COLLEGE OF ENGINEERING
KEVIN T. CROFTON DEPARTMENT OF
AEROSPACE AND OCEAN ENGINEERING
VIRGINIA TECH.

AOE 4065 - 4066
Air Vehicle Design

Overview of AVD Courses @ VT

Pradeep Raj, Ph.D.

Professor, Kevin T. Crofton Department of Aerospace and Ocean Engineering*

Virginia Tech, Blacksburg, VA 24061

*Retired in August 2024

Disclaimer

Prof. Pradeep Raj, Aerospace and Ocean Engineering, Virginia Tech, collected and compiled material contained herein from publicly available sources solely for educational purposes during the 2012-2024 time frame.

Although a good-faith attempt is made to cite all sources of material, we regret any inadvertent omissions.

Outline

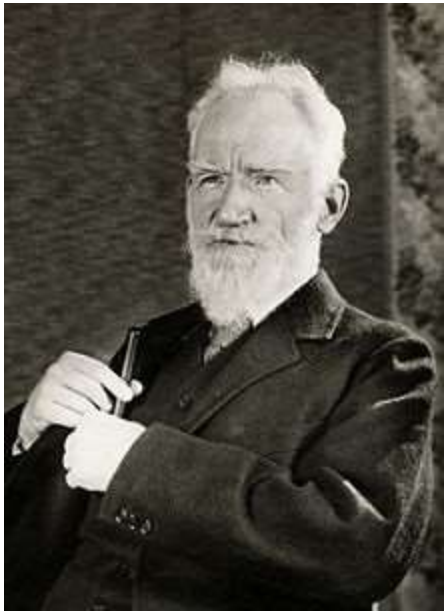
Overview of AVD Courses @ VT

- **Introductory Remarks**
- ***Why*** **we have to take the Design courses**
- ***What*** **we will learn in these courses**
- ***How*** **we will learn what we need to learn**
  - **Approach & Plan**
  - **Resources**
  - **Deliverables & Evaluation/Grading**
  - **Design Team Formation**
- ***Who*** **will help us learn**
- **Appendix**

Air Vehicle Design

"Both optimists and pessimists contribute to the society."

"The optimist invents the aeroplane, the pessimist the parachute."



George Bernard Shaw
1856-1950

A Corollary*:

***Realists* design fixed-wing air vehicles.**

***Extremists* design rotary-wing air vehicles!**

*with due apologies to my friends designing rotorcraft!

Welcome to the 'Optimistic Realists' Club!

Source: Image Wikipedia

COLLEGE OF ENGINEERING
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Air Vehicle Design at VT

A Two-semester Sequence

Learn by Doing

Fall Semester: AOE 4065

- **Scope:** Learn air vehicle ***conceptual design*** process by *independently* doing a ***capstone air vehicle design project*** as a member of a multidisciplinary team while upholding the highest standards of ethics and integrity. Study and apply fundamentals of design. Participate in informal weekly project reviews and formal oral project reviews.
- **Focus:** Hands-on application of knowledge and skills acquired in previous courses (aero, performance, propulsion, S&C, structures, etc.) plus new knowledge acquired by studying material on topics like avionics, landing gear, cost, manufacturing, etc.
- **Classes:** Twice a week, 75-minute long, mainly for discussions; some guest lectures.
- **Outcome:** An innovative feasible baseline design, aka preferred system concept (PSC), that best meets customer needs & expectations; a final written report in proposal style documenting project accomplishments.

Spring Semester: AOE 4066

- **Scope:** Learn air vehicle ***preliminary design*** process by refining and maturing the baseline design. Participate in informal weekly project review meetings and formal oral project reviews. Prepare a final project report in proposal style.
- **Focus:** Peer-to-peer learning and development of life-long learning skills
- **Classes:** Twice a week, 75-minute long, mainly for discussions; some guest lectures.
- **Outcome:** An innovative air vehicle system that is matured enough for detailed design. A final written report in proposal style documenting project accomplishments.

Capstone Design Project: "*Learn by Doing!*"

- Students work as a team on a project to apply what they have learned in earlier classes, and to go beyond what they had in class to find additional information pertinent to their project.
- Students learn the fundamental ideas of the design discipline, and practice teamwork with highest levels of ethical and professional conduct.
- Students acquire/ sharpen and demonstrate the ability to focus on an identified need, create solution concepts, analyze and evaluate those concepts, choose from among them, develop the design to a level appropriate for the resources available, and then deliver a system that meets the need, is ethical and is affordable.
- Students move from *"one problem – one answer"* to *"one need – many answers"* paradigm.

"It Will Complete Your Aerospace Engineering Education."

Capstone Air Vehicle Design Project

The First Day of AOE 4065

Request For Proposal

Request for Proposal

High Capacity Short Range Transport Aircr[illegible]

Background

As the world economy has advanced, [illegible] has access to [illegible]mmercial air travel. A recurring problem that arises [illegible] in air travel is the [illegible]estion of major commercial airports. For [illegible]gestion at airports [illegible]F Kennedy International [illegible]athrow (LHR) result in [illegible]ough flights to meet deman[illegible]rs needing to fly to smalle[illegible]rports. As many of the major world e[illegible] such as China and In[illegible] problem will only become worse.

This Request for Proposal (R[illegible] for the design of an aircraft that addresses this market problem. Specifically, a high ca[illegible]city, short range transport aircraft designed to alleviate airport congestion, without the size and cost that comes with long range capability. This aircraft will have an entry into service (EIS) of 2029, with a passenger capacity of 400 in a dual class configuration, and 3,500 nautical miles of range.

This aircraft should be designed to best serve the market stipulated in the first paragraph. Historical trends of key airplane characteristics may not be appropriate for the non-standard combination of this large seat count and design range.

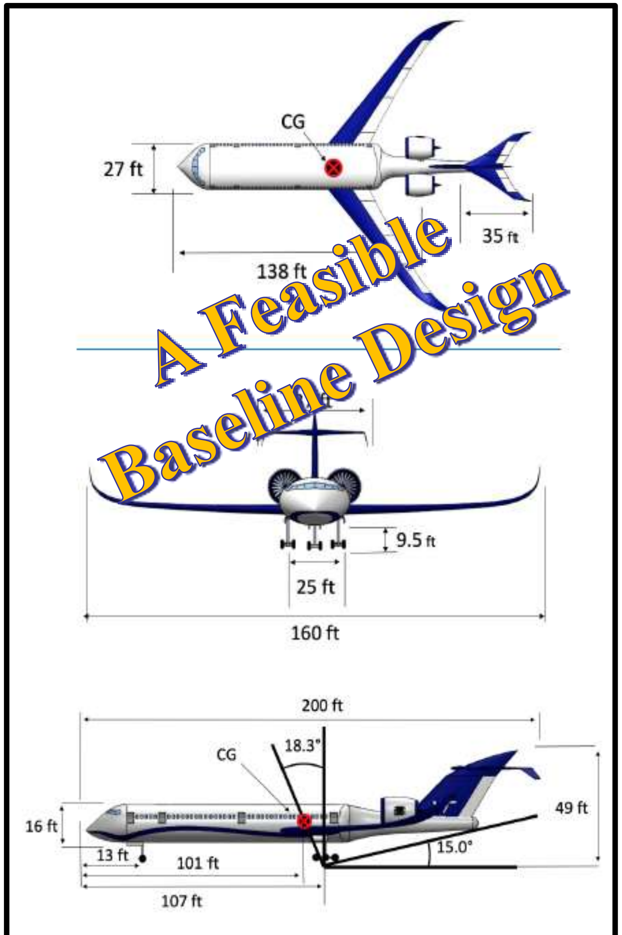
The aircraft is to be designed to meet all the requirements in General Requirements and the requirements in Mission Requirements. The objectives for designer optimization are listed in Design Objectives.

Requirements (M) = Mandatory Requirement (T) = Tradable requirement

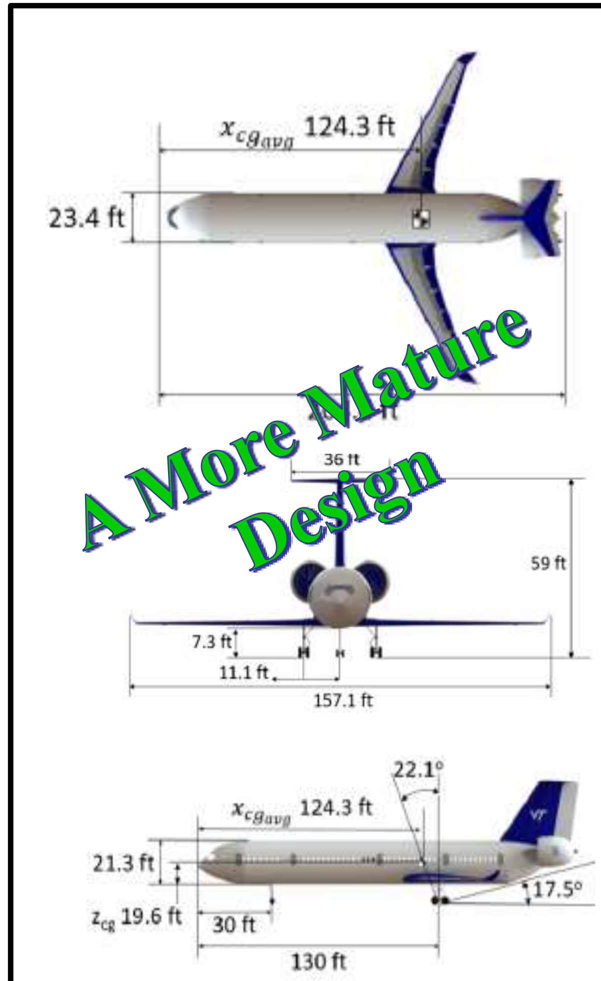
General Requirements

- (M) Capable of taking off and landing from runways (asphalt or concrete)
- (M) Capable of VFR and IFR flight with an autopilot
- (M) Capable of flight in known icing conditions
- (M) Meets applicable certification rules in FAA 14 CFR Part 25
  - All missions below assume reserves and equipment required to meet applicable FARs
- (M) Engine/propulsion system assumptions documented
  - Use of engine(s) that will be in service by 2029

The Last Day of AOE 4065 and the First Day of AOE 4066



The Last Day of AOE 4066!



Importance of Capstone Design Project

The capstone design experience changes the students from

Classroom learner to Life-long learner

Student mindset to Professional mindset

"It's not what they design, but how."

Dr. Leland M. Nicolai
Aircraft Designer

It's the experience, stupid!*

*from famous snowclone *"It's the economy, stupid."* James Carville, 1992

Source: Courtesy of Lee Nicolai; Picture from Internet

Air Vehicle Design:
The Enduring Challenge

"There is no older nor more fascinating question in aeronautical engineering than: *How do you design the best airplane?"*

B.W. Silver

(Grad Student, Stanford University, 1971)

Note: The question isn't "*how do you design an airplane?*"

The question is "*how do you design the best airplane?*"

Air Vehicle Design courses help you learn the skills and competencies required to answer the question.

But first…

What characterizes "best" airplane?

Source: Internet

What Characterizes "*Best*" Airplane

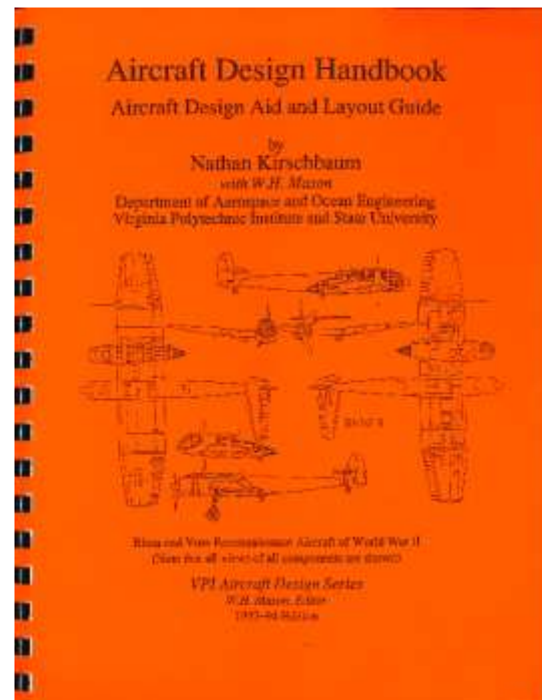
"INTEGRATION of all…geometrical and dimensional requirements, equipment, structural components…into a vehicle that is BALANCED in all phases of its flight envelope and operation on ground... SATISFYING the desired REQUIREMENTS with the lightest weight (or least cost)."

-- Nathan Kirschbaum

Helping VT aircraft design students

Nathan Kirschbaum
(1927-2006)

US Navy (1944-1946)
MIT AE student (1946-1951)
Boeing (1951-1955)
Grumman (1955-1989)
Retired in 1989 as
Chief of Configuration Design
Virginia Tech (1989-2001)
Adjunct Professor of
Aerospace Engineering



Source: Ref. AVD 6

How to Design the “Best” Airplane

Engineers in various disciplines provide “expert advice” and data—on time and on budget—to system integrator (configurator) who generates an INTEGRATED air vehicle that is BALANCED in all phases of flight envelope and ground operations while satisfying all DESIRED REQUIREMENTS with the lightest weight (or least cost).

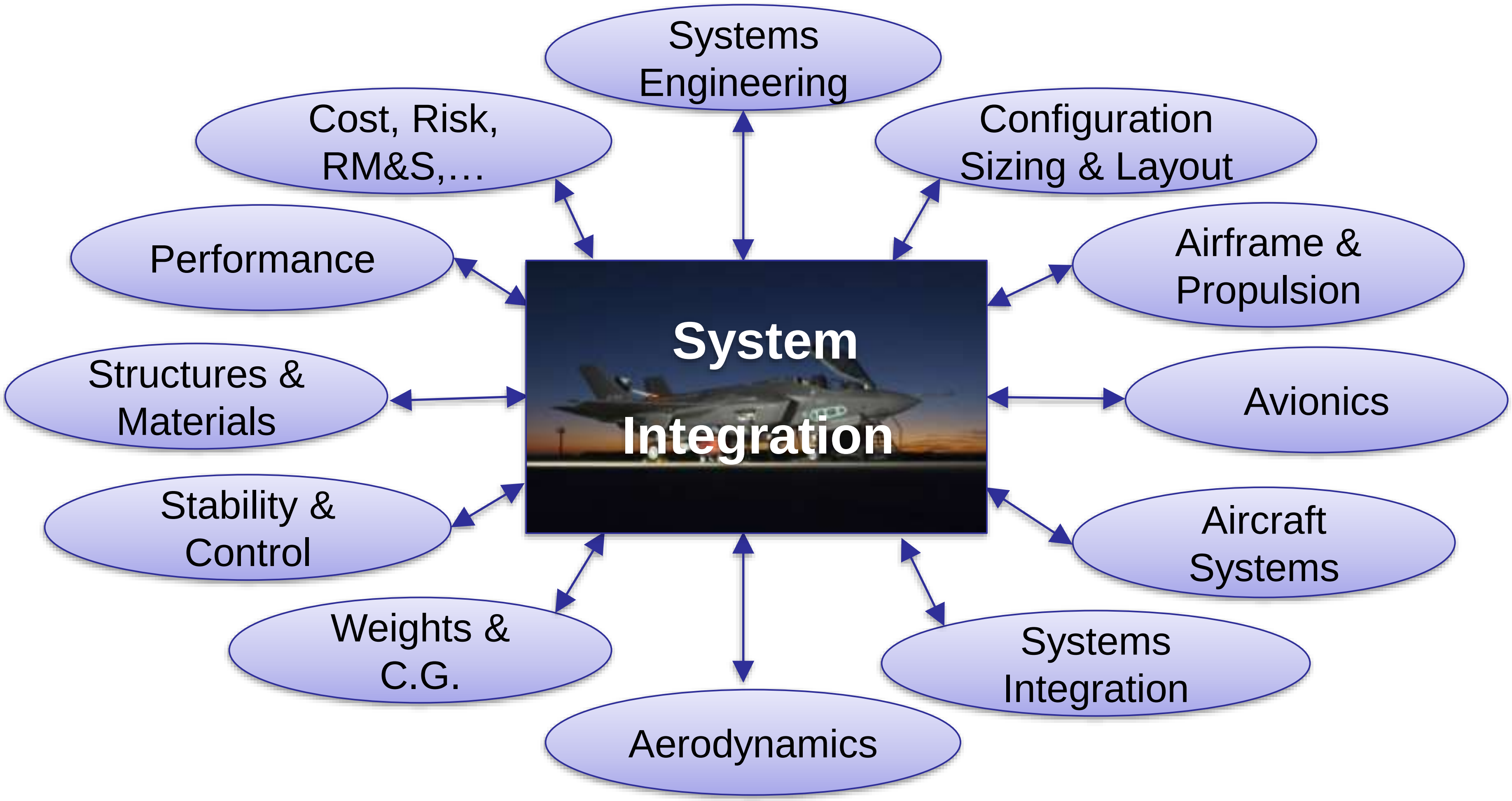
Scope is Too Broad for One Person*

*for typical schedule and cost constraints

Design is a Team Sport!

Source: Internet, Ref. AVD 1, and Ref. AVD 6

A Typical Air Vehicle Design Project



"A Compromise of the Best Efforts of Many Talented Engineers!"

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You Take the Design Courses to Become an ENGINEER!

By taking these courses, you are guaranteed to be fifty percent smarter than you are now!

Engineers don't ask "*Then What?*"

They ask <u>themselves</u> "How" and "Why" and then <u>find answers all by themselves</u>.

Source: http://dilbert.com/strip/2018-07-21

What Distinguishes an Engineer from a Scientist?

"A scientist discovers that which exists.
An engineer creates that which never was."

Theodore von Kármán
1881-1963

"Engineering is in the end *about making something*."

Eugene E. Covert, MIT
1926 - 2015

Engineers use knowledge "for developing new devices"

Source: Internet

"An engineer is *not* a scientist"

Throughout my years in Cal Tech I like to believe that I gave **engineering education** a little push in the right direction and this helped subsequently in creating the kind of engineers needed in the United States. But eventually a strange thing happened. During those years I had emphasized the importance of physics and chemistry in the engineering curriculum and urged **closer cooperation of science and engineering**. I even suggested **social sciences for engineers** interested in management. So, many educators started to think that if a little science is good for engineers a whole lot is better. They gave students more physics and more chemistry, until now the pendulum seems to have swung the other way and **engineering education has become indiscernible from science education**.

I am sorry to say that I do not like this trend. ***An engineer is not a scientist. In addition to basic technical knowledge he must have the creative capacity to design new hardware.*** Engineering schools that fail to recognize and encourage this dual role are remiss in their duty to the profession.

Whether we call future scientists physicists or engineers is not important. What is important I think is to **repair the imbalance** in the scientific world and turn out ***people who not only understand fundamental phenomena but can use this knowledge for developing new devices***. This in turn will not only bring some glory to the engineer, but I think it will contribute substantially to the pace of progress.

-- **Theodore von Kármán**
The Wind and Beyond: Theodore von Kármán, 1967, pp. 157 & 159

Note: Highlighting is mine.

Engineering Design Education—A Brief History

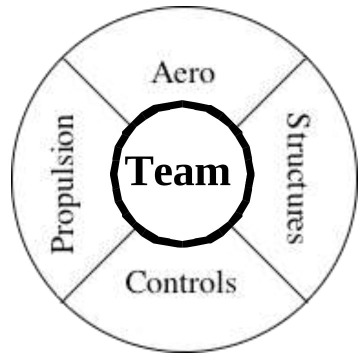
Evolution of Design Practices in Industry

Desire for Higher Performance Led to Increasingly Complex Systems

From early days until the 1950s

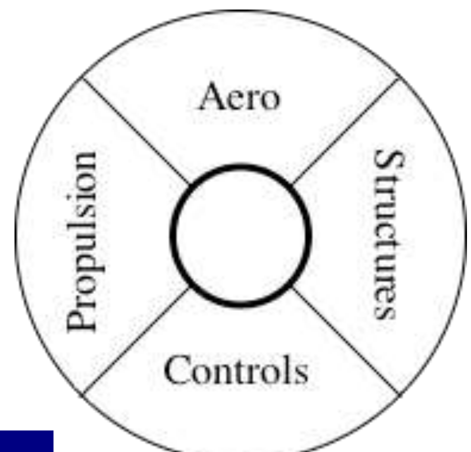
Pioneers, the Central Designer

1960s early 1970s



The Specialty Pie

late 1970s 1980s



The Pie with no center

Dr. Gene Bouchard
Lockheed Corp.

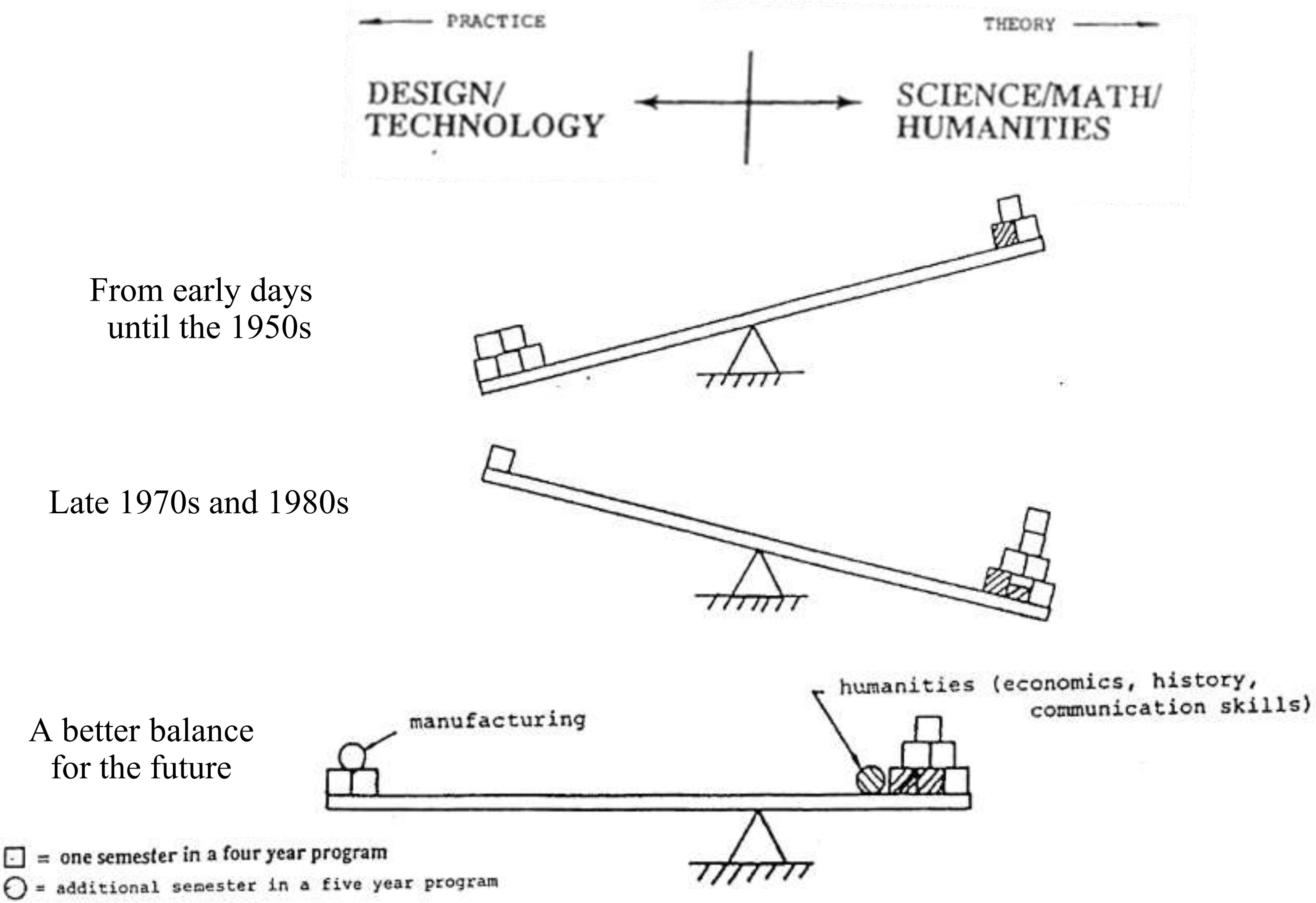
1952 - 2001

How & why did it happen?

Courtesy of W.H. Mason

Engineering Design Education— A Brief History

Evolution of Typical Design Education in Universities (ca 1990)



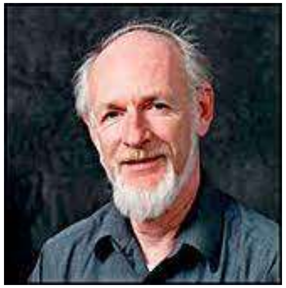
Source: Addendum to AIAA-90-3259, McMasters & Ford

Engineering Design Education

Industry's Perspective of New Hires in the 1980s

McMasters & Ford, AIAA Paper 90-3259, 1990

John H. McMasters, Ph.D.
Boeing Corp.



1939 - 2008

As potential employers of the universities' graduates, we see a pale reflection of what could be. We are no longer "satisfied customers."

- *New hires must serve excessively long apprenticeships before they become fully productive (i.e. we must fill **significant gaps in their educations** as well as providing job-specific training).*
  - *We see **too many new graduates with an inadequate grasp of what engineering** (as contrasted with engineering science) **is and how one practices it**, particularly in the currently evolving industry environment.*
- *There seems to be a dislocation in "value systems" between academia and industry. **Academic success** (measured by test scores and grade point average) **shows no discernable correlation with subsequent performance on the job** (as measured by salary growth and perceived value of an employee to a company).*

A Company is its People--YOU!
People Design and Deliver Products and Services.

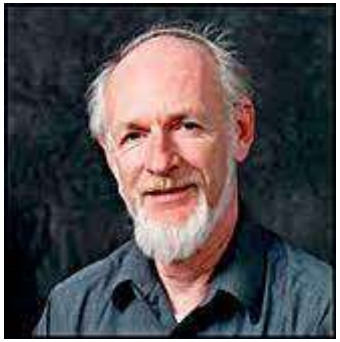
Source: AIAA-90-3259, McMasters & Ford

Engineering Design Education

Attributes of an Attractive Engineering Graduate

- A good grasp of **engineering science fundamentals** (mathematics including statistics; physical and life sciences; information technology)
- A good understanding of the design process and manufacturing (i.e., **understand engineering**)
- A basic understanding of the **context in which engineering is practiced** (economics; history; legal aspects and the environment; and customer and societal needs)
- Good **communication skills** (written, verbal, graphic, listening)
- High **ethical standards**
- An **ability to think** both critically and creatively – independently and cooperatively
- **Flexibility** – an ability and the self-confidence to adapt to rapid/major changes
- **Curiosity** and a **desire to learn – *for life***
- A profound understanding of the **importance of team work**

John H. McMasters, Ph.D.
Boeing Corp.



1939 - 2008

Note: Highlighting is done by the author.

What to Expect in Industry?

Aircraft Conceptual Design Lessons Learned

Lee Nicolai, Lockheed Martin Aeronautics

- **Do a BOEA (Back of the Envelop Analysis) Before Turning On Computer**
  - *Hand calculations are used to*
    - Show understanding of what the computer code is doing
    - Scope out the critical part of the design space
    - Develop inputs and boundary conditions
    - Define the character and size of the computer results

- **Question the Requirements and Identify the MoM (Measure of Merit)**
  - *Listen to the customer*
  - *The requirements are often missing or flawed*
  - *Share observation with customer but be diplomatic and sensitive*
  - *Negotiate a credible set of requirements, then meet them but design for the Measures of Merits (MoMs)*

- **Industry Product Solutions Are Not Optimized**
  - *The requirements (pressures) are only good for today*
  - *The requirements (pressures) will change with time*
  - *We want our solution to still be viable over the lifetime of the product*
  - *We offer the most robust solution for a lifetime of service*

What to Expect in Industry?

Aircraft Conceptual Design Lessons Learned

Lee Nicolai, Lockheed Martin Aeronautics

- **Conduct Trade Studies (Design – Mission – Technology/Risk)**
  - *It is good design practice and the Customer expects it*
  - *Major element in Systems Engineering*
  - *Start in conceptual design and continue through EMD (Engineering & Manufacturing Development)*
  - *Conducting good trade studies is an ART!*
- **You will work in a team called an IPT (Integrated Product Team)**
  - *Include the Customer*
  - *Develop good communication skills*
  - *Learn how to flip your brain from left to right and back again*
- **Make learning a life time endeavour (*and learn how to spell!*)**
- **Remember**
  - ***Ethics – Ethics –Ethics***
    - We cannot afford to not be
  - Cost is King
    - Because DoD says so
  - KISS (Keep It Simple Stupid)
    - Hard for a left brain engineer

What to Expect in Industry?

***Aircraft Conceptual Design Lessons Learned* by Lee Nicolai**
Lockheed Martin Aeronautics

- **Work hard to establish your technical credentials**
  - *You will need technical credibility to get promoted*
    - Either as an engineer or into management
      - You must have the respect of the technical staff beneath you
      - You must avoid the label “Technical Lightweight” or “He couldn’t make it as an engineer so he became a manager”

- **Be active in your professional society (AIAA, SAE, ASME, IEEE, etc.)**
  - *Be an officer in the local chapter*
  - *Be a member of a national TC (technical committee)*
  - *Present or publish papers*
  - *Good way to stay technically current*
  - *Very rewarding professionally*
  - *Great way to network*

- **Bottom Line**
  - *Your job will be to help build a product that can be sold for a profit*

"An Engineer's Mentality"

"…the current engineering education paradigm consists of giving the students all the data at the top of the page, and the solution (?) consists of rearranging the data on the bottom of the page and handing it in as a "worked" assignment. In many years *in industry* I *never encountered* anything even remotely close to this process. In my experience, *the overwhelming majority of the engineering problem is gathering information and interpreting results.* Although this is the engineering problem it almost never occurs in our science-based engineering education system. *Engineering design may be the student's only exposure to this process.*"

"The student response in evaluations [of Mason's course] comes across as "problem statements too vague." If that's the case with these problems, we have not yet helped the students ***develop an engineer's mentality.***"

William H. Mason
AIAA Paper 92-2661

William H. Mason, Ph.D.
VT AOE Professor Emeritus
Grumman Corp. (1974-1989)
19 Jan 1947 - 27 Mar 2019

Note: Highlighting is done by the author (Raj).

"An Engineer's Reality"

"One of the **characteristics of engineers** which I have frequently observed, and which must be guarded against **is the *search for exact answers***, and the feeling of frustration if the exact answer is not forthcoming. This probably stems from the many years of high school and college training where the answer is always to be found in the back of the book, and the feeling of elation which comes when, after trying several solutions, and looking furtively at the answer, the latest trial finally works.

Unfortunately, **in real life, there are no exact or final answers**. In a job, which must go ahead at a rapid pace, we cannot withhold judgment "until all the facts are in". Rarely is all the evidence at hand. Decisions must be made, and action taken, before complete knowledge can be acquired.

I have for some time thought that **a few of our present day ills stem from this childish faith in the existence of perfect answers**. It requires a degree of maturity to realize that all solutions are partial ones."

Adm. Hyman G. Rickover (1900–1986)
"Administering a Large Military Development Project"
Delivered to U.S. Naval Postgraduate School, Monterey, CA, 15 March 1954

Note: Highlighting is done by the author (Raj).

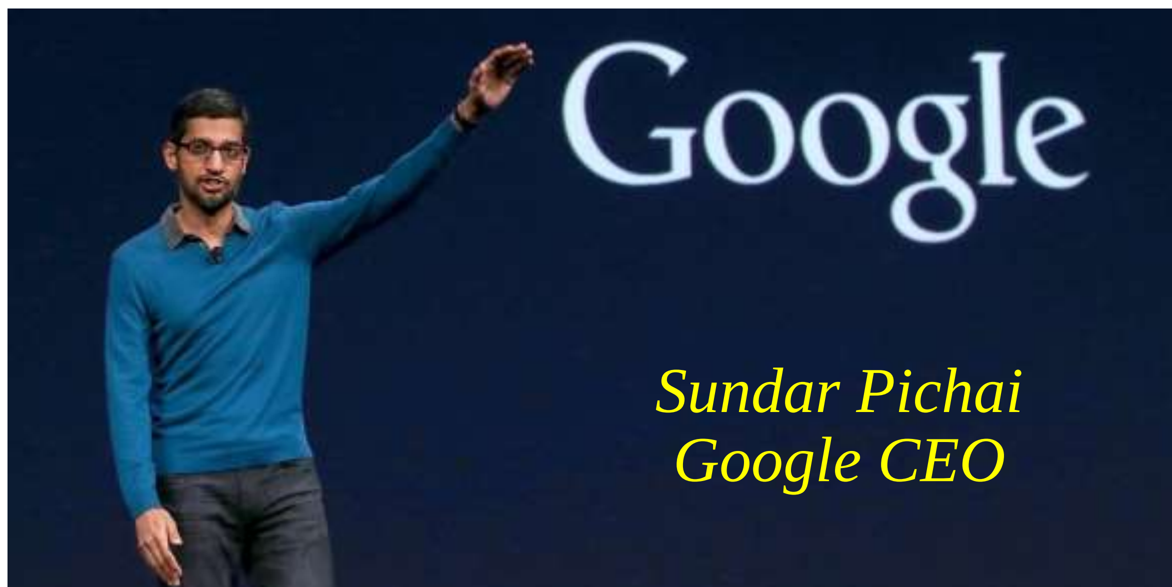
Source: http://hdl.handle.net/10945/59370

Engineers Make the World a Better Place!

"Engineers use science to solve problems and make things. Engineering applies a combination of logic and intuition to problem solving.
It's a way of thinking that leaves one well suited to run a company."

Bill Nye on Sundar Pichai
The 100 Most Influential People
TIME, May 2/May 9, 2016

"Bill Nye the Science Guy"
American Science Educator
Mechanical Engineer



"Engineers Make a Difference!"

Source: Internet

"…the old definition of an airplane—half humorous, half truthful [is]—an airplane is a device that almost won't work."

A.M.O. Smith
AIAA Paper 74-939, Aug 1974
"37th Wright Brothers Lecture"

Chief Aerodynamics Engineer, Research
Douglas Aircraft Company,
Long Beach, CA
2 July 1911 – 1 May 1997

Engineers Make the Device Work!

Source: Wikipedia

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Aerospace Engineers
<u>Shape the Future</u>!

Global Mobility

Shrink the Globe

World Security

Change the Game

They Add Value by Meeting Challenging Societal Needs.

Source: Images from Internet and Ref.. AVD 1

Aerospace Engineers: *Succeed Beyond Boundaries*!

In 2016, Crofton (Class of 1982) committed $14 million to the Aerospace and Ocean Engineering department at Virginia Tech—his alma mater.

"In many ways Ut Prosim is an extension of the values of which I live by and a humble expression of my desire to make a difference. I have always wanted to give back to Virginia Tech in a meaningful way–one that makes a significant contribution and will impact future generations."

Kevin T. Crofton
President, SPTS Technologies

"I left the aerospace industry in the mid-90s to go into the semiconductor sector. However, the skills I learned at Tech and in my early professional life, have carried me through a great career in semiconductor capital equipment development and delivery. We've created a leading company in our field, that is well-recognized for technical excellence and extreme focus on contributing to our customers' success."

*"…the whole Virginia Tech experience gave me a great foundation for a long and (so far) successful career…I left the school with a **good set of problem solving skills**, and an appreciation of the importance of being able to **look at technical problems from multiple viewpoints**—and to analytically **interpret experimental data to project outcomes based on a limited set of information**."*

Source: https://eng.vt.edu/about/distinguished-alumni/academy-of-engineering-excellence/kevin-t--crofton.html

Aerospace Engineers:
Succeed Beyond Boundaries!

In 2021, Norris Mitchell ’58 and his wife, Wendy, have committed $35 million to the Virginia Tech College of Engineering. The gift will go toward construction as well as activities and programming for a showcase building.

“Virginia Tech equipped me with the knowledge and skillset to have an extremely fulfilling career across several industries. I appreciate the university’s key role in my life. Wendy and I are happy to be able to make this gift to help Virginia Tech prepare tomorrow’s engineers.”

Norris and Wendy Mitchell

Mitchell spent the first two years of his career at Douglas Aircraft, and progressed to become chief of the aerodynamics program. He next worked for the Research Analysis Corporation and Science Applications International Corporation (SAIC). He got involved in real estate in 1968 and left the aerospace industry entirely in 1974 to focus on real estate and banking.

“Engineering teaches you to think. It teaches you how to determine what’s important and what’s not important, how to determine what makes sense and what doesn’t. That, to me is engineering, and it can be broken down and applied in a lot of fields.”

Source: https://vtx.vt.edu/articles/2021/12/mitchell.html

What if I don't aspire to design airplanes, then why do I need to take the design courses?

- **The genesis, rationale and value of your professional contributions will be directly or indirectly *linked* to engineering design—regardless of your primary areas of interest and career paths whether research, technology, modeling & simulation, testing, manufacturing, etc., be it in academia, government or industry.**

- **If you don't see a *link* to engineering design, stop and ask: "*why am I doing it?*"**
  - Don't proceed until you find the answer!

- ***Designers initiate the "Value" chain!***

Good Understanding and Appreciation of the Fundamentals of Design is Not a Choice, but a Necessity.

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In the Air Vehicle Design courses,

you learn all about the whys, the whats,

and the hows of aircraft design….

…But you learn more—much more—than

the fundamentals of air vehicle design…

…you learn a unique way of thinking:

Applying Logic and Intuition to

Solve Problems That Don't Have Unique

Solutions!

Successfully Completing the Courses Will Help You Learn To

- **Solve *open-ended problems* by asking the right questions**
- **Identify/ collect/ compile *relevant data* and information**
- **Conduct quantitative/qualitative *trade-offs***
- **Use *analyses*—as rigorous as the task demands—*to make decisions* to select a *preferred approach/ concept***
- **Recognize and factor-in societal, legal and financial *constraints***
- **Practice highest standards of *ethical* and *professional* conduct**
- **Become a *valued team player***
- **Sharpen skills for *effective two-way communication (verbal and written)* with peers and superiors**

These Are Universally Valuable Skills Regardless of Your Future Career Aspirations

AOE 4065-4066
13 Learning Objectives (LOs)

LEARNING OBJECTIVES (LO)	
LO 1	Apply systems thinking and an aircraft design process to create feasible air vehicle concepts.
LO 2	Apply qualitative and quantitative decision-making tools to compare candidate concepts and choose the ones that best meets design requirements.
LO 3	Estimate initial air vehicle weight, wing size, and engine size based on mission profile.
LO 4	Perform tradeoff studies to select values of design variables.
LO 5	Assess feasibility of baseline air vehicle for meeting design requirements through engineering analyses.
LO 6	Design innovative air vehicles that meet all customer requirements.
LO 7	Develop a project plan, assess project risks, and prepare risk mitigation plans.
LO 8	Contribute to a multidisciplinary design team as a member with highest levels of ethics, integrity, and professionalism.
LO 9	Deliver oral presentations for informal and formal design reviews.
LO 10	Write an engineering design project report in proposal style (response to Request for Proposal).
LO 11	Refine the baseline aircraft concept to create an integrated system with lightest weight and lowest cost to meet customer requirements.
LO 12	Perform engineering analyses to quantitatively assess air vehicle capabilities against specific design requirements.
LO 13	Validate the final air vehicle design through analyses to demonstrate compliance with all customer requirements.

AOE 4065-4066 is ABET* Certified

We Address All Seven ABET Outcomes Listed Here

Coverage of the following seven (7) ABET outcomes in relation to each course learning objective is assessed on the following scale: *0 (blank) = none, 1 = low, 2 = moderate, 3 = high.*

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge, as needed, using appropriate learning strategies.

*Accreditation Board for Engineering and Technology

All 13 Learning Objectives Map to 7 ABET* Outcomes

Course Learning Objective ▼	ABET Outcome ▶	1.	2.	3.	4.	5.	6.	7.
LO 1. Apply systems thinking and an aircraft design process to create feasible air vehicle concepts.		1	3		2			2
LO 2. Apply qualitative decision-making tools to compare candidate concepts and choose the ones that best meet design requirements.		3	3		2			2
LO 3. Estimate initial air vehicle weight, wing size, and engine size based on mission profile.		2			2		2	
LO 4. Perform tradeoff studies to select values of design variables.					2		2	
LO 5. Assess air vehicle feasibility for meeting design requirements through engineering analyses						2	3	2
LO 6. Design innovative air vehicles using systems thinking to meet all customer requirements.		1	3		2			2
LO 7. Develop a project plan, assess project risks, and prepare risk mitigation plans.		2			2			
LO 8. Contribute to a multidisciplinary design team as a member with highest levels of ethics, integrity, and professionalism.		2	2	2	3	3	2	2
LO 9. Deliver oral presentations for informal and formal design reviews.		2	3	3	1	2	1	2
LO 10. Write an engineering design project report in proposal style (response to Request for Proposal).		2	3	3	1	2	3	2
LO 11. Refine the aircraft concept (from the first semester) to create an integrated system with lightest weight and lowest cost to meet customer requirements.		2	3		2		2	2
LO 12. Perform engineering analyses to quantitatively assess air vehicle capabilities against specific design requirements.		3					2	2
LO 13. Validate the final air vehicle design through analyses to demonstrate compliance with all customer requirements.		3					3	

*Accreditation Board for Engineering and Technology

Outline

Overview of AVD Courses @ VT

- Introductory Remarks
- ***Why*** **we have to take the Design courses**
- ***What*** **we will learn in these courses**
- ***How*** **we will learn what we need to learn**
  - **Approach & Plan**
  - **Resources**
  - **Deliverables & Evaluation/Grading**
  - **Design Team Formation**
- ***Who*** **will help us learn**
- **Appendix**

"Adult Learning" Approach

- ***People only learn when they do something***, **and they learn more whenever they feel the task is really important.**
- **Learning is deepest when it *involves the whole person*, mind, values, body and emotions.**
- **We learn not so much when we are motivated to learn, as when we are *motivated to achieve something*.**
- **The *learner knows* more than anyone else *what he/she* has learned, and *needs to learn*. Nobody else has much chance of knowing.**

> ***Tell me and I forget.***
> ***Teach me and I remember.***
> ***Involve me and I learn.***
> ***— Benjamin Franklin***

This Approach is also Best Suited for *Life-long Learning*

High-level Plan

Fall semester

- **Individual assignments to lay the groundwork**
- **Team assignments to stimulate teamwork**
- **Classroom Discussions common to all teams**
- **Targeted Discussions with each team**
- **Team Design Projects (Capstone Design Projects)**
- ***Use Conceptual Design Process to***
  - *Create* several concepts that meet customer need outlined in the Request for Proposal (RFP), and participate in oral project reviews
  - *Choose* one preferred concept by the end of the semester, and submit Final Report (in proposal style) documenting the problem, progress made, and future plans

Spring semester

- ***Undertake Preliminary Design to***
  - Further refine the preferred concept by analyzing and/or testing to validate assumptions and to add more detail
  - Submit a Final Proposal and give a Final Presentation

Less Lecturing, More Practicing!

You Will Achieve Learning Objectives by Doing a Capstone Aircraft Design Project

Source: NASA

RFP

Describes customer's need (among other things)

Supersoni[illegible]ans-[illegible]ific [illegible]raft

Since the demis[illegible]on[illegible]e in 2003, [illegible] have been no scheduled supersonic passenger service[illegible] [illegible]arket f[illegible] supersonic civil transport is for a prem[illegible] class trans-Pacific [illegible]e. It [illegible]ged that the aircraft would carry 50–10[illegible] [illegible]engers in a first/business c[illegible]nfiguration on routes such as Los Angeles (L[illegible])-Singapore (SIN) or San Francis[illegible] (SFO)-Sydney (SYD). These are extreme[illegible]ng-range routes (in excess of 16 hours), and significant time could be saved b[illegible] [illegible]rsonic flight. [illegible]ver, it may be impractical for a supersonic aircraft to fly these legs non-sto[illegible] [illegible] need to refuel en-route.

Requirements

Although a major task in the first part of the project is to determine customer requirements, so[illegible] [illegible] performance [illegible]ents are:

- Range, at least 6000 [illegible]
- Cruising speed, at least Mach 2.0
- Passengers, at least 50

This project will be completed in collaboration with Virginia Polytechnic Institute and State University (better known as Virginia Tech) in Blacksburg, Virginia, USA. On 22 August 2016, 7 final year students at Virginia Tech started work on this project. Approx. 8 students from AAE will also work independently on the design until November when there will be teleconferences to show progress and plan future work. See the separate documents for this project for the full details.

There may be opportunities to visit and/or host the VT students around Thanksgiving 2016 and/or Easter 2017 respectively.

The First Day!

BSP

To be filled with your design that best meets the need!

RFP: Request for Proposal

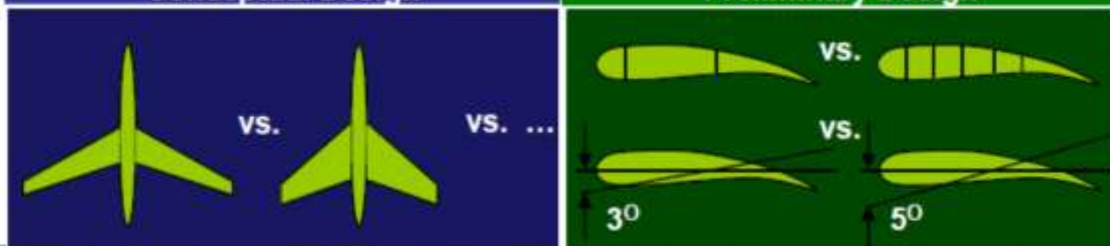
BSP: Blank Sheet of Paper

COLLEGE OF ENGINEERING
KEVIN T. CROFTON DEPARTMENT OF
AEROSPACE AND OCEAN ENGINEERING
VIRGINIA TECH.

Aircraft Design Project Overview

Customer's Request for Proposal (RFP) Kicks off the Aircraft Design Project

AOE 4065 (Fall) — AOE 4066 (Spring)



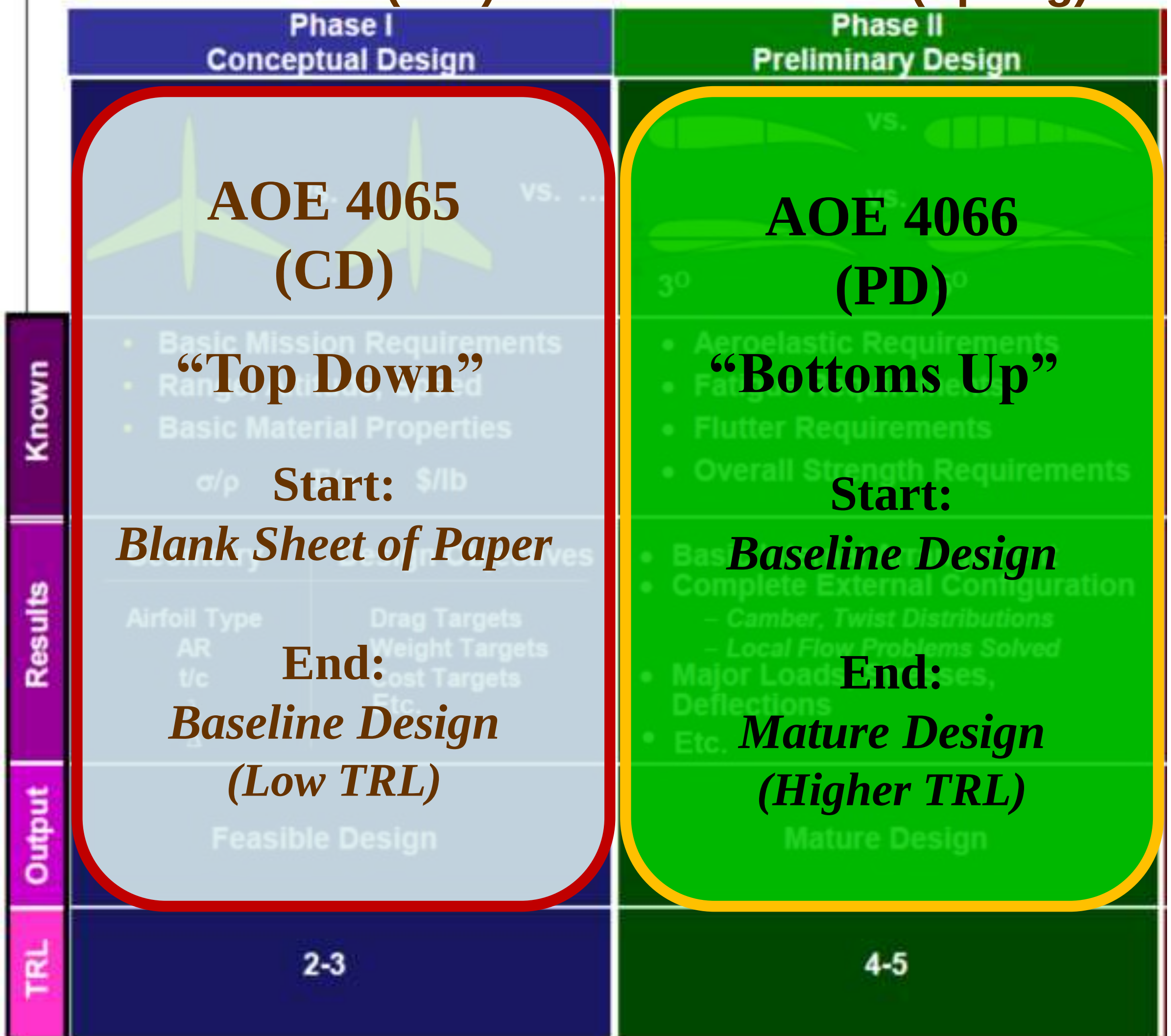
	Phase I Conceptual Design	Phase II Preliminary Design
Known	• Basic Mission Requirements • Range, Altitude, Speed • Basic Material Properties σ/ρ E/ρ $/lb	• Aeroelastic Requirements • Fatigue Requirements • Flutter Requirements • Overall Strength Requirements
Results	**Geometry:** Airfoil Type, AR, t/c, λ, Δ **Design Objectives:** Drag Targets, Weight Targets, Cost Targets, Etc.	• Basic Internal Arrangement • Complete External Configuration – *Camber, Twist Distributions* – *Local Flow Problems Solved* • Major Loads, Stresses, Deflections • Etc.
Output	Feasible Design	Mature Design
TRL	2-3	4-5

TRL: Technology Readiness Level (see Appendix)

Source: Adapted from Dr. Lee Nicolai's slides

Aircraft Design Project Overview

AOE 4065 (Fall) AOE 4066 (Spring)



AOE 4065 (CD)

"Top Down"

Start: ***Blank Sheet of Paper***

End: ***Baseline Design (Low TRL)***

AOE 4066 (PD)

"Bottoms Up"

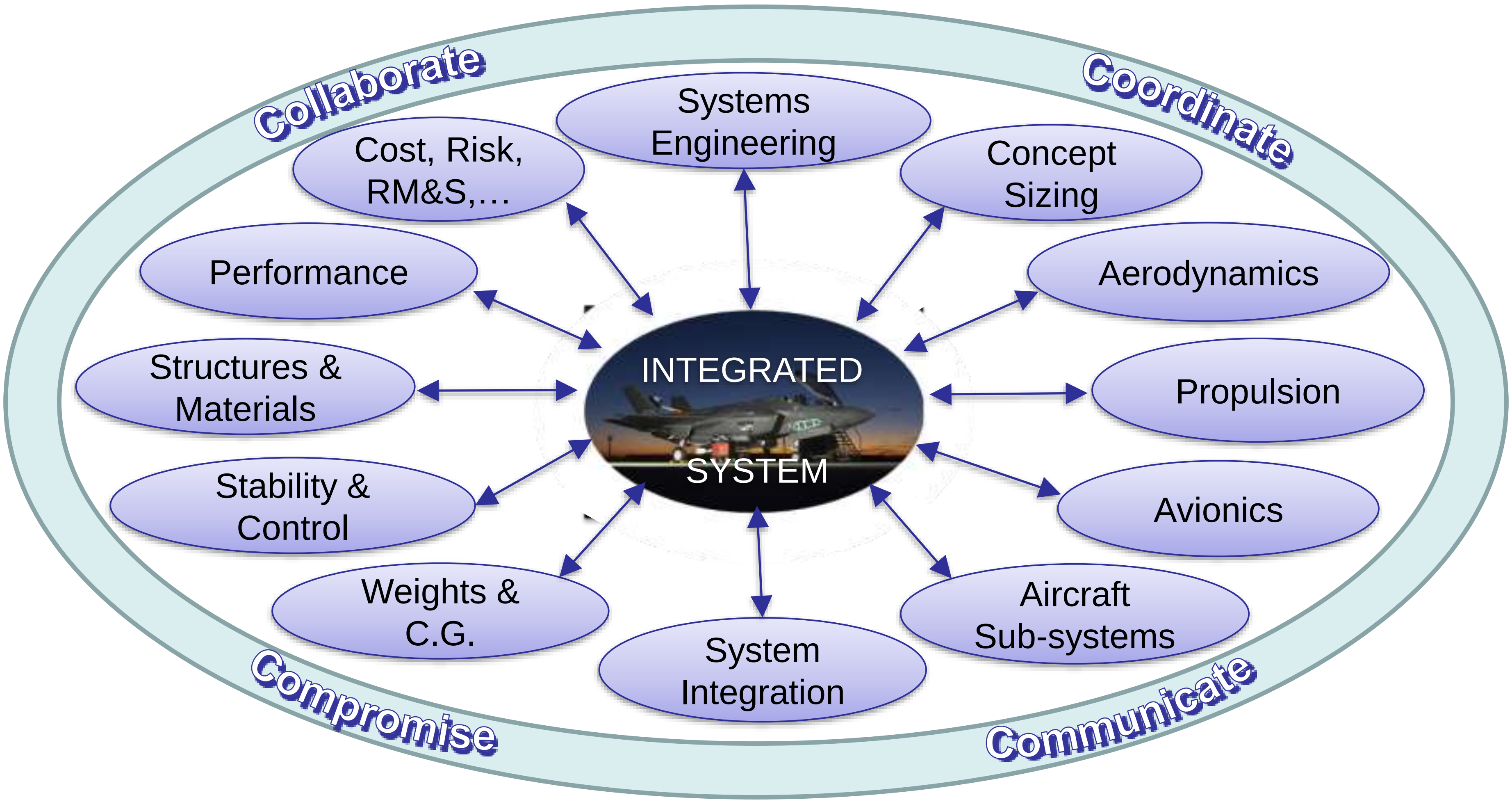
Start: ***Baseline Design***

End: ***Mature Design (Higher TRL)***

Creating a Feasible Baseline Design in AOE 4065 and Generating a More Mature Design in AOE 4066

Capstone Aircraft Design Project

A Truly Multidisciplinary Endeavor



Disciplinary "experts" must provide advice and *data*—*<u>on time and on budget</u>*—to configuration designer who integrates it all into an innovative configuration.

Aircraft Design Needs "Experts" From Multiple Disciplines

How to get *There* from *Here* on time?

HERE

Request for Proposal

Formation of Team

Classroom Discussions

- Discussion of relevant topics
- *View from 10 thousand feet*

CHALLENGE

Many paths!

RESOURCES

Course Modules

- Highlight key ideas…but insufficient detail
- *View from 5 thousand feet*

+

References

- Sufficient details on all topics of interest
- *View from the ground*

THERE

Final Design

Deliver a Proposal

Project Reviews

- Feedback for course correction as needed

Use Resources to Avoid Long and Winding Paths!

Outline

Overview of AVD Courses @ VT

- Introductory Remarks
- ***Why*** we have to take the Design courses
- ***What*** we will learn in these courses
- ***How*** we will learn what we need to learn
  - Approach & Plan
  - **Resources**
  - Deliverables & Evaluation/Grading
  - Design Team Formation
- ***Who*** will help us learn
- Appendix

AOE 4065-4066:
Capstone Air Vehicle Design (AVD) Course Modules (CMs)

Overview of AVD Courses

I. Foundational Elements

F1. Design: *An Engineering Discipline*

F2. Systems and Systems Thinking

F3. Basics of Systems Engineering

F4. Decision Making with Ethics and Integrity

II. Air Vehicle Design Fundamentals

A1. Purpose & Process

Conceptual Design

A2. Understand the Problem

A3. Solve the Problem

A4. Initial Sizing: *Takeoff Weight Estimation*

A5. Initial Sizing: *Wing Loading and Thrust Loading Estimation*

A6. Cost Considerations

A7. Concept to Configuration: *Key Considerations*

A7A. Configuration Layout: *Drawings & Loft*

Conceptual & Preliminary Design

A8. Trade Studies

A9. Use of Software Tools

A10. Preliminary Design: *Baseline Design Refinement & Validation*

III. Project Management Topics

P1. Basics of Project Management and Project Planning

P2. Project Organization

P3. Roles & Responsibilities of Team Members

P4. Project Execution: *Teamwork for Success*

P5. Project Risk Management

P6. Delivering Effective Oral Presentations

P7. Writing Effective Design Reports

AOE 4065-4066: CM – LO Mapping

	LEARNING OBJECTIVES (LOs)												
COURSE MODULES (CMs)	LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12	LO 13
I. Foundational Elements													
F1. Design: *An Engineering Discipline*	*					*							
F2. Systems and Systems Thinking	*	*	*	*		*	*		*	*			
F3. Basics of Systems Engineering	*	*	*	*		*	*		*	*			
F4. Decision Making with Ethics & Integrity	*	*	*	*	*	*		*			*	*	
II. Air Vehicle Design Fundamentals													
A1. Purpose & Process	*		*	*	*	*	*	*					
A2. Understand the Problem	*		*	*	*	*	*	*	*	*	*	*	*
A3. Solve the Problem	*		*			*		*		*			
A4. Initial Sizing: *Takeoff Weight Estimation*	*		*		*	*		*	*	*			
A5. Initial Sizing: *Wing Loading and Thrust Loading Estimation*	*		*		*	*		*	*	*			
A6. Cost Considerations	*		*		*		*		*	*	*		
A7. Concept to Configuration: *Key Considerations*	*		*	*	*	*		*	*	*	*		
A7A. Conceptual Sketch_3D-Layout_Drawings	*			*	*				*	*	*	*	*
A8. Trade Studies	*			*				*		*	*		
A9. Use of Software Tools	*	*	*		*			*			*	*	*
A10. Preliminary Design: *Baseline Design Refinement & Validation*	*	*	*		*			*			*	*	*
III. Project Management Topics													
P1. Basics of Project Management and Project Planning	*	*	*		*	*	*		*	*	*	*	*
P2. Project Organization					*	*	*		*	*		*	*
P3. Roles & Responsibilities of Team Members						*	*	*				*	*
P4. Project Execution: *Teamwork for Success*	*	*	*	*		*		*	*	*		*	*
P5. Project Risk Management	*	*	*			*	*		*	*	*	*	
P6. Project Deliverables and Evaluation													
P7. Tips for Effective Oral Presentation and Written Report	*					*		*	*	*			

AOE 4065 (Fall Semester)
10 Learning Objectives (LOs)

LEARNING OBJECTIVES (LO)	
LO 1	Apply systems thinking and an aircraft design process to create feasible air vehicle concepts.
LO 2	Apply qualitative and quantitative decision-making tools to compare candidate concepts and choose the ones that best meets design requirements.
LO 3	Estimate initial air vehicle weight, wing size, and engine size based on mission
LO 4	Perform tradeoff studies to select values of design variables.
LO 5	Assess feasibility of baseline air vehicle for meeting design requirements through engineering analyses.
LO 6	Design innovative air vehicles that meet all customer requirements.
LO 7	Develop a project plan, assess project risks, and prepare risk mitigation plans.
LO 8	Contribute to a multidisciplinary design team as a member with highest levels of ethics, integrity, and professionalism.
LO 9	Deliver oral presentations for informal and formal design reviews.
LO 10	Write an engineering design project report in proposal style (response to Request for Proposal).

Note: Five of these LOs (6 through 10) are also the LOs for AOE 4066.

AOE 4065 (Fall): CM - LO Mapping

	LEARNING OBJECTIVES (LOs)									
COURSE MODULES (CMs)	LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10
I. Foundational Elements										
F1. Design: *An Engineering Discipline*	*					*				
F2. Systems and Systems Thinking	*	*	*	*		*	*		*	*
F3. Basics of Systems Engineering	*	*	*	*		*	*		*	*
F4. Decision Making with Ethics & Integrity	*	*	*	*	*	*		*		
II. Air Vehicle Design Fundamentals										
A1. Purpose & Process	*		*	*	*	*	*	*		
A2. Understand the Problem	*		*	*	*	*	*	*	*	*
A3. Solve the Problem	*		*			*		*		*
A4. Initial Sizing: *Takeoff Weight Estimation*	*		*		*	*		*	*	*
A5. Initial Sizing: *Wing Loading and Thrust Loading Estimation*	*		*		*	*		*	*	*
A6. Cost Considerations	*		*		*		*		*	*
A7. Concept to Configuration: *Key Considerations*	*		*	*	*	*		*	*	*
A7A. Conceptual Sketch_3D-Layout_Drawings	*			*	*				*	*
A8. Trade Studies	*			*				*		*
A9. Use of Software Tools	*	*	*		*			*		
A10. Preliminary Design: *Baseline Design Refinement & Validation*	*	*	*		*			*		
III. Project Management Topics										
P1. Basics of Project Management and Project Planning	*	*	*		*	*	*		*	*
P2. Project Organization					*	*	*		*	*
P3. Roles & Responsibilities of Team Members						*	*	*		
P4. Project Execution: *Teamwork for Success*	*	*	*	*		*		*	*	*
P5. Project Risk Management	*	*	*			*	*		*	*
P6. Project Deliverables and Evaluation										
P7. Tips for Effective Oral Presentation and Written Report	*					*		*	*	*

AOE 4066 (Spring Semester)
8 Learning Objectives (LOs)

LEARNING OBJECTIVES (LO)	
LO 1	Design innovative air vehicles that meet all customer requirements.
LO 2	Develop a project plan, assess project risks, and prepare risk mitigation plans.
LO 3	Contribute to a multidisciplinary design team as a member with highest levels of ethics, integrity, and professionalism.
LO 4	Deliver oral presentations for informal and formal design reviews.
LO 5	Write an engineering design project report in proposal style (response to Request for Proposal).
LO 6	Refine the baseline aircraft concept to create an integrated system with lightest weight and lowest cost to meet customer requirements.
LO 7	Perform engineering analyses to quantitatively assess air vehicle capabilities against specific design requirements.
LO 8	Validate the final air vehicle design through analyses to demonstrate compliance with all customer requirements.

Note: The first five LOs (1 - 5) are the same as the last five LOs (6 - 10) for AOE 4065. However, they have expanded scope in AOE 4066.

<u>AOE 4066 (Spring):</u> CM - LO Mapping

	LEARNING OBJECTIVES (LOs)							
<u>COURSE MODULES (CMs)</u>	LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8
<u>I. Foundational Elements</u>								
F1. Design: *An Engineering Discipline*	*							
F2. Systems and Systems Thinking	*	*		*	*			
F3. Basics of Systems Engineering	*	*		*	*			
F4. Decision Making with Ethics & Integrity	*		*			*	*	
<u>II. Air Vehicle Design Fundamentals</u>								
A1. Purpose & Process	*	*	*					
A2. Understand the Problem	*	*	*	*	*	*	*	*
A3. Solve the Problem	*		*		*			
A4. Initial Sizing: *Takeoff Weight Estimation*	*		*	*	*			
A5. Initial Sizing: *Wing Loading and Thrust Loading Estimation*	*		*	*	*			
A6. Cost Considerations		*		*	*	*		
A7. Concept to Configuration: *Key Considerations*	*		*	*	*	*		
A7A. Conceptual Sketch_3D-Layout_Drawings				*	*	*	*	*
A8. Trade Studies			*		*	*		
A9. Use of Software Tools			*			*	*	*
A10. Preliminary Design: *Baseline Design Refinement & Validation*			*			*	*	*
<u>III. Project Management Topics</u>								
P1. Basics of Project Management and Project Planning	*	*		*	*	*	*	*
P2. Project Organization	*	*		*	*		*	*
P3. Roles & Responsibilities of Team Members	*	*	*				*	*
P4. Project Execution: *Teamwork for Success*	*		*	*	*		*	*
P5. Project Risk Management	*	*		*	*	*	*	
P6. Project Deliverables and Evaluation								
P7. Tips for Effective Oral Presentation and Written Report	*		*	*	*			

CRUCIALLY IMPORTANT

CMs only introduce key topics and highlight some important concepts and ideas…but without sufficient detail.

We use lots of Reference Material* to add the necessary details!

(*see Appendix for specifics)

Keeping Current

AW&ST (*Aviation Week Network)*

Vertiflite *(AHS)*

Aerospace America *(AIAA)*

Flight International *(Flight Global)*

Source: Internet

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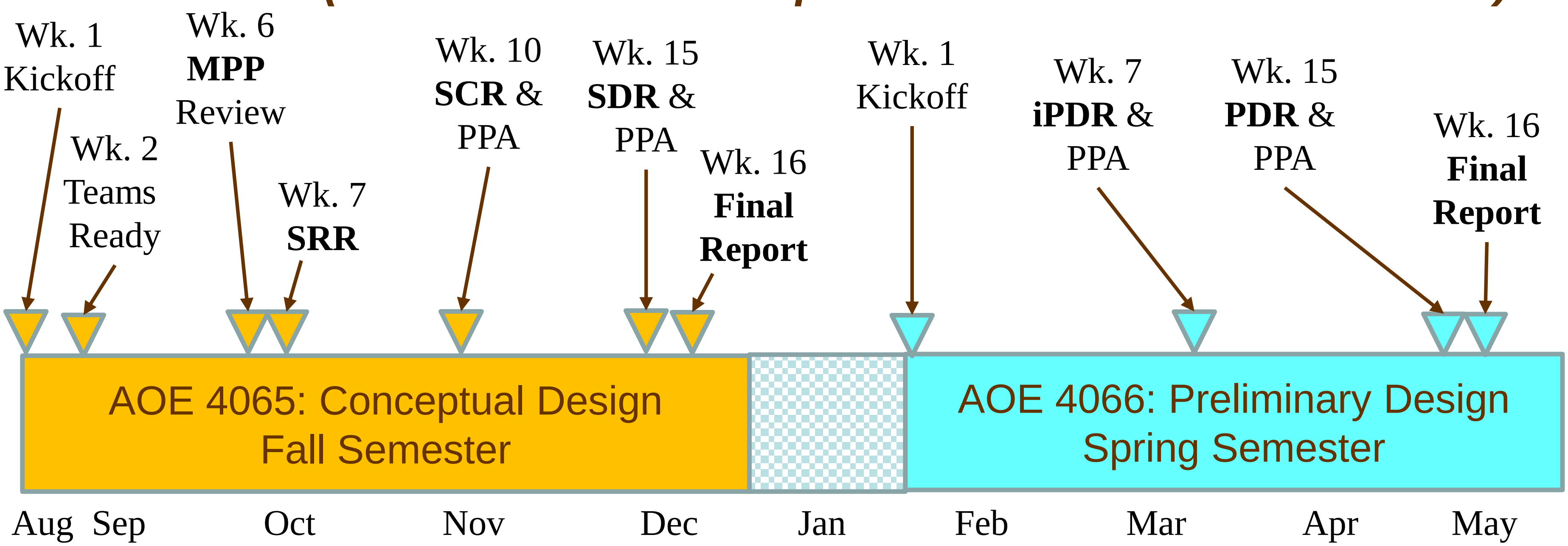
  - Resources
  - **Deliverables & Evaluation/Grading**
  - Design Team Formation
- *Who* will help us learn
- Appendix

Course Deliverables & Milestones

(What each team is expected to deliver for the courses)



- Weekly Project Reviews (WPRs)
- Team Activities/ Assignments

MPP – Master Project Plan

SRR – System Requirements Review

SDR – System Design Review

- Weekly Project Reviews (WPRs)
- Peer-to-peer Learning Meetings

iPDR – interim Preliminary Design Review

PDR – Preliminary Design Review

Learn to be an Effective Communicator – Verbal and Written

Course Evaluation Framework

1. Students form teams, and each team chooses a RFP for its own design project
2. Teams conceive and design a system that best meets customer needs
3. **Deliverables are formal *Oral Presentations* and *Written Report***
4. Teams give several **oral presentations** each semester
   - To mimic the "Real World" environment in an academic setting
   - All teams receive *Evaluation Criteria* and *Guidelines* in advance
5. Teams submit **written reports (in proposal style)**, one each at the end of the fall and the spring semesters
   - Format and content must comply with RFP specifications and be fully responsive to the RFP requirements
   - All teams receive *Evaluation Criteria* and *Key Considerations* documents in advance
6. A few individual and team assignments (fall semester)—intended to aid learning new skills to support Capstone Design Projects
7. Students conduct Peer Performance Assessments (PPAs), twice each semester, to provide feedback on the performance of teammates

Evaluation Challenge

- **Open-ended problems: no “right” answer**
  - Each problem in each project requires different assumptions, and has different data requirements
- **Design courses expect all students to acquire, develop and demonstrable new skill sets to meet the ABET criteria**
  - Examples of new skills include: making decisions, teamwork, dealing with uncertainty, **effective oral and written communication**, etc., etc.
- **All RFPs have their own—and different—set of evaluation criteria!**
  - RFPs generally specify different formats for reports
  - Example: AIAA Undergraduate Team Aircraft Design
    - ✓ maximum 100 pages, double spaced, no less than 10-pt Times New Roman font

How to Conduct Fair and Equitable Evaluation of a Diverse Set of Projects

Exhibit A:
AIAA Undergraduate Team Aircraft Design

Basis of Judging

1. Technical Content (35 points)

This concerns the correctness of theory, validity of reasoning used, apparent understanding and grasp of the subject, etc. Are all major factors considered and a reasonably accurate evaluation of these factors presented?

2. Organization and Presentation (20 points)

The description of the design as an instrument of communication is a strong factor on judging. Organization of written design, clarity, and inclusion of pertinent information are major factors.

3. Originality (20 points)

The design proposal should avoid standard textbook information, and should show the independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the method show an adaptation or creation of automated design tools?

4. Practical Application and Feasibility (25 points)

The proposal should present conclusions or recommendations that are feasible and practical, and not merely lead the evaluators into further difficult or insolvable problems.

That's it!

A “Real-world” Example

AFRL OPTIMUS Solicitation
(a Technology Development Project)

Proposal Evaluation Criteria

The selection of one or more sources for award will be based on an evaluation of each offeror’s proposal (both technical and cost/price aspects) to determine the overall merit of the proposal in response to the announcement. The technical aspect, which is ranked as the first order of priority, shall be evaluated based on the following criteria that are of **equal** order of importance as well as on Agency need and funding availability.

A "Real-world" Example (contd.)

Proposal Evaluation Criteria (contd.)

Technical:

i. Availability of qualified technical personnel and their experience with the applicable technologies. Team composition and leadership (at the right levels to assure aircraft level benefits focus) exhibited with corporate level teaming is considered critical for integrated MDO approaches. Prime and subcontractor/subrecipient SOWs will also be evaluated.

ii. Unique and innovative approach proposed to accomplish the technical objectives. New and creative solutions, methods and/or advances in knowledge, understanding, technology, and the state of the art. Prime and subcontractor/subrecipient SOWs will also be evaluated.

iii. The offeror's understanding of the scope of the technical effort.

iv. Soundness of the offeror's technical approach using a high speed application such as next generation air dominance vehicles. Prime and subcontractor/subrecipient SOWs will also be evaluated. The potential for AFRL to transition the research and development deliverables to future Government needs. Any proposed restriction on technical data or computer software will be considered. Prime and subcontractor/subrecipient SOWs will also be evaluated. Availability, from any source, of necessary research, test, laboratory, or shop facilities.

A "Real-world" Example (contd.)

Proposal Evaluation Criteria (contd.)

Cost/Price: Cost/Price includes the reasonableness and realism of the proposed cost and fee and consideration of proposed budgets and funding profiles. Cost/Price is a substantial factor, but ranked as the second order of priority. (If an offeror proposes the use of GFP other than any GFP identified in this BAA, and that proposed GFP provides the offeror an unfair competitive advantage, then FAR 45.202 requires rental equivalent be applied to the Cost Factor for evaluation purposes only).

Proposal Risk Assessment: Proposal risk for technical, cost, and schedule will be assessed as part of the evaluation of the above evaluation criteria. Proposal risk relates to the identification and assessment of the risks associated with an offeror's proposed approach as it relates to accomplishing the proposed effort. Tradeoffs of the assessed risk will be weighed against the potential payoff.

Rationale for Our Evaluation Approach

1. Use a common set of *Evaluation Criteria* and a *Uniform Evaluation Process* for all teams subject to the constraints of RFP specifications

2. Use criteria that require students to learn and exercise fundamental skills that are critical for success in their future careers

3. Minimize “Busy Work”

4. Strike the right balance between *“Too Prescriptive”* and *“Too Descriptive”* for defining Evaluation Criteria and Evaluation Process

Grading Summary (AOE 4065)

Contributors to your Grade

- (15%) Individual homework assignments +
  Midterm & Final Peer Performance Assessments (PPAs)
- (5%) Master Project Plan (MPP) Review
- (10%) System Requirements Review (SRR)
- (10%) System Concepts Review (SCR)
- (10%) System Design Review (SDR)
- (50%) Final report in proposal style

Grading Procedure

- Compute midterm scaling factor (*sf-midterm*) and final scaling factor (*sf-final*) from respective PPAs
- Use *msf* to convert team scores into individual scores for SRR, MPP, and SCR (Midterm Individual scores = *sf-midterm* * Team scores)
- Use *fsf* to convert team scores into individual scores for SDR & Final Report (Final Individual scores = *sf-final* * Team scores)
- Combine numerical scores from all contributors to determine total numerical score for each individual student
- Convert numerical scores into letter grades

It All Depends on You…Learn and Earn!

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VIRGINIA TECH.

Grading (AOE 4065)

- **Read and Understand the Posted *Grading Procedure***
  - In converting the numerical score to a letter grade, the *relative standing* determines your final letter grade.
  - *We do not use any set grade distribution targets (such as a certain percentage of A's and B's) or cut-offs (e.g., A=90 and above, or B = 80-90).*
  - It's your responsibility to read and fully understand the posted grading procedure.

AOE 4065 - Air Vehicle Design
Grading Procedure

Grades in this course are based on three components: (1) individual home works (10%); (2) four oral project reviews: (i) "SRR" (10%), (ii) "MPP" (5%), (iii) midterm "SCR" (10%), (iv) final "SDR" (10%); and (3) one final written report in proposal style (50%). The remaining 5% of the grade is for Peer Performance Assessment (PPA) which is a key factor in converting team grades into individual grades. PPA is a measure of an individual performance as assessed by their teammates.

Final Grades
- First we determine the total numerical score which combines the individual numerical scores of the three components, namely, individual home works (10%), four oral project reviews (35%), a final report (50%), and the PPAs (5%).
- **The total numerical score is then converted into to a letter grade. *We do not use any set distribution targets (such as a certain percentage of A's and B's) or cut-offs (e.g., A=90 and above, or B = 80-90).* It's the relative standing that determines your final letter grade.**

Oral Project Review Grades
- Standardized forms are used to evaluate oral project review presentations. TA(s) and instructor(s)—'*acting' as customer representatives*—fill out the forms.
- Data from the forms are used to determine a "teaching assistant average (TAA)," and an "instructor average (IA)."
- Each team's composite score is computed using the following weighted-average formula:
  - Team Composite Score = A×(TAA) + B×(IA)
  - Typical values of A and B are: A = 0.35, and B = 0.65.
  - The numerical values of a team's composite score range from a minimum of zero to a maximum of 100.
- A score for each individual team member is calculated next by multiplying the team composite score by a PPA scaling factor (SF). For example, if the team composite score is 80 and an individual student's PPA scaling factor is 0.75, then the individual score is 60.

Final Report Grades
- The report is evaluated and graded *only by the instructors acting as customer representatives*. You need to convince the 'customer' that your proposal best meets their requirements outlined in the RFP.
- Each team receives a numerical score out of a maximum of 100.
- A score for each individual team member is calculated by multiplying the team report score with the PPA scaling factor (SF). That is, Individual Score = SF × Team Report Score

Peer Performance Assessment (PPA) Scaling Factor (SF)
- You will be asked to assess the performance of your team members twice in the semester: in the middle, and at the end. You will be asked to complete two individual PPA assignments, each requiring you to fill out a standard PPA form. See the course site for a sample form and instructions.
- You will be tasked to assess your teammates' overall Performance in two categories: *Contributions* and *Attributes*. Each category has five factors, for a total of 10 PPA factors. Maximum score for each factor is 10. Your filled out form is confidential and will provide us with your numerical scores for each of your team members.
- For each student, the scores given by his/her team members are averaged and then normalized using the highest value to determine a "scaling factor (SF)." The SF values range from 0 to 1. For example, if the averaged scores of three students on a three-person team are 100, 80 and 75, the corresponding SFs are 1.0, 0.8, and 0.75.

August 20, 2021

Ask questions about things that are unclear.

Grading Summary (AOE 4066)
Spring Semester

Components of Final Grade

- (15%) interim Preliminary Design Review (15%)
- (20%) Preliminary Design Review (SDR)
- (60%) Final report in proposal style
- (5%) *Midterm and Final Peer Performance Assessments (PPAs)*

Grading Procedure

- In converting the numerical score to a letter grade, the ***relative standing*** determines your final letter grade.
- ***We do not use any set grade distribution targets (such as a certain percentage of A's and B's) or cut-offs (e.g., A=90 and above, or B = 80-90).***
- **It's your responsibility** to read and fully understand the posted grading procedure.

What Could Improve Your Grade?

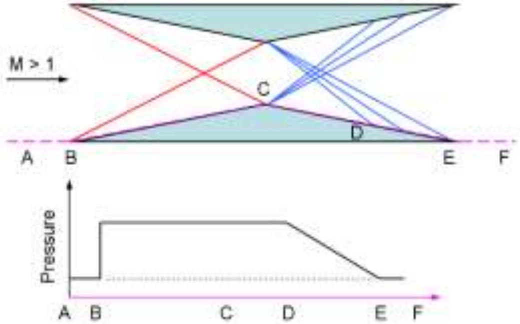
- **Study Evaluation Criteria, Considerations, and Guidelines to make sure your response resonates with the ’customer’!**
  - ***Project Reviews***
    - It’s your responsibility to read and fully comprehend the posted evaluation criteria, considerations and/or guidelines for formal oral reviews.
  - ***Final Report***
    - It’s your responsibility to read and fully understand the posted evaluation criteria and/or guidelines for writing a good report.
    - Reports will not be approved for submission to the customer unless they meet minimum quality standards posted on the course site.
  - ***PPAs:***
    - It’s your responsibility to read and fully comprehend the 10 performance assessment factors that your teammates will use.
    - Understand the Rating Scale that your teammates will use to assign numerical score to each factor

Work hard, do your best…and the grade will take care of itself

Additional Incentive To Work Hard and Do Your Best!

Every Team is Eligible for the Prize for Excellence in Capstone Air Vehicle Design Project

Adolf Busemann
(1901 – 1986)



Awarded Annually to the Top Three Teams in Aerospace and Ocean Engineering Virginia Tech, Blacksburg, Virginia

Prize made possible by a generous $5,000 annual donation by Judith and William* Grossmann

(*Class of 1958)

Outline

Overview of AVD Courses @ VT

- Introductory Remarks
- *Why* we have to take the Design courses
- *What* we will learn in these courses
- ***How* we will learn what we need to learn**
  - Approach & Plan
  - Resources
  - Deliverables & Evaluation/Grading
  - **Design Team Formation**
- *Who* will help us learn
- Appendix

Formation of Design Teams

- **Approach**
  - 'Self Forming' by students
  - Prospective/ Aspiring Team Leads submit their name and preferred project to the TA
  - Entire team selects a Lead after making sure that the individual possesses *five (5) key attributes*
    - Effective Two-way Communicator
    - Exceptional Organizational Skills
    - Excellent Interpersonal Skills
    - Open-minded Decision Maker
    - Able to *"herd cats"*

- **Team Size Target**
  - Team Size: *Nominal 8 students per team*

Formation of Design Teams (contd.)

- **Team Composition**
  - Each team must have members with a diversity of aptitudes, interests, and skillsets. To accomplish this All students must fill out and submit an ***'Interests, Aptitudes and Skills'*** form within 24 hours

Just do it!
Don't Overthink

- **Name**, **Email, Favorite Airplane(s)**
- **Aptitude**
  - ✓ Synthesis or Analysis
- **Technical Interest (check all that apply)**
  - ✓ Configuration Layout (Engineering Drawing); System Integration; Aerodynamics; Mission/Flight Performance; Propulsion-Airframe Integration; Stability & Control; Structures; Cost & Manufacturing; Other
- **Relevant Skills or Training (check all that apply)**
  - ✓ CAD (Computer Aided Design) software; VSP (Vehicle Sketch Pad) software; SolidWorks software; CFD analysis; FEM analysis; Project Planning; Project Management; Technical Writing; Public Speaking; Leadership; Other
- **Project Preference (select one)**
  - ✓ AIAA; NASA
- **Would you like to be part of LU-VT team?**

  - TA will share with the entire class a spreadsheet with survey information about every student's aptitude, interests, skillsets, and preferences

Team Formation (contd.)

- **Actions for prospective/aspiring "Leads"**
  - ✓ Send TA an e-mail expressing their desire to lead a team
  - ✓ Directly reach out to those you want on your team ASAP
    - When your team is fully subscribed, e-mail

      (i) project title, and

      (ii) names of the team members to the TA and cc the instructors

- **Once teams are formed**
  - ✓ Each Team Lead should schedule "Weekly Project Review (WPR)" meetings with Teaching Staff at a time and place best suited for all involved *starting Week 3*
  - ✓ Each team will fill out a "Team Contract" to be finalized in the 1st WPR

Let's get the teams formed by Monday of Week 2

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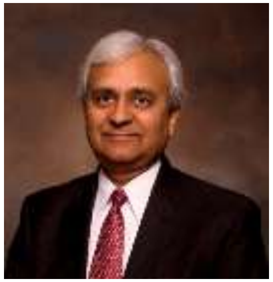
- ***Who*** **will help us learn**
- Appendix

About The Instructor

Pradeep Raj



https://www.aoe.vt.edu/people/adjunct/raj.html

- **Virginia Tech, Blacksburg, VA – Professor (2012–2024)**
  - ***Teaching:*** **Capstone Air Vehicle Design and Applied CFD**
  - ***Research:*** **Applied Aerodynamics and Aircraft Design**
- **Lockheed Martin**
  - ***Technical (1979–2000):*** **Aeronautics Co., California/Georgia**
  - ***Leadership & Management (2000–2011):*** **Advanced Development Programs, Skunk Works®, Palmdale, California**
- **UMR*, Rolla, Missouri**
  - **– Asst. Prof. (1978–79)**

  **now Missouri S&T University*
- **ISU, Ames, Iowa**
  - **– Res. Asst. Prof. (1976–78)**
- **GT, Atlanta, Georgia**
  - **– Ph.D. Aerospace Engineering (1976)**
- **IISc, Bangalore, India**
  - **– M.E. Aeronautical Engr. (1972)**
  - **– B.E. Electrical Tech. (1970)**
- ***AIAA Fellow (2011), FRAeS (2016),* and *FIAE (1991)***

Image Source: Internet

Why join VT after retiring from LM?

Kelly's Rules for Happy Retirement

1. *Retirement is like a job and must be approached as such*
2. *Don't travel too much, you want to establish a daily grind*
3. *Don't think about living someplace new, that's why God created hotels*
4. *Drive till you can't remember where you parked*
5. *Be pleasantly reckless - but if you have never done it before, now may not be the time to start*
6. *Don't hang with the children too much - visit, give presents and then move on*
7. *Maintain your bad habits, but never get drunk more than once a day. You're not a kid anymore*
8. *Hang with young people; they mostly have it right*

Clarence Leonard "Kelly" Johnson (1910-1990)

Legendary Aircraft Designer

Founder of World-renowned Skunk Works®

National Security Medal 1983

SR-71 Blackbird

"Hang with young people; they mostly have it right"

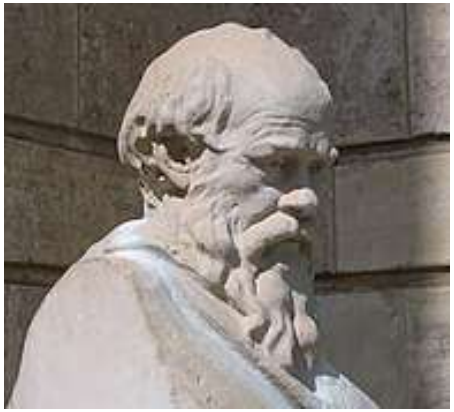
What's the Role of Instructors and Teaching Assistants?

Serve as Advisors, Coaches, Guides, and Mentors!

(We do not 'teach' in a 'traditional' mode.)

Raj's Teaching Philosophy

"I cannot teach anybody anything. I can only make them think."



Socrates
Greek Philosopher
c. 470 BC

"You cannot teach a man anything; you can only help him find it within himself."

Galileo Galilei
Italian Polymath,
Renaissance man
15 Feb 1564 – 8 Jan 1642

What is the Proper Amount of Guidance?

Dr. William H. Mason, AIAA-2010-9065, 2010

"…much of my time working with the students was talking about the process they should be using to arrive at decisions. **They would much rather be told exactly what to do, the usual engineering education paradigm, but only appropriate for engineering aides, not engineers."**

Dr. Vicki Johnson, AIAA Paper 92-1040, 1992

"There is an extremely fine line defining the proper amount of guidance the professor should provide to the students. Part of the design education process is starting out overwhelmed by options and generally narrowing in on the best options after exploring the many possibilities. Some of these possibilities will include going down blind alleys and spending time on useless alternatives. However, **if the students are guided directly to the best options and are not given the opportunity to search around *in some confusion*, they have missed the opportunity to understand what design is all about and to gain some confidence in their ability to work from the unknown to the known**."

Instructors' Expectations of You

Excellent Contribution & Exemplary Behavior

- **A**ttitude – *Be positive, cheerful, upbeat (All of the time!)*
- **E**xcellence – *Strive and you will achieve it!*
- **R**eliability – *Deliver what you promise, promise what you can deliver*
- **O**pen-mindedness – *Be receptive to new and different ideas—always!*
- **S**ense of humor – *Use it to bear trivial annoyances everyday*
- **P**rofessionalism – *Good judgment and polite behavior in all situations*
- **A**ttention to detail – *Achieve thoroughness and accuracy in all tasks*
- **C**ommunication – *Make sure the intended receiver got your message*
- **E**thics & integrity – *Do what is right, every time, all the time!*

Performance Befitting an AEROSPACE Engineer!

Epilogue

Learning to Ride a Bike is Hard!

So is Learning <u>New</u> Skills to Design "Best" Aircraft!

Source: Images from Internet

When Things Get Tough—and They Will, Remind Yourself and Others

"Life is like running an ultramarathon.

There are times when it's like,

Why are we doing this?

This is hard.

But you come back stronger."

Scott Jurek
American Ultramarathoner, Author, Public Speaker
Born: 26 Oct 1973

Are You Ready for an Exciting Journey?

Source: Wikipedia

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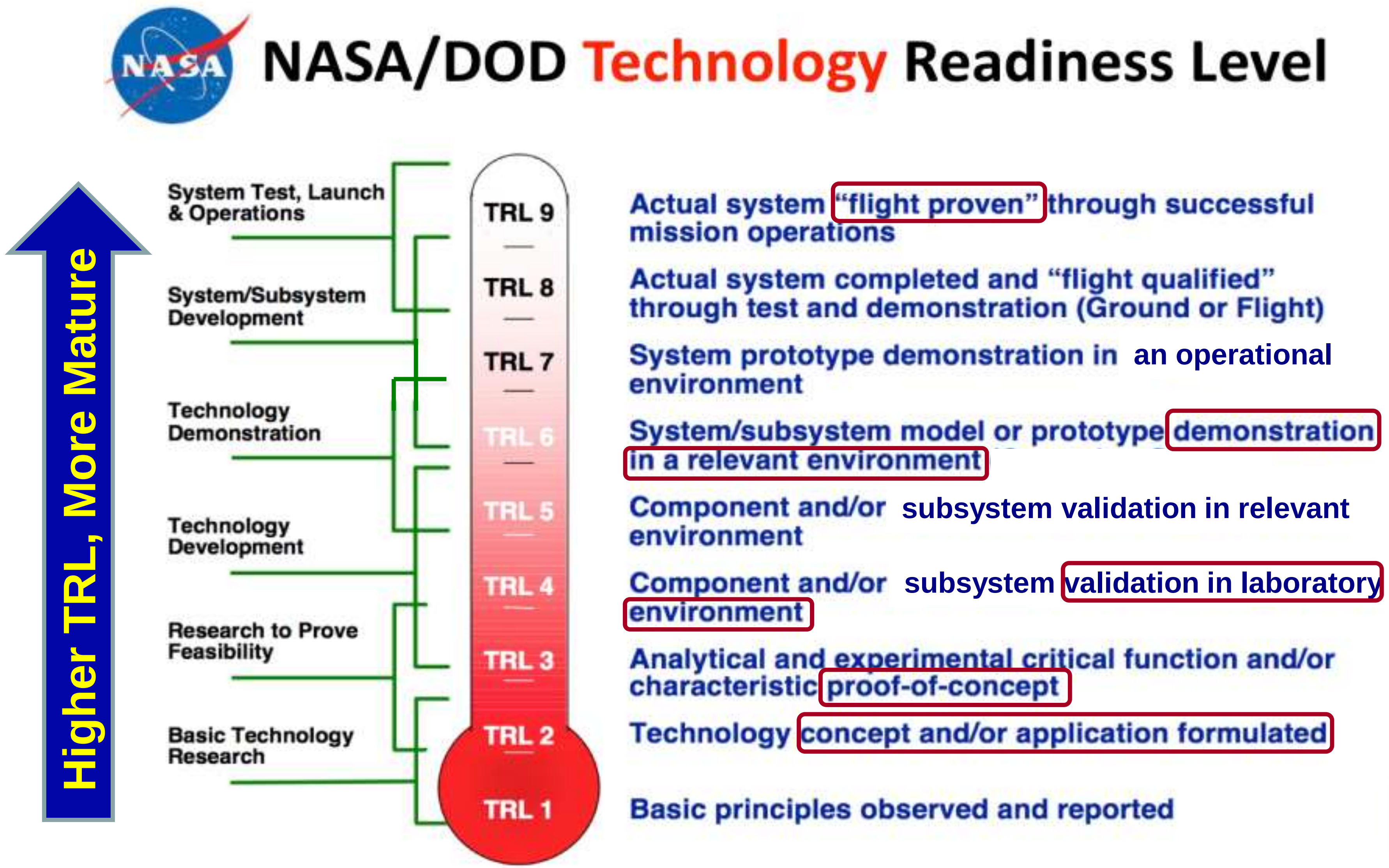
- ***Who*** will help us learn
- **Appendix**

Appendix

- Technology Readiness Levels (TRLs)
- Reference Material: Primary and Supplemental

What is TRL?



Higher TRL > More Mature > Less Risk

Source: Fig. 1.4, Ref. AVD 1 (Nicolai & Carichner)

AOE 4065-4066 Primary References

- **Primary References are mostly books, and a few articles, organized in nine (9) groups:**
  1. General Engineering Design (GED)
  2. Systems Thinking and Systems Engineering (SE)
  3. Air Vehicle Design (AVD)
  4. Flight Mechanics (FM)
  5. Propulsion Systems (PS)
  6. Structures (STR)
  7. Aircraft Subsystems (AS)
  8. Project Management (PM)
  9. Ethics & Integrity (EI)

See Complete List on Course Site and Appendix

Primary References (contd.)

Example

Ref. No.	Author(s)	Title
		AIR VEHICLE DESIGN (AVD)
AVD 1	Nicolai, L.M. and Carichner, G.E.	*Fundamentals of Aircraft and Airship Design, Volume I—Aircraft Design*, AIAA Education Series, AIAA, Reston, VA, 2010 FIVE copies in ASDI Library https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpFAADVIA3/viewerType:toc//root_slug:fundamentals-aircraft-2/url_slug:fundamentals-aircraft-2
AVD 2	Raymer, D.P.	*Aircraft Design : A Conceptual Approach*, AIAA Education Series, AIAA, Reston, VA, 2012 FOUR copies in ASDI Library
AVD 3	Gundlach, J.	*Designing [illegible] Aircraft Systems: A Comprehensive Approach*, AIAA Education Series, AIAA, Reston, VA, 2012 ONE [illegible] https://app-[illegible].vt.edu/web/toc.v/cid:kpDUASACA1/viewerType:toc//root_slug:designing-unmanned-aircraft-[illegible]
AVD 4	Gudmundsson, S.	*General Aviation Aircraft Design: [illegible] Procedures*, 1st Ed., Butterworth-Heinemann, September 2013. https://www-sciencedirect-com.ezproxy.lib.vt.[illegible]085/general-aviation-aircraft-design
AVD 5	Sadrey, M.H.	*Aircraft Design: A Systems Engineering Approach*, John [illegible] Sons, Inc., 2013. https://onlinelibrary-wiley-com.ezproxy.lib.vt.edu/doi/book/10.1002/9781118352700
AVD 6	Kirschbaum, N. and Mason, W.H.,	*Aircraft Design Handbook: Aircraft Design Aid and Layout Guide*, VPI Aircraft Design Series, 1992-93 EIGHT copies in ASDI Library
AVD 7	Roskam, J.	*Aircraft Design*, **Parts I-8**, Roskam Aviation and Engineering Corp., Lawrence, KS, 1985 TWO complete sets in ASDI Library
AVD 8	Kundu, A.K.	*Aircraft Design*, Cambridge University Press, 2010 https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpAD000015/viewerType:toc//root_slug:aircraft-design/url_slug:aircraft-design
AVD 9	Torenbeek, E.	*Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes*, John Wiley and Sons, Ltd, June 2013. https://onlinelibrary-wiley-com.ezproxy.lib.vt.edu/doi/book/10.1002/9781118568101
AVD 10	Loftin, Jr., L.K.	**Subsonic Aircraft: Evolution and the Matching of Size to Performance**, NASA Reference Publication 1060, 1980 https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800020744.pdf

42

25 August 2021

- **Hard copies of some references are in the VT Library or the ASDI Library; many are available online**

AOE 4065-4066
Primary References (1 of 6)

Also on Course Site: **Files > Reference Material > Primary References**

Ref. No.	Author(s)	Title	Hyperlink
GENERAL ENGINEERING DESIGN (GED)			
GED 1	Post, M.L., Brandt, S.A., and Barlow, D.N.	***Introduction to Engineering: A Project-Based Experience in Engineering Methods*** , AIAA Education Series, AIAA, Reston, VA, 2017.	
GED 2	Brandt, S.A., Stiles, R.J., Bertin, J.J., and Whitford, R.	***Introduction to Aeronautics: A Design Perspective*** , AIAA Education Series, AIAA, Washington DC, 2004.	https://app-knovel-com.ezproxy.lib.vt.edu/kn/resources/kpIAADPE01/toc?kpromoter=marc
GED 3	Dieter, G.E.	***Engineering Design: A Materials and Processing Approach*** , 3rd Edition, McGraw-Hill Higher Education, New York, NY, 1999	
GED 4	Ullman, D.G.	***The Mechanical Design Process*** , McGraw-Hill Higher Education, New York, NY, 1991	
GED 5	Ertas, A., and Jones, J.C.	***The Engineering Design Process*** , John Wiley & Sons, Inc., New York, NY, 1993	
GED 6	Norman, D.	***The Design of Everyday Things*** , Basic Books, New Your, NY, 1988	
GED 7	National Research Council	***Theoretical Foundations for Decision Making in Engineering Design.*** The National Academies Press, Washington, DC, 2001.	https://doi.org/10.17226/10566
GED 8	Woodson, T.T.	***Introduction to Engineering Design,*** McGraw-Hill Book Company, 1966	
SYSTEMS THINKING & SYSTEMS ENGINEERING (SE)			
SE 1	Burge, S.E.	***Systems Engineering: Using Systems Thinking to Design Better Aerospace Systems*** , Wiley Online Library	https://doi.org/10.1002/9780470686652.eae536
SE 2	Kossiakoff, A. and Sweet, W.N.	***Systems Engineering Principles and Practice*** , John Wiley and Sons, Ltd., 2003.	https://onlinelibrary-wiley-com.ezproxy.lib.vt.edu/doi/book/10.1002/0471723630
SE 3	Haberfellner, R., de Weck, O., Frickle, E., and Vossner, S.	***Systems Engineering: Fundamentals and Applications*** , Birkhauser, 2019.	https://link.springer.com/book/10.1007/978-3-030-13431-0
SE 4	NASA	***NASA Systems Engineering Handbook*** **, NASA SP-2007-6105 Rev 1**, December 2007	https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook
SE 5	DoD	***Systems Engineering Fundamentals*** , Defense Acquisition University Press, Fort Belvoir, VA, 2001	https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/readings/sefguide_01_01.pdf

Some hyperlinks might not work from outside the Virginia Tech domain

Primary References (2 of 6)

Ref. No.	Author(s)	Title	Hyperlink
AIR VEHICLE DESIGN (AVD)			
AVD 1	Nicolai, L.M. and Carichner, G.E.	***Fundamentals of Aircraft and Airship Design , Volume I—Aircraft Design ,*** AIAA Education Series, AIAA, Reston, VA, 2010. **FIVE copies in ASDI Library**	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpFAADVIA3/viewerType:toc//root_slug:fundamentals-aircraft-2/url_slug:fundamentals-aircraft-2
AVD 2	Raymer, D.P.	***Aircraft Design : A Conceptual Approach ,*** AIAA Education Series, AIAA, Reston, VA, 2012. **FOUR copies in ASDI Library**	
AVD 3	Gundlach, J.	***Designing Unmanned Aircraft Systems: A Comprehensive Approach ,*** AIAA Education Series, AIAA, Reston, VA, 2012. **ONE copy in ASDI Library**	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpDUASACA1/viewerType:toc//root_slug:designing-unmanned-aircraft?kpromoter=marc
AVD 4	Gudmundsson, S.	***General Aviation Aircraft Design: Applied Methods and Procedures ,*** 1st Ed., Butterworth-Heinemann, September 2013.	https://www-sciencedirect-com.ezproxy.lib.vt.edu/book/9780123973085/general-aviation-aircraft-design
AVD 5	Sadrey, M.H.	***Aircraft Design: A Systems Engineering Approach ,*** John Wiley & Sons, Inc., 2013.	https://onlinelibrary-wiley-com.ezproxy.lib.vt.edu/doi/book/10.1002/9781118352700
AVD 6	Kirschbaum, N. and Mason, W.H.,	***Aircraft Design Handbook: Aircraft Design Aid and Layout Guide ,*** VPI Aircraft Design Series, 1992-93. **EIGHT copies in ASDI Library**	
AVD 7	Roskam, J.	***Aircraft Design,* Parts 1-8*,*** Roskam Aviation and Engineering Corp., Lawrence, KS, 1985. **TWO complete sets in ASDI Library**	
AVD 8	Kundu, A.K.	***Aircraft Design ,*** Cambridge University Press, 2010.	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpAD000013/viewerType:toc//root_slug:aircraft-design/url_slug:aircraft-design
AVD 9	Torenbeek, E.	***Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes ,*** John Wiley and Sons, Ltd., June 2013.	https://onlinelibrary-wiley-com.ezproxy.lib.vt.edu/doi/book/10.1002/9781118568101
AVD 10	Loftin, Jr., L.K.	**Subsonic Aircraft: Evolution and the Matching of Size to Performance**, NASA Reference Publication 1060, 1980.	https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800020744.pdf
AVD 11	Kuchemann, D.	***The Aerodynamic Design of Aircraft ,*** *Pergamon Press, New York, 1978.*	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpADA0000T/viewerType:toc//root_slug:aerodynamic-design-aircraft/url_slug:references-pages-515?b-q=aerodynamica%20design%20of%20aircraft&sort_on=default&b-subscription=true&b-group-by=true&page=1&b-s
AVD 12	Corning, G.	***Supersonic and Subsonic Airplane Design ,*** Braun-Brumfield, Inc., Ann Arbor, MI, 1964. **ONE copy in ASDI Library**	

Primary References (3 of 6)

Ref. No.	Author(s)	Title	Hyperlink
		AIR VEHICLE DESIGN (AVD)	
AVD 13	Schaufele, R.D.	***The Elements of Aircraft Preliminary Design*** , Aries Publications, 2000.	
AVD 14	Fielding, J.P.	***Introduction to Aircraft Design*** , 2nd Edition, Cambridge University Press, New York, NY, 2017.	
AVD 15	Jenkinson, L.R., Simpkin, P., and Rhodes, D.	***Civil Jet Aircraft Design*** , Co-published by AIAA, Reston, VA, 1999	
AVD 16	Stinton, D.	***The Design of the Aeroplane*** , Van Nostrand Reinhold Co., New York, NY, 1983	
AVD 17	Wood, K.D.	***Aerospace Vehicle Design Vol. I. Aircraft Design*** , Johnson Publishing Co., Boulder, CO, 1968	
AVD 18	Raymer, D.P.	***Enhancing Aircraft Conceptual Design using Multidisciplinary Optimization,*** *Doctoral Thesis, Department of Aeronautics, Royal Institute of Technology, Stockholm, Sweden, Report 2002-2, May 2002.* **ONE copy in ASDI Library**	http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A9120&dswid=_new
AVD 19	Carichner, G.E., and Nicolai, L.M.	***Fundamentals of Aircraft and Airship Design*** **,** ***Volume II—Airship Design and Case Studies*** , AIAA Education Series, AIAA, Reston, VA, 2010. **ONE copy in ASDI Library**	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpFAADVADF/viewerType:toc//root_slug:fundamentals-of-aircraft?kpromoter=marc
AVD 20	Nicolai, L.M.	***Lessons Learned: A Guide to Improved Aircraft Design*** , AIAA Library of Flight, AIAA, Reston, VA, 2016.	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpEGPDSB01/viewerType:toc//root_slug:lessons-learned-guide/url_slug:lessons-learned-guide?b-q=Lessons%20Learned%3A%20A%20Guide%20to%20Improved%20Aircraft%20Design&sort_on=default&b-subscription=true&
AVD 21	Jenkinson, L.R., and Marchman, J.F.	***Aircraft Design Projects for Engineering Students*** , Co-published by AIAA, Reston, VA, 1999	https://web-s-ebscohost-com.ezproxy.lib.vt.edu/ehost/ebookviewer/ebook?sid=615c9cc6-9b5a-4bc2-8698-82e66a81e242%40redis&vid=0&format=EB

Some hyperlinks might not work from outside the Virginia Tech domain

Primary References (4 of 6)

Ref. No.	Author(s)	Title	Hyperlink
FLIGHT MECHANICS (FM)			
FM 1	Pamadi, B.N.	***Performance, Stability, Dynamics, and Control of Airplanes*** , 3rd edition, AIAA Education Series, AIAA, Reston, VA, 2015. **ONE copy in ASDI Library**	https://ebookcentral.proquest.com/lib/vt/detail.action?docID=3111614
FM 2	Yechout, T.R. with Morris, S.L., Bossert, D.E., and Hallgren, W.F.	***Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, and Classical Feedback Control*** , AIAA Education Series, AIAA, Reston, VA, 2003. **ONE copy in ASDI Library**	
FM 3	Stinton, D.	***Flying Qualities and Flight Testing of the Airplane,*** AIAA Education Series, AIAA, Reston, VA, 1996. **ONE copy in ASDI Library**	
PROPULSION SYSTEMS (PS)			
PS 1	Mattingly, J.D.	***Elements of Propulsion: Gas Turbines and Rockets,*** AIAA Education Series, AIAA, Reston, VA, 2006	https://app-knovel-com.ezproxy.lib.vt.edu/web/view/khtml/show.v/rcid:kpEPGTR002/cid:kt0046LK6H/viewerType:khtml//root_slug:1-introduction/url_slug:introduction-2?kpromoter=marc&b-toc-cid=kpEPGTR002&b-toc-root-slug=&b-toc-url-slug=introduction-2&b-toc-titl
PS 2	Oats, G.C.	***Aircraft Propulsion Systems Technology and Design,*** AIAA, 1989. **ONE copy in ASDI Library**	https://app-knovel-com.ezproxy.lib.vt.edu/web/toc.v/cid:kpAPSTD00K/viewerType:toc/root_slug:aircraft-propulsion-systems?kpromoter=federation
PS 3	Mattingly, J.D., Heiser, W.H., and Daley, D.H.	***Aircraft Engine Design*** 2nd ed., AIAA Education Series, AIAA, Reston, VA, 2002	https://app-knovel-com.ezproxy.lib.vt.edu/web/view/khtml/show.v/rcid:kpAEDE000J/cid:kt0046IK63/viewerType:khtml//root_slug:aircraft-engine-design/url_slug:front-matter?b-toc-cid=kpAEDE000J&b-toc-root-slug=aircraft-engine-design&b-toc-title=Aircraft%20Engi
STRUCTURES (STR)			
STR 1	Niu, Michael C.Y.	***Airframe Structural Design,*** 2nd Ed., Adaso/Adastra Engineering Center, 2011 **ONE copy in ASDI Library**	
STR 2	Niu, Michael C.Y.	***Composite Airframe Structure,*** 3rd Ed., Hong Kong Conmilit Press Ltd., 2010 **ONE copy in ASDI Library**	

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Primary References (5 of 6)

Ref. No.	Author(s)	Title	Hyperlink
AIRCRAFT SUBSYSTEMS (AS)			
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PM 1	Ruskin, A.M., and Estes, W.E.	***What Every Engineer Should Know About Project Management,*** 2nd Ed., Marcel Dekker, Inc., New York, NY, 1995. **ONE copy in ASDI Library**	
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		ETHICS & INTEGRITY (EI)	
EI 1	Hoover, K., Fowler, W.T. and Stearman, R.O.	***Studies in Ethics, Safety, and Liability for Engineers,*** The University of Texas at Austin	http://www.tsgc.utexas.edu/archive/general/ethics/
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EI 6	Glasgow, E.R. "Ed"	***Supercruise Challenge during Flight Test of the Lockheed Martin YF-22 Advanced Tactical Fighter (ATF) Prototypes***	

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Supplemental Reference Material

Course Site: **Files > Reference Material > Supplemental Reference Material**

List of Folders (*in alphabetical order*)

- Aerodynamics
- AeroPropulsion Integration
- Aircraft Certification
- Aircraft Configuration Layout Considerations
- Aircraft Drawings & Illustrations
- Aircraft Initial Sizing
- Aircraft Integrated Designs (AEAs, HEAs, GAAs, etc.)
- Aircraft OML Modeling_Lofting
- Automated and Autonomous Systems
- ConOps
- Cost
- Cybersecurity
- Ethics
- FAR & MIL-SPEC Documents
- ICD Example
- Misc Articles
- Noise
- Oral Presentations
- Performance
- Proposal (Dsgn Report) Writing
- Risk
- Stability & Control
- Stealth
- Structures
- Subsystems
- Systems Engineering
- Weights & Balance

Repository of Numerous Articles, Papers, Reports, etc.