

The Critical Need for Increased IT Education in Aerospace Undergraduate and Graduate Programs

Lyle N. Long

Distinguished Professor of Aerospace Engineering
The Pennsylvania State University

Presented at the AIAA InfoTech@Aerospace Conference
Seattle, WA, April, 2009

This talk would apply equally well to virtually all disciplines. You could replace “Aerospace” with Chemistry, Physics, ME, English, Biology, or Psychology, etc.

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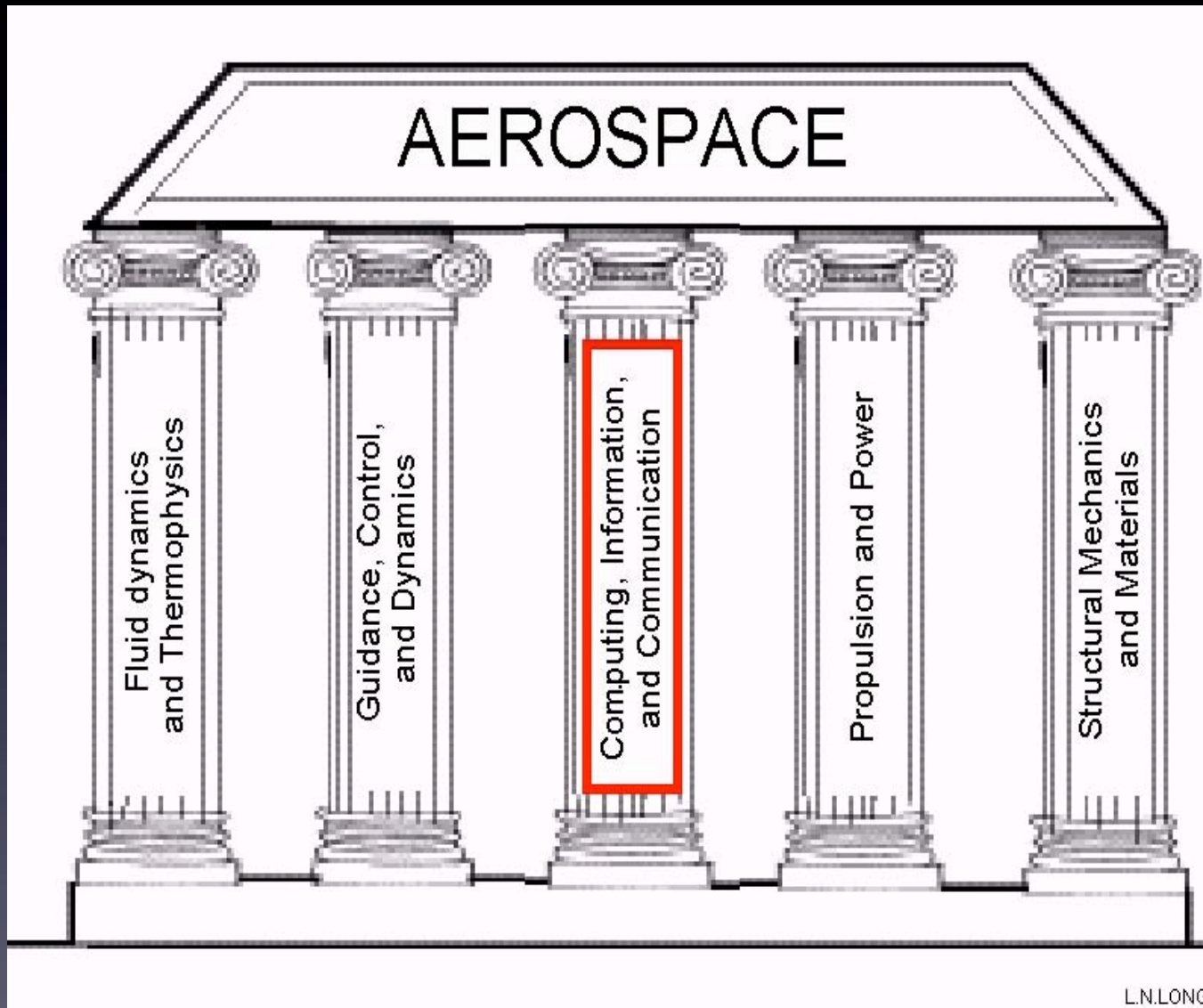
Put any
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Modern Aerospace Systems Are Dominated by Computers, Networks, and Software

- IT is crucial for modern aerospace systems
- 65% of new engineers hired recently in Aerospace were involved in computer and related work
- The Boeing 777 has 4 million lines of software onboard and 1,280 processors
- The F/A-22 Raptor has 2 million lines of software
- A Blackhawk S.O. helicopter has roughly 2,000 pounds of wire
- Autonomous Vehicles and Intelligent Systems will mean more complex and less deterministic software
- A few quotes:
 - Boeing: “It’s not about the airplane.”
 - Lockheed: “The wiring harness is more difficult than the airplane structure.”
 - U.S. Air Force: “The airplane is just “the platform” and it is mainly there to carry the computers”

Long, Lyle N., "The Critical Need for Software Engineering Education," in *CrossTalk: The Journal of Defense Software Engineering*, Vol. 21, No. 1, Jan., 2008.

There are Five Technology Pillars in Aerospace Engineering – Not Four



The four traditional areas are now fairly mature, while software has been called the Achille's heel of aerospace systems.

Long, L.N., *Journal of Aerospace Computing, Information, and Communication*, Vol. 1, No. 1, Jan., 2004.

<http://www.personal.psu.edu/lnl/papers/LNL2005e.pdf>

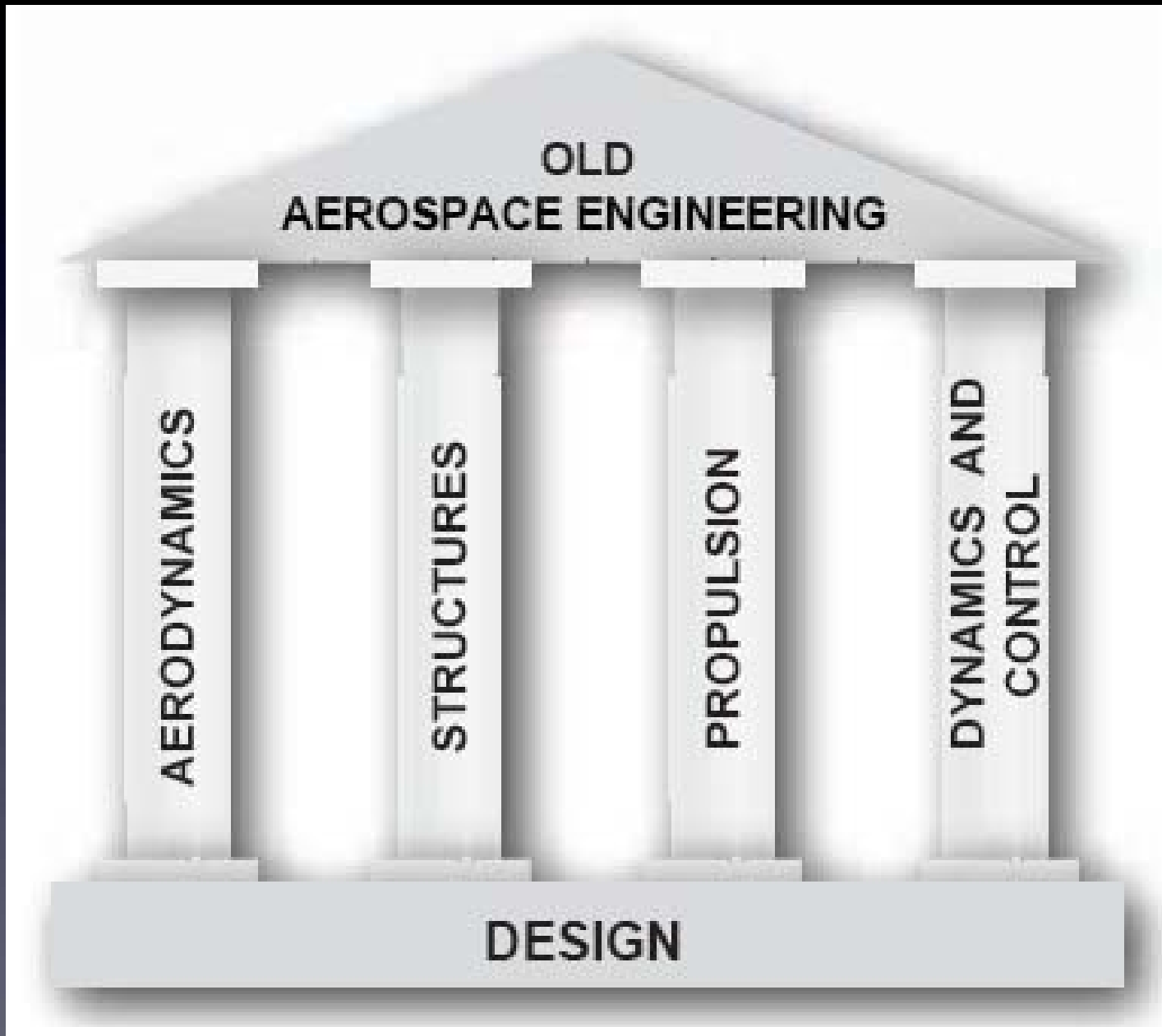
How to Define Aerospace “Information Technology” ?

- The main elements of IT are: computing, information, and communication
- Thus, the name of the new AIAA journal: “Journal of Aerospace Computing, Information, and Communication” (<http://www.aiaa.org/jacic>)
- Software ties the three areas together
- Sensors and avionics rely on software, computing, information, and communication

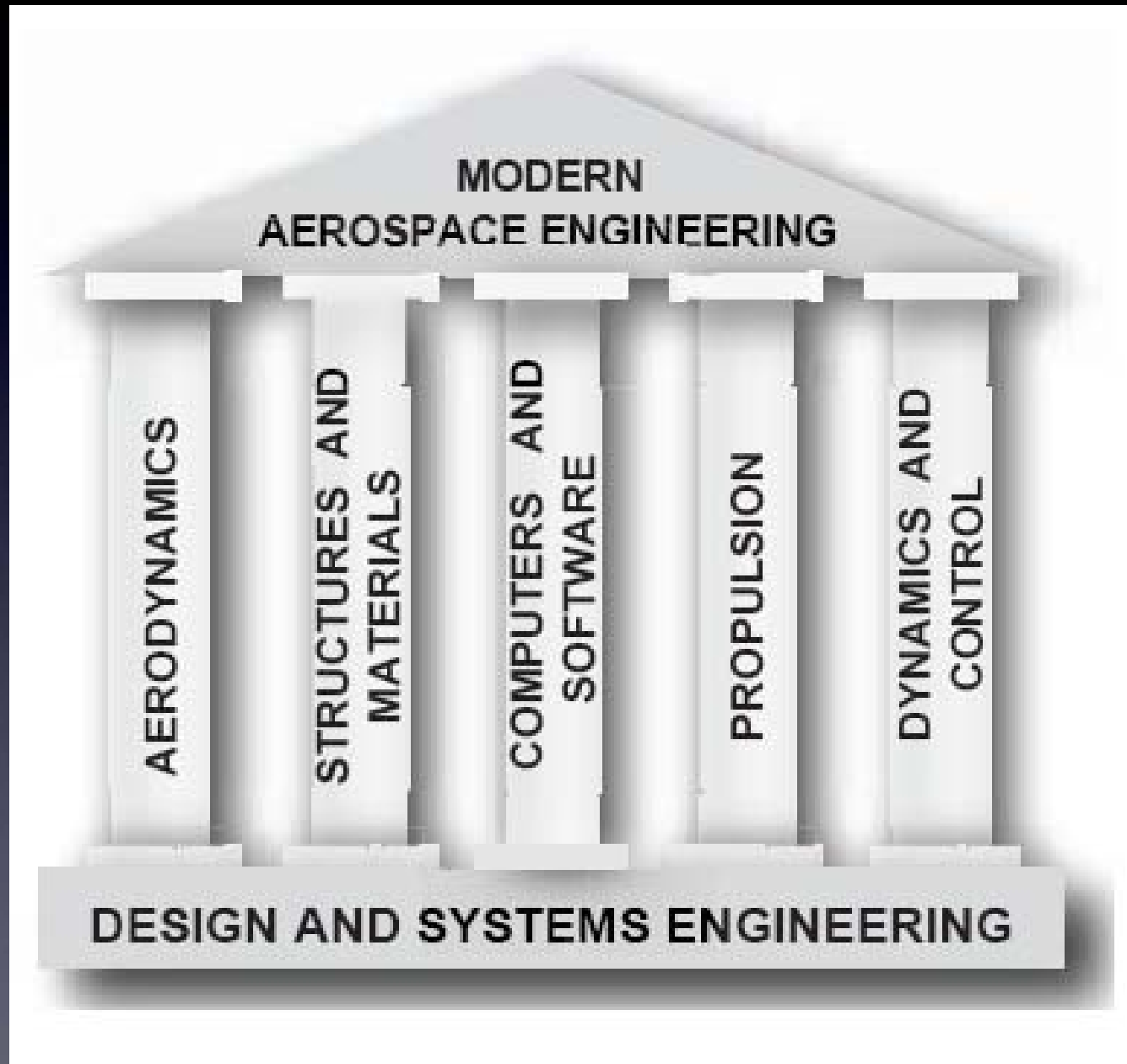
Aerospace Engineering Education Programs Need More Computing, Software, and EE

- Penn State (Aero degree) requires 131 credits
- Only 6 credits in IT are *required*:
 - Freshman programming (c): 3 credits
 - Intro to Software Engineering *or* Circuits: 3 credits
 - This is typical of other programs
- Most aerospace engineering faculty are in traditional areas: aerodynamics, structures, guidance/control, or propulsion – not IT – and change happens at glacial speed
- 50% of the cost of many Aerospace Systems is now in computing, software, and EE
- Engineering education programs have not adjusted fast enough to these changes

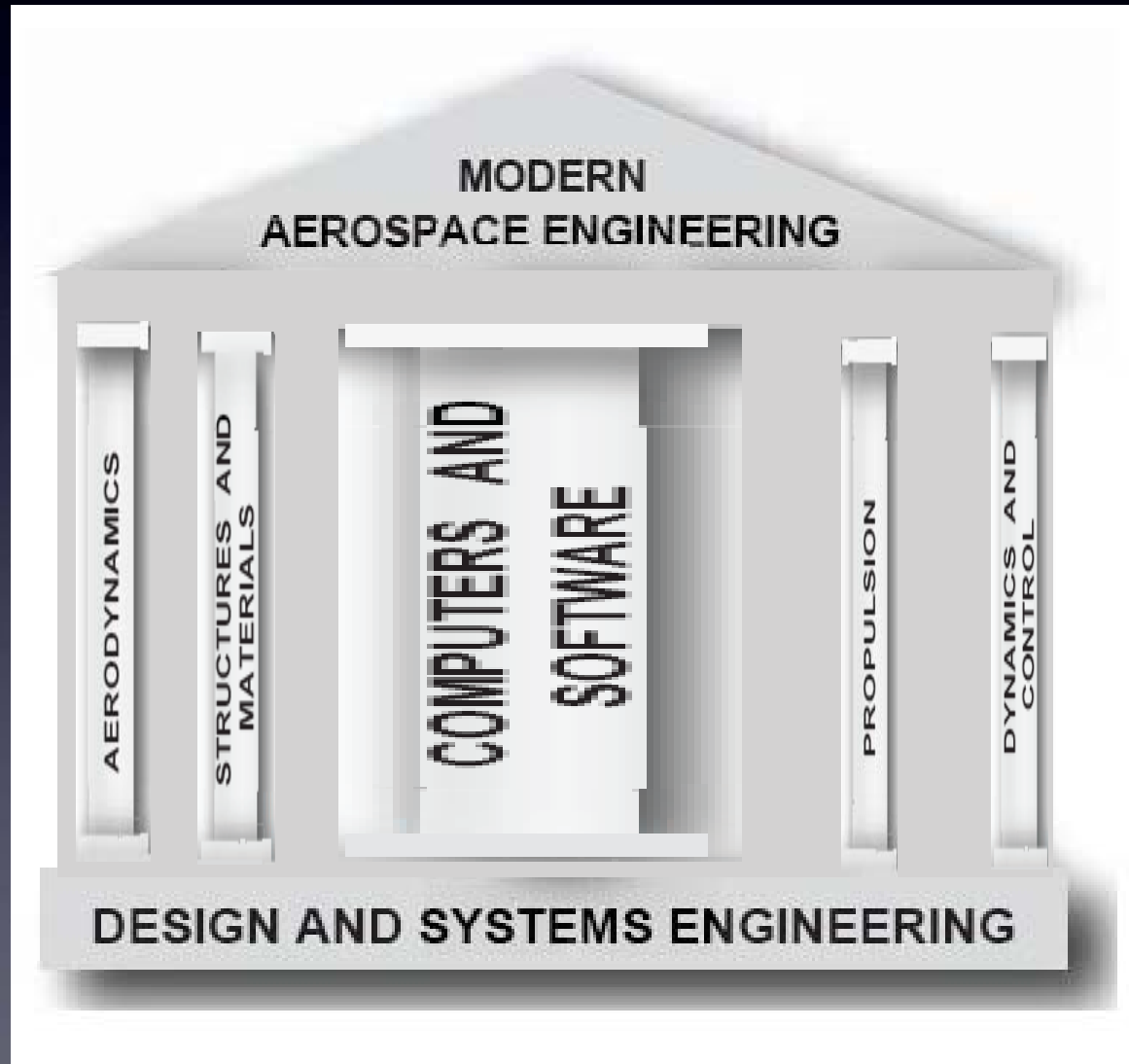
Unfortunately, too many Aerospace Education Programs Look Like this



Aerospace Education Programs Should Really Look Like This

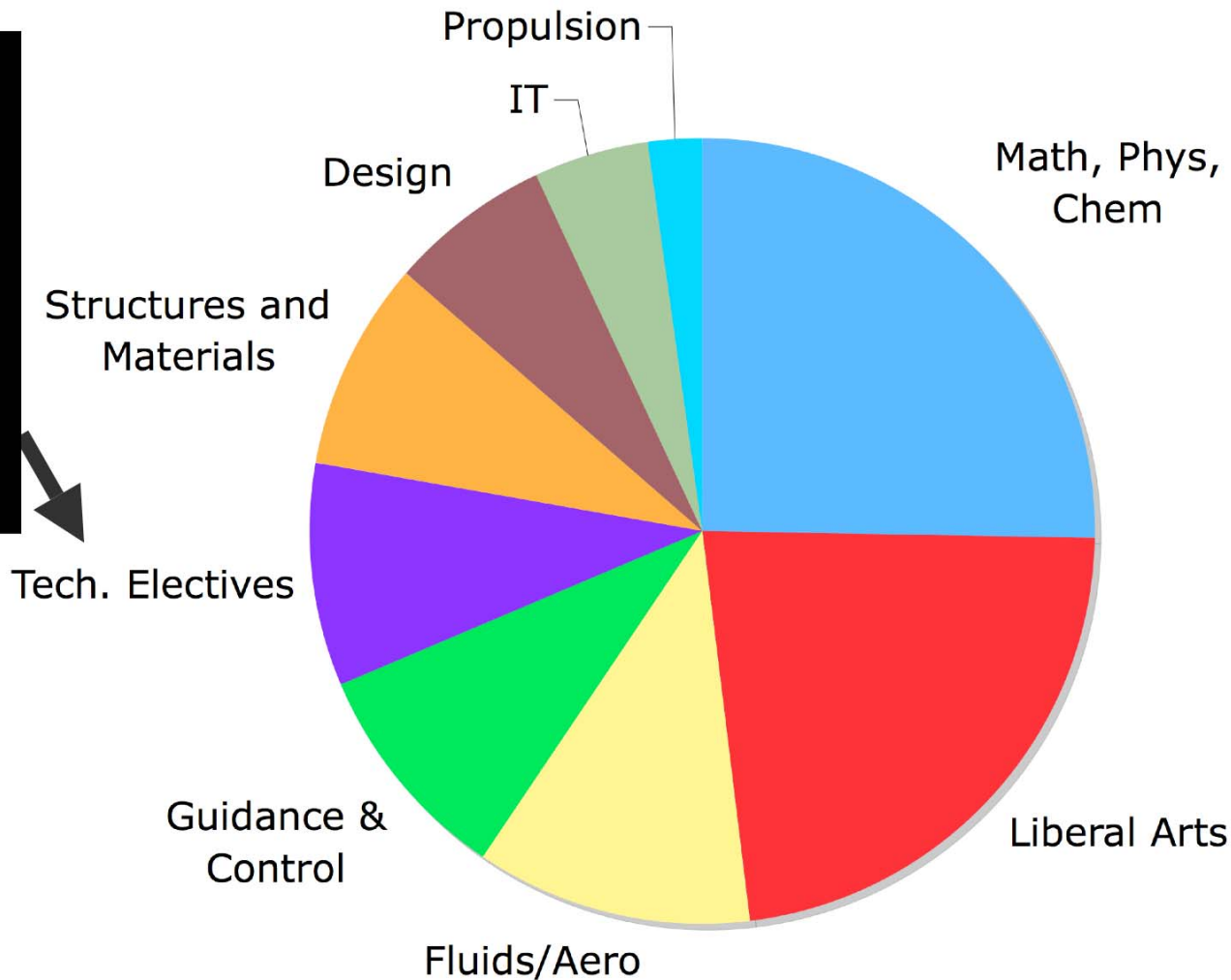


Or ... Based on Importance of Topics,
Maybe Aerospace Programs should Look
like this !



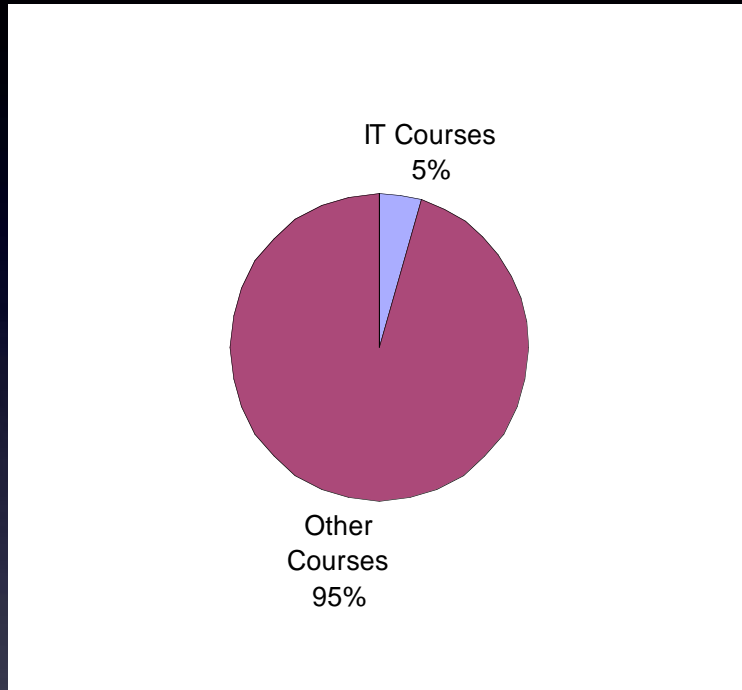
Aerospace Engineering Undergrad Program

This might be OK, if most of these are IT related (software, CS, EE, ...)

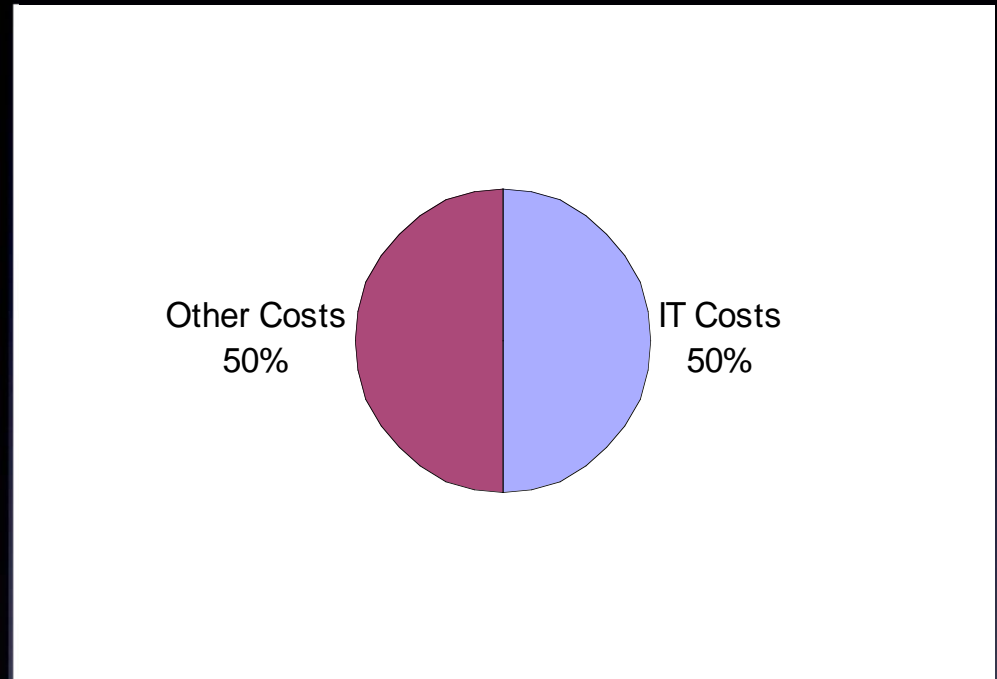


The Big Mismatch in Teaching vs Needs

Course Requirements



Typical Aerospace System Cost or Effort



- Because of this mismatch, aerospace engineering students cannot understand the entire system unless they learn more beyond their requirements.
- We need to stop teaching people how to design/build 50 year old aircraft and spacecraft

Penn State's "IST for Aerospace" Minor

- Requires these additional courses (13 cr.):
 - IST 110, Information, People, and Technology
 - CMPSC 201C, Computer Programming for Engineers using C
 - IST 210, Organization of Data
 - IST 220, Networking and Telecommunications
- Plus two of these (6 cr.):
 - AERSP 423, Intro. to Numerical Methods in Fluid Dynamics
 - AERSP 424, Advanced Computer Programming
 - AERSP 440, Intro. to Software Engineering for Aersp. Engrs.
 - AERSP 460, Aerospace Control Systems
- <http://www.personal.psu.edu/lnl/ist/>

Minor's are a great way for students to complement the content of their major programs, and get acknowledged for their extra efforts.

Current Aerospace Ph.D. Programs

A typical Ph.D. candidacy exam includes:

- Fluid Dynamics
- Structures
- Dynamics
- Mathematics

Much of the material the students are required to learn is of historical significance only, and the students will most likely never use it.

Too often we are testing material that the faculty learned in grad school, not what is important to succeed today

Aerospace Ph.D. Programs

A better Ph.D. candidacy exam would include:

- Fluids, aerodynamics, thermophysics, CFD, ...
- Structures, materials, finite elements, ...
- Dynamics, control, guidance, navigation, GPS, ...
- Propulsion, combustion, chemistry, power, ...
- Software, computing, information, communication, numerical analysis, sensors, avionics, ...

The students could choose to be examined in 2-3 of the above areas

Of the top 10 aerospace programs, only MIT seems to have such a program, the others have candidacy exams that have changed very little in 30 years.

Penn State's Graduate Minor in Computational Science

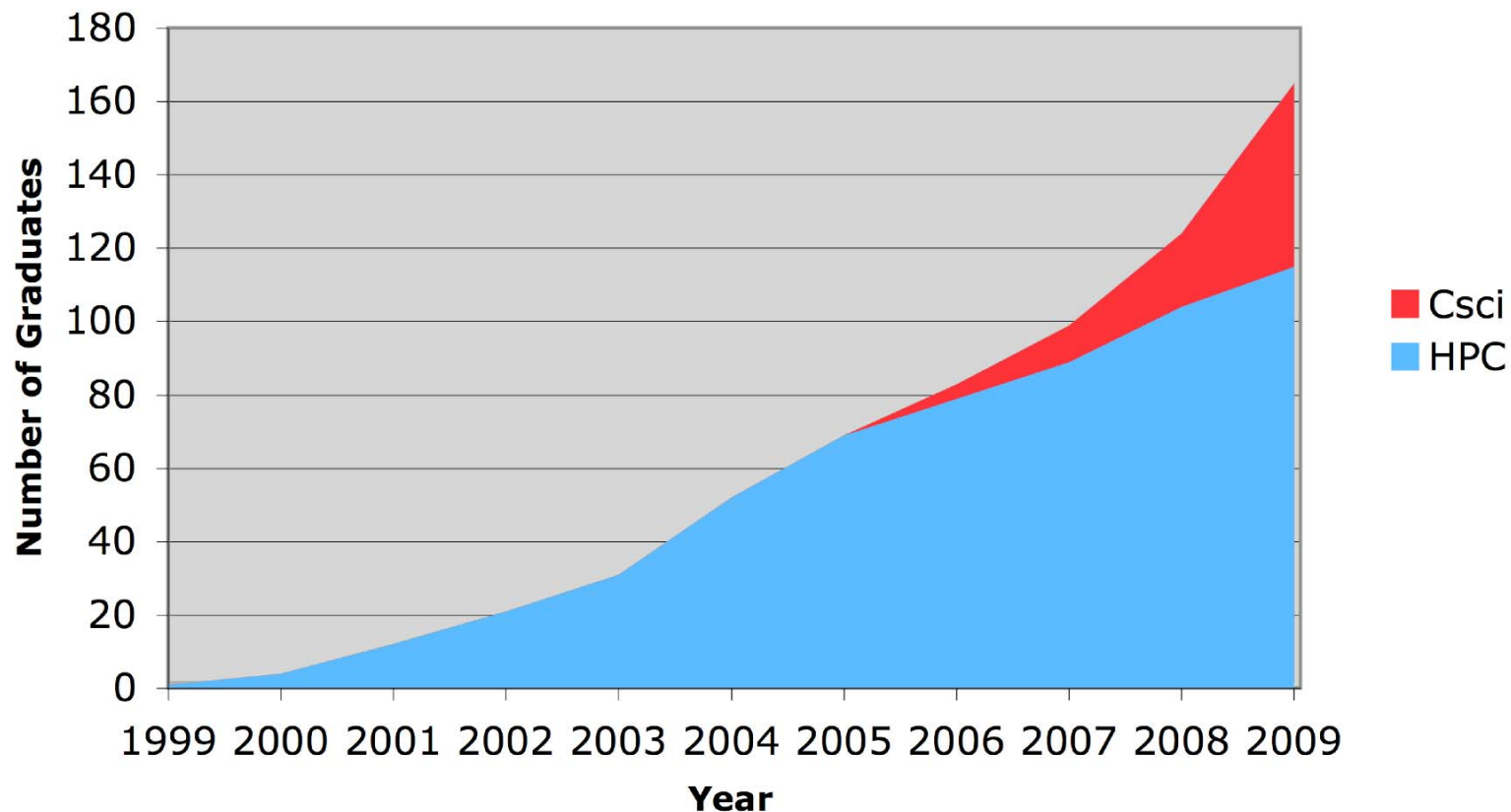
Core Requirements:

- Computational Science Tools (2 cr.)
- Computational Science Invited Lectures (1 cr.)
- And two of these (3 cr. each):
 - AERSP 424: Advanced Computer Programming
 - CSE 557: Concurrent Matrix Computation OR
NucE 530: Parallel and Vector Computing
 - Math 523: Numerical Analysis
- M.S. degree Minor (9 credits)
 - Core Requirements (9 cr.)
- Ph.D. degree Minor (15 credits):
 - Core Requirements (9 cr.)
 - And two courses from the list of 73 CSci courses from 20 different departments (6 cr.)
- The courses can also be applied towards their major degree
- Previously, called the Graduate Minor in High Performance Computing

Minor's are a great way for students to complement the content of their major programs, and get acknowledged for their extra efforts.

Penn State's Grad Minor in Computational Science

Cummulative Number of Grad Minor Degrees Awarded (www.csci.psu.edu)



Roughly 25% were from Aerospace Engineering

AIAA Organization: Seven Major Technical Groups

1. Aerospace Design and Structures

- Structures, materials, ...

2. Aerospace Sciences

- Fluids, aerodynamics, wind tunnels, guidance, navigation, control, ...

3. Information Systems

- Communications, computers, software, avionics, intell. systems, sensors, ...

4. Propulsion and Energy

- Jet engines, rockets, nuclear, combustion, ...

5. Aircraft and Atmospheric Systems

- Aircraft, balloons, flight testing, GA, V/STOL

6. Space and Missile Systems

- Space, microgravity, missiles, ...

7. Engineering and Technology Management

- CAD, economics, history, legal, management, systems engineering, ...

Aerospace
Engineering
educational
programs
need to
address *ALL*
these areas

Aerospace Industry Needs

Lockheed Martin (Feb. 2005)

- 708 Job Openings for recent graduates:
 - 167 in Systems Engineering (23 %)
 - 136 in Software Engineering (19 %)
 - 56 in Information Technology (8 %)
 - 59 in Mechanical Engineering (8 %)
 - 45 in Electrical Engineering (6 %)
 - 21 in Aerospace Engineering (3 %)
- } 50 %

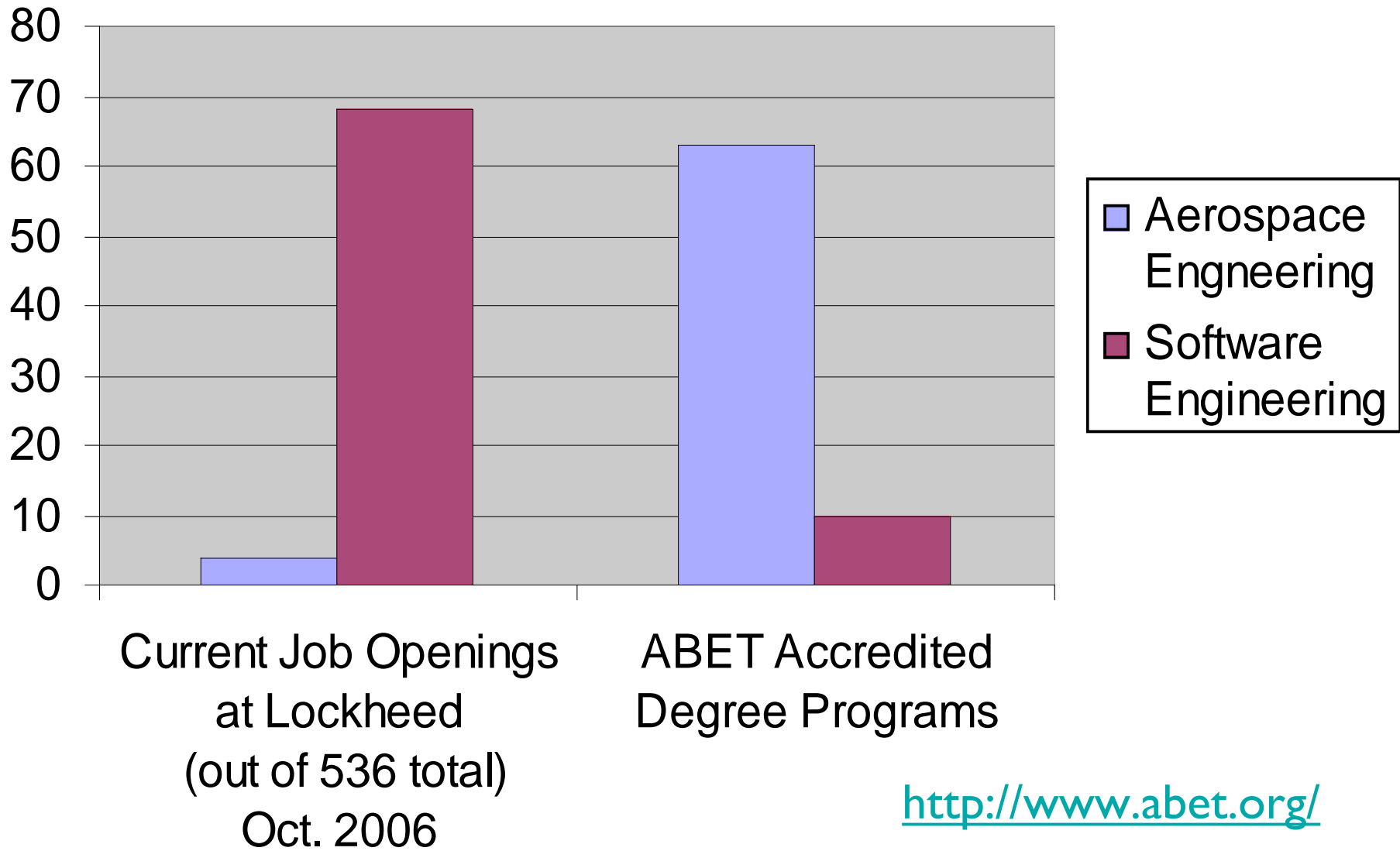
<https://www.lmpeople.com/careers/search/search.asp>

Software Engineering Programs

- The IEEE has the Certified Software Development Professional (CSDP) program, its a great start but it is not Software Engineering. It does not require someone have a science or engineering background
- I don't think we want people managing software development programs who have little or no training in science or engineering
- Also, a Comp Sci undergrad degree (at Penn State) *requires* only 9 credits in software out of 125 credits
- Good curriculum definition efforts from Computer Society and ACM (see refs)
- We need more Software Engineering education programs and certification (there are only 10 accredited programs in U.S., there are 63 aerospace programs)

<http://www.computer.org/portal/pages/ieeecs/education/certification/>
<http://www.stsc.hill.af.mil/crosstalk/2000/03/vaughn.html>

Mismatch in Educational Programs vs Employer Needs



Conclusions

- Educational programs are simply out of balance, and too slow to change
- Aerospace Engineering education needs much more material on IT
- Undergrad and Grad Minors are valuable
- Need to remember that aerospace engineers usually need at least a Masters degree
- Aerospace Engineers don't learn enough about software, and software engineers don't learn enough about science and engineering
- Universities are hesitant to start new educational programs because they usually just draw students away from existing programs ... We need federal funding to initiate them!

Questions?

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<http://www.personal.psu.edu/lnl>

Long, Lyle N., The Critical Need for Software Engineering Education in CrossTalk: The Journal of Defense Software Engineering, Vol. 21, No. 1, Jan., 2008.

<http://www.stsc.hill.af.mil/CrossTalk/2008/01/0801Long.pdf>