to read and understand book, he combines his knowledge and skill from being a Curator of Aerodynamics at the Smithsonian and Professor Emeritus at the University of Maryland.
2. Focus on flight and especially flight test will be on four typical manuvers of flight test: the dutch roll, short period, phugoid, roll, and spiral.