WHITE EAGLE
AEROSPACE

Fundamentals of 6-DOF Aerodynamics Models

MAKE YOUR CAREER SOAR

Welcome

Thank you very much for your interest in White Eagle Aerospace. Since our founding in 2006, we have become a trusted leader in professional technical training and education throughout the aerospace industry.

As a fellow aerospace professional with over 50 years of industry experience, I understand the critical need for ongoing technical training in the workplace. White Eagle Aerospace was established in order to meet this pressing need.

For many years, we have recognized a looming crisis in the aerospace workforce. Throughout the industry, there is an increasingly bimodal distribution of aerospace professionals. One end of that distribution contains young, well trained, highly motivated, but very inexperienced professionals. The other end of that distribution involves individuals who have been around for a long time, have a great deal of experience and are on their way out of their chosen profession. This leaves a valley between the two.

Who is going to pass the baton to the upcoming generation of aerospace professionals? Where will they get their knowledge – knowledge that goes beyond academia and even graduate degrees? Much of what they need to know is not available in today's standard university curricula. What they need is:

- Specialized knowledge over a range of disciplines
- Knowledge provided by an experienced expert in the field
- Knowledge conveyed by a master instructor

White Eagle Aerospace recognizes these issues and provides effective solutions for your workforce. We are pleased to present you with this brochure, which outlines our Aerodynamics For Engineers (AFE) professional short course. Our team of industry experts and master instructors is dedicated to your success. Should you have any questions about our course catalog or desire more information on how we can help MAKE YOUR CAREER SOAR, please contact us today.

Best Regards,

John Terry White

John Terry White,
President/CEO
White Eagle Aerospace

About Our Company

Whether you are new to the aerospace industry or have years of professional experience, we are your provider-of-choice for expert technical training.

Acquiring key knowledge, critical lessons-learned and technical know-how are crucial ingredients for success in today's complex and highly competitive aerospace market. Our nationally-acclaimed short courses cover a wide range of highly useful technical subjects. Each course is delivered by a subject matter expert who is also an expert technical instructor.

We offer you comprehensive technical training in essential topics, with minimal time away from work – all at a price that fits today's tight training budgets.

Target Audience

The Fundamentals of 6-DOF Aerodynamics Models (FAM) short course provides participants with in-depth technical training in the proper synthesis of coupled 6-degree-of-freedom aerodynamic force and moment models applicable to missile-like airframes configured with control surfaces arranged in cruciform.

This course is intended for those seeking to learn and correctly apply rigorous methodological schemes for producing high-fidelity 6-DOF aerodynamics models used in the flight simulation of tactical missiles, sounding rockets, launch vehicles, projectiles and similar vehicular configurations.

Special emphasis is placed on the accurate modeling of coupled 6-DOF in-channel and cross-channel aero effects associated with simultaneous pitch, yaw, and roll control deflections. Modeling scheme-required wind tunnel test and aero uncertainties requirements are also considered.

Delivered by a master instructor and subject matter expert with over 50 years of professional aerospace experience, this novel 3-day training course will provide participants with invaluable real-world knowledge, enhanced understanding and improved competency in this critical discipline.

Who Will Benefit

- **Aerodynamics Engineers**
- **Flight Simulation Specialists**
- **Airframe Designers**
- **Launch Vehicle Designers**
- **Flight Controls Specialists**
- **Systems Engineers**
- **Sounding Rocket Specialists**
- **Autopilot Specialists**
- **Program Managers**
- **Project Engineers**
- **College Students**
- **College Faculty**
- **Flight Test Engineers**
- **Flight Dynamicists**
- **Wind Tunnel Engineers**

Group Discounts

White Eagle Aerospace is dedicated to meeting your organization's professional training needs. In order to better serve you, we offer special group discounts rates and on-site training. If you have a group of 15 or more participants, we will bring our nationally acclaimed AFE short course to your location at a discounted rate. Please contact us today to learn how we can help MAKE YOUR ORGANIZATION SOAR!

Course Description

Fundamentals of 6-DOF Aerodynamics Models (FAM) offers an in-depth training experience in the formal and rigorous synthesis of professional-grade 6-DOF force and moment aerodynamics models used in 6-DOF trajectory flight simulations. Pertinent applications include tactical missiles, sounding rockets, launch vehicles, and projectiles.

The Body Axis and Maneuver Axis Coordinate Systems are discussed in detail. Airframe aerodynamic attitude is defined in terms of total angle-of-attack and aerodynamic roll position . Body Axis and Maneuver Axis steering controls are defined and their use in the aero modeling process.is explained.

The subject of mutual aerodynamic interference is clearly delineated as is the closely allied principles of aerodynamic coupling. Roll-dependent basic stability aerodynamic force and moment characteristics are discussed from the standpoints of data periodicity and recurrence.

The attributes of a high-fidelity 6-DOF Aerodynamics Model architecture for body-wing-tail and body-tail configurations are highlighted. The basic stability and control effectiveness components of the aero model are thoroughly discussed.as is the topic of a companion, high-quality aero uncertainties model.

Single Panel, Dual Panel, and Multi-Panel Modeling Schemes are presented and thoroughly examined. The ability of each scheme to capture important panel-panel interference effects is characterized.

Key Course Topics

- Missile Coordinate Systems
- Body Axis System
- Aero Forces and Moments
- Maneuver Axis System
- Steering Controls Schemes
- Mutual Aerodynamic Interference
- Aerodynamic Coupling
- 6-DOF Aero Models
- Aerodynamic Modeling
- Wind Tunnels
- Aerodynamic Architecture
- Basic Stability
- Control Effectiveness
- Aero Uncertainties
- Aero Data Tables
- Body-Wing-Tail
- Body-Canard-Tail
- Body Alone
- Combined Tail
- Panel-Panel Interference
- Roll-Dependent Aerodynamics
- Body-Tail

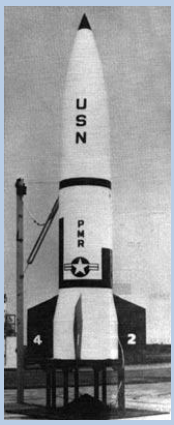


Course Outline

Fundamentals of 6-DOF Aerodynamics Models (FAM) is a first course in the discipline of 6-DOF aerodynamic force and moment modeling. With an emphasis on accurately capturing aerodynamic coupling effects for vehicles with control surfaces arranged in cruciform, powerful, but little-known, aerodynamic modeling schemes are presented. Real-world applications include tactical missiles, sounding rockets, launch vehicles, and projectiles.

Fundamentals of 6-DOF Aerodynamic Models Module Overview

Day	Module	Lecture Title	Key Topics
1	1	Coordinate Systems	Body Axis system, Maneuver Axis System, Body Axis Controls Scheme, Maneuver Axis Controls Scheme, Aerodynamic Attitudes.
	2	Mutual Aerodynamic Interference	Panel-due-to-body, body-due-to-panel, panel-due-to-panel, body upwash, panel carryover, body and panel vortices
	3	Aerodynamic Coupling	Cruciform control surface group. Intended aero effects. Aero Coupling effects. Byproduct aero effects.
2	4	Roll-Dependent Aerodynamic Characteristics	Control panel arrangement. Periodicity interval. Recurrence interval, basic stability aerodynamics.
	5	6-DOF Aerodynamics Models	Modeling architecture. Modeling structure. Basic stability. Control effectiveness. Panel-panel interference.
	6	Single Panel Modeling Scheme	Individual control panel deflection. Aero force and moment build-up equations. 6-DOF body axis aero data.
3	7	Dual Panel Modeling Scheme	Pitch, yaw, and roll body axis controls. Aero force and moment build-up equations. 6-DOF body axis aero data.
	8	Multi-Panel Modeling Scheme	Elevator, rudder, and aileron maneuver axis controls. Aero force and moment build-up equations. 6-DOF maneuver axis aero data.
	9	6-DOF Aerodynamics Database	Wind tunnel testing. Computational Fluid Dynamics. Aero force and moment data table generation. Aero data uncertainties.



Aerospace History

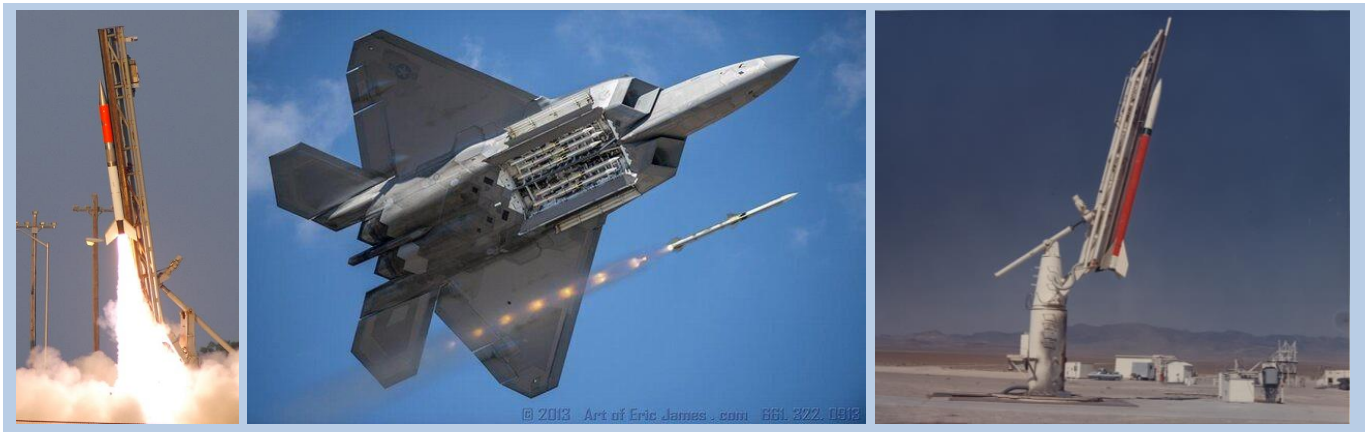
Much has transpired during the 100-plus years of powered flight. We are both the beneficiaries and stewards of the technological progress that previous generations have bequeathed to us.

However, many professionals in today's aerospace workforce have little knowledge of the key people, events and innovations that comprise the history of their own profession. While we cannot live in the past, we must learn from it if we are to be successful now and in the future. Further, like our predecessors, we must protect and preserve this legacy knowledge for succeeding generations.

It is for these reasons that White Eagle Aerospace strongly emphasizes aerospace history in its technical short courses. This is done through the mediums of lecture material, videos, and photos. The Fundamentals of 6-DOF Aerodynamics Models (FAM) short course features several key historical programs.

Featured Programs

- **STANDARD Missile**
- **Sparrow**
- **Sidewinder**
- **HARM**
- **RAM**
- **Tomahawk**
- **AMRAAM**
- **HARPOON**
- **ATACMS**
- **Genie**
- **Patriot**



Information at a Glance

The Fundamentals of 6-DOF Aerodynamics Models (FAM) short course provides a comprehensive training experience in the synthesis of high-fidelity 6-DOF Aerodynamics Models applicable to tactical missiles, sounding rockets, launch vehicles projectiles, and similar vehicular configurations.

This novel training course is intended for those seeking to learn and correctly apply rigorous methodological schemes for producing high-fidelity 6-DOF aerodynamics force and moment models applicable to missile-like vehicles configured with control surfaces arranged in cruciform.

Delivered by a master instructor and subject matter expert with over 50 years of professional aerospace experience, this novel 3-day training course will provide participants with invaluable real-world knowledge, enhanced understanding and improved competency in this critical discipline.

Contact White Eagle Aerospace

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Key Course Information

- **Instructor:** J. Terry White
- **Duration:** 3 instructional days; 24 instructional hours.
- **Materials:** 1) Comprehensive set of course lecture slides in bound form and 2) DVD containing course lecture slides, images, videos, reference documents and homework solutions.
- **Cost:** $2,000 for single seat.
- **Registration:** Please visit our website to view the most current Course Calendar. To register for a scheduled course, simply complete and submit the online registration form.
- **Group Discounts:** In order to better serve your organization, we offer special group discount rates and on-site training. For information, please contact Phyllis White at pjwhite@whiteeagleaerospace.com.

J. Terry White

Aerosciences Instructor

John Terry White is president and CEO of White Eagle Aerospace. With headquarters in Oro Valley, Arizona, White Eagle Aerospace is a leading provider of engineering consulting, professional training, historical flight lectures and technical publication services to the aerospace community.

White's over 50 years of professional aerospace experience includes the NASA Space Shuttle Program, NASA X-43A Flight Project, and United States Navy STANDARD Missile Program. During his extensive career, he has served on the engineering technical staff of Rockwell International, General Dynamics Corporation, Hughes Missile Systems Company, NASA Dryden Flight Research Center and Raytheon Missile Systems.

In 2009, White completed a 2-year assignment as manager of the Aerodynamics Department in the Guidance, Navigation, and Control Center at Raytheon Missile Systems in Tucson, Arizona. In this capacity, he was responsible for all aerodynamics work performed at the world's largest tactical missile producer. White resigned from Raytheon in 2010 as an Engineering Senior Fellow in Aerodynamics.

White has authored more than 180 technical papers on a wide variety of aeroscience and aerospace subjects. His teaching credentials include 15 years as an instructor in the Aerospace Engineering Department of the California State Polytechnic University, Pomona, 10 years as an instructor in the professional development program at Raytheon and 6 years developing and teaching courses at White Eagle Aerospace. Those who have taken his courses say that White brings an uncommon passion and extensive technical knowledge to the training environment.

White is particularly well known for his inspiring aerospace history lectures and presentations. These "techno-histories" are intense, fast-paced reviews of historically-significant events in United States aerospace history. He has lectured extensively on aerospace history topics at the USAF Test Pilot School, the Society of Experimental Test Pilots, the National Aeronautics and Space Administration, the American Institute of Aeronautics and Astronautics, academia, and industry. White also serves as a motivational keynote speaker for aerospace conferences, business functions, commemorative events, public service organizations, special interest groups, and private business.

Courses Offered

- **Aerodynamics for Engineers**
- **Aerospace Lessons-Learned**
- **Advanced Missile Aerodynamics**
- **Aerospace Vehicle Performance**
- **Basic Missile Aerodynamics**
- **Basic Rocket Science**
- **Fundamentals of Earth Reentry**
- **Fundamentals of Gas Dynamics**
- **Fundamentals of Hypersonics**
- **Fundamentals of 6-DOF Aerodynamics Models**

Contact Information

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