Systems vs. Software Engineering Skills: A Gap Analysis

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Who I am

- Retired AF Officer (23 years) where I qualified for the Air Force Specialty Code for Software Engineer. I taught software engineering at the USAF Academy and the Air Force Institute of Technology. I also taught at Keesler AFB (technical training) for 6 years
- Former Consultant for the Software Technology Support Center (12 years)
- Professor of Computer Science, Stephen F. Austin State University
- Columnist for Crosstalk, the Journal of Defense Software Engineering (I write the Backtalk column for every issue)
- ABET Program Evaluator since 1998, and a Commissioner and/or Team Chair since 2007

Who is paying for this trip?

SFA is in Nacogdoches, TX. It is NOT in Austin, nor is it associated with any school of higher learning in Austin.

In fact, it is generally acknowledged by those of us who graduated from Texas A&M that there ARE no schools of higher education in Austin. 😂

What this talk is about

- Software engineering is a distinct discipline from Systems Engineering, although they share many of the same course in academia
- Both types of engineering are distinct and different from any CS related degree (Computer Science, Information Technology, or Information Systems)
- Knowing the similarities and differences help you know the strengths and weaknesses of your hires

Typical formal definitions of software engineering are:

- [those who] **"research, design, develop, and test operating systems-level software, compilers, and network distribution software for medical, industrial, military, communications, aerospace, business, scientific, and general computing applications."**
- **"the systematic application of scientific and technological knowledge, methods, and experience to the design, implementation, testing, and documentation of software";**
- **"the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software";**
- **"an engineering discipline that is concerned with all aspects of software production";**
- **and "the establishment and use of sound engineering principles in order to economically obtain software that is reliable and works efficiently on real machines."**

PREMISE – from an earlier talk

- We don't really know what a software engineer is or does – except that they "engineer software".
- This is NOT a criticism – software engineering is HARD – and requires a lot of skill that separate it from computer science, information technology, or even "traditional engineering".
- On the other hand, **"An *engineer* is a professional practitioner of *engineering*, concerned with applying scientific knowledge, mathematics, and ingenuity to develop solutions for technical, societal and commercial problems."**

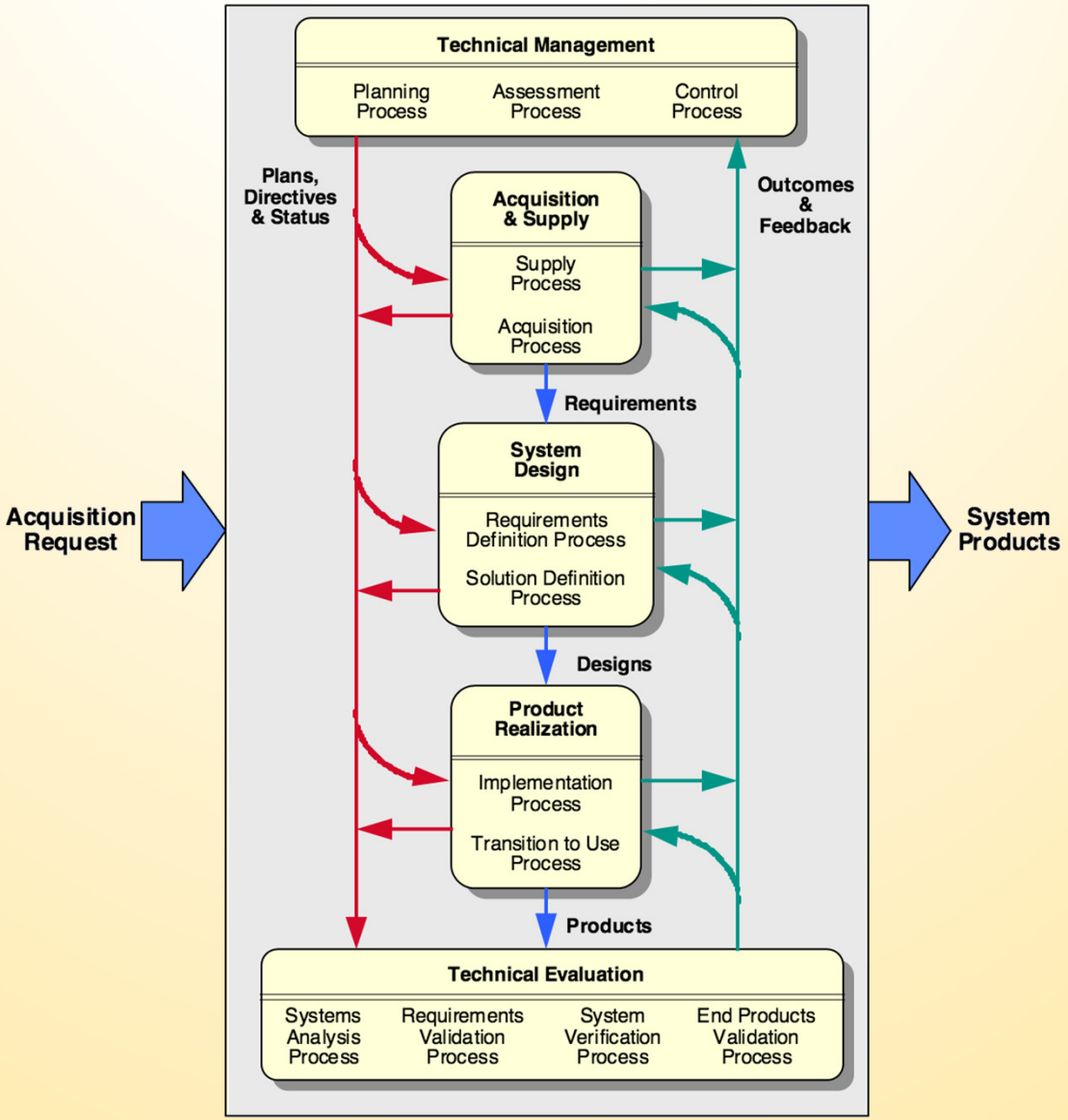
What is a system?

- According to the Oxford English Dictionary, a system is
  - An organized or connected group of objects
  - A set or assemblage of things connected, associated or interdependent so as to form a complex unity
- A system is a set of
  - Hardware
  - Software
  - People
  - Policies, procedures, directives, etc.

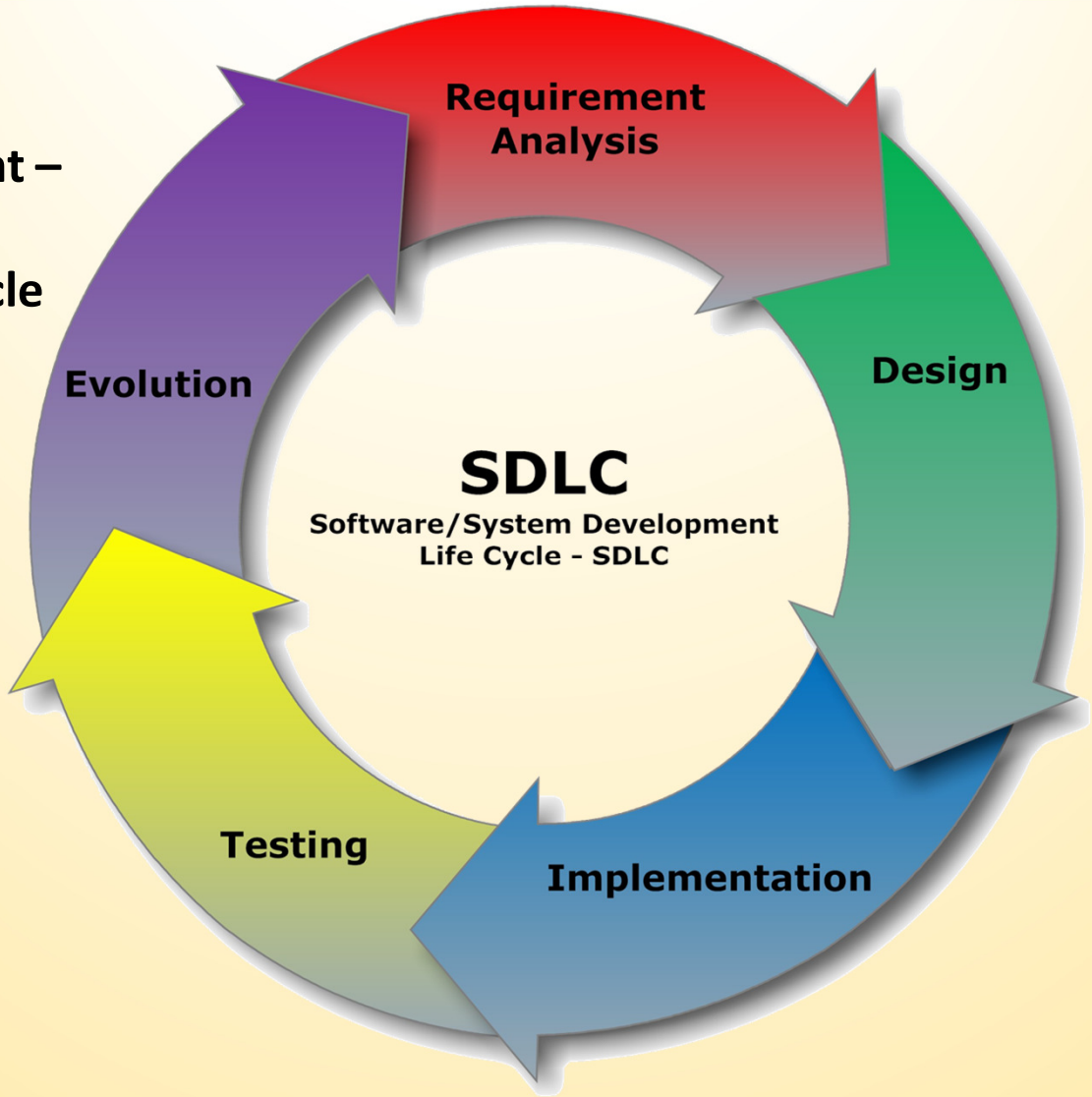
To make the distinction harder,

- Software engineering, while focusing on software, needs to address (or meet requirements) involving software AMD
  - Hardware
  - People
  - Processes, policies, procedures, etc.

INCOSE (International Council on Systems Engineering) Systems Engineering Process



The software engineering viewpoint – the Software Development Lifecycle



- What can systems engineering learn from software engineering?
  - Disciplined approach to cost estimation
- What can software engineering learn from systems engineering?
  - Consideration of trade-offs and use of “framework methods” such as Quality Function Deployment (QFD)
- What is the most effective relationship between systems & software engineering?
  - Systems led, for technical systems
  - Software led, for software intensive systems

John A McDermid, FREng
Professor of Software Engineering
University of York

How do we determine what engineers know?

- We need to look at the accreditation agency for all three
- ABET (formerly Accreditation Board for Engineering Technology)
- ABET accreditation sets the global standard for programs in applied science, computing, engineering, and engineering technology.

ABET (from their web site)

- We are a not-for-profit, non-governmental accrediting agency for programs in applied science, computing, engineering, and engineering technology and we are recognized as an accreditor by the Council for Higher Education Accreditation.
- ABET accreditation provides assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates.
- We accredit programs, not institutions. We provide specialized accreditation for post-secondary programs within degree-granting institutions already recognized by national or regional institutional accreditation agencies or national education authorities worldwide.
- Our accreditation is voluntary, and to date, more than 3,400 programs at nearly 700 colleges and universities in 28 countries have received ABET accreditation. Approximately 85,000 students graduate from ABET-accredited programs each year, and millions of graduates have received degrees from ABET-accredited programs since 1932.

Differences between programs

- Software Engineering falls under the EAC (Engineering Accreditation Commission), which sets general and program-specific requirements.
- Computer Science falls under the CAC (Computer Accreditation Commission), which sets general and program-specific requirements.
- Software Engineering:
  - **Lead Society: CSAB (Computer Science Accreditation Board)**
    Cooperating Society: Institute of Electrical and Electronics Engineers
- Computer Science / IT / CIS:
  - **Lead Society: CSAB (Computer Science Accreditation Board)**

General Criteria - Engineering

GENERAL CRITERION 3. STUDENT OUTCOMES

The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multidisciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

General Criteria - Engineering

GENERAL CRITERION 5. CURRICULUM

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:

(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.

(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.

One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.

Specific Criteria - Software Engineering

SOFTWARE AND SIMILARLY NAMED ENGINEERING PROGRAMS

Lead Society: CSAB
Cooperating Society: Institute of Electrical and Electronics Engineers

These program criteria apply to engineering programs that include "software" or similar modifiers in their titles.

1. Curriculum
The curriculum must provide both breadth and depth across the range of engineering and computer science topics implied by the title and objectives of the program.

The curriculum must prepare graduates to analyze, design, verify, validate, implement, apply, and maintain software systems; to appropriately apply discrete mathematics, probability and statistics, and relevant topics in computer science and supporting disciplines to complex software systems; to work in one or more significant application domains; and to manage the development of software systems.

Specific Criteria - Systems Engineering

SYSTEMS AND SIMILARLY NAMED ENGINEERING PROGRAMS

Co-Lead Societies: American Society of Mechanical Engineers, CSAB,
Institute of Electrical and Electronics Engineers, Institute of Industrial Engineers,
ISA, International Council on Systems Engineering, or
SAE International

These program criteria apply to systems engineering programs without modifiers in their title.

There are no program-specific criteria beyond the General Criteria.

What this means

- The “common core” for engineering is all a systems engineer needs.
- Bluntly – the term “systems engineer” could apply to any engineer
- Software engineering, however, requires a lot of additional coursework
-

Software Engineers

- The curriculum must provide both breadth and depth across the range of engineering and *computer science topics* implied by the title and objectives of the program.

- The curriculum must prepare graduates to *analyze, design, verify, validate, implement, apply, and maintain software systems*; to appropriately *apply discrete mathematics, probability and statistics, and relevant topics in computer science and supporting disciplines to complex software systems*; to *work in one or more significant application domains*; and to *manage the development of software systems*.

“analyze, design, verify, validate, implement, apply, and maintain software systems”

- This implies coverage of
  - Lifecycles
  - Analysis and Design
  - Some verification and validation

  - Unsure how Maintenance can thoroughly be taught and tested (not enough time in coursework)

“apply discrete mathematics, probability and statistics, and relevant topics in computer science and supporting disciplines to complex software systems”

- Discrete mathematics not usually part of a engineering program
- Statistics almost certainly part of prerequisites for and Engineering program
- Discrete math (and analysis of algorithms) gives software engineers insight into orders of complexity, and also into additional design options

"manage the development of software systems"

- Usually implies a capstone course, or at least a semester-long course with simplified real-world development project
- Again – implies familiarity with lifecycle design
- Probably includes familiarity with lifecycle tradeoffs

How does a software engineer fit all of this in?

- Typically, by taking less options and more required courses (typically 128 – 135 hours)

- Many (most) courses in the Software Engineering degree replace corresponding “General Engineering” courses (except Engineering Physics)

Systems Engineering

- Most Systems Engineering programs use Engineering courses – because they have to satisfy the General Criteria

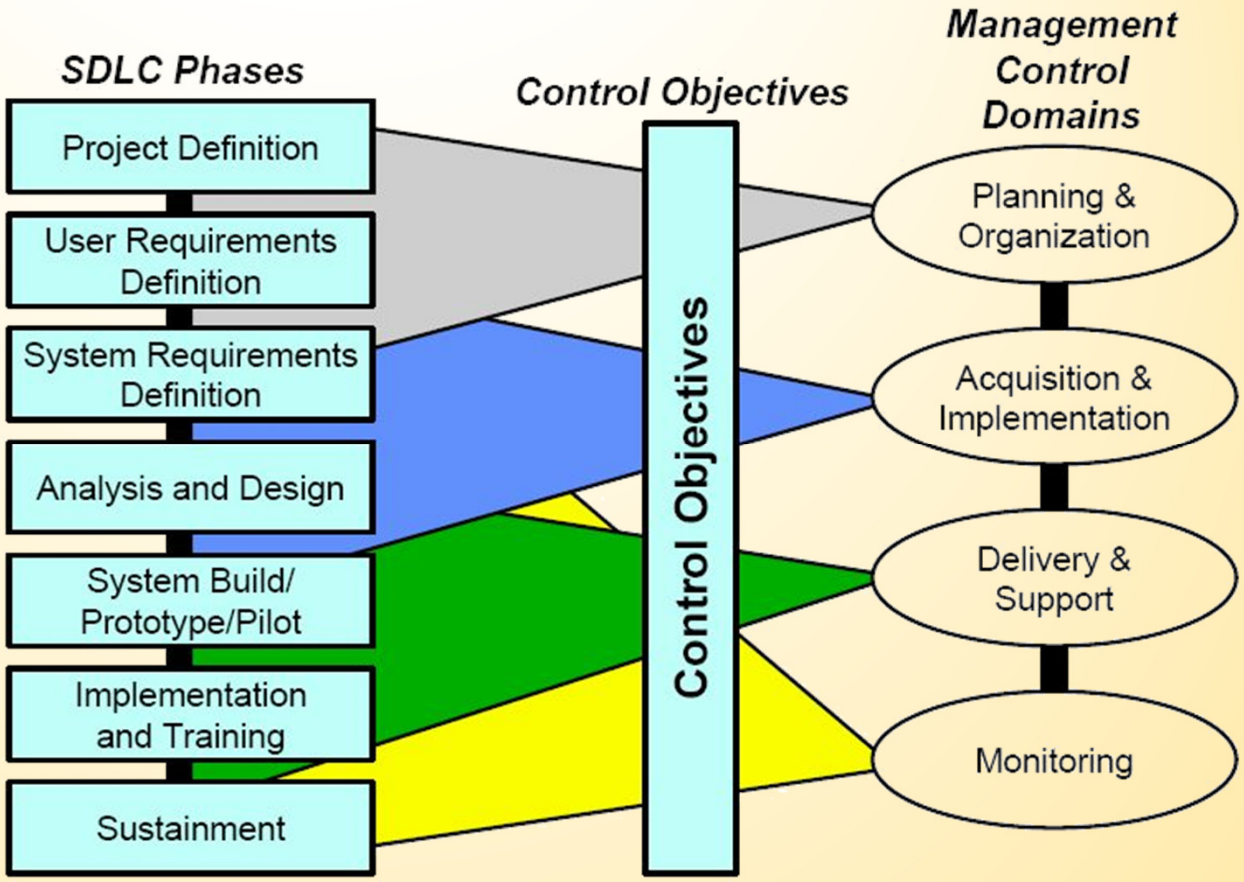
- Many Systems Engineering have a smattering of Software Engineering courses – maybe two or three (general programming, possibly data structures and analysis of algorithms if they are lucky)

In short

- ABET accredited Systems Engineering programs focus on general engineering. No software is required, although most programs have some.
- Management is from a global large-scale view

- ABET accredited Software Engineering programs focus on software – and are generally located in the Computer Science department
- Management is from the Program Management point of view

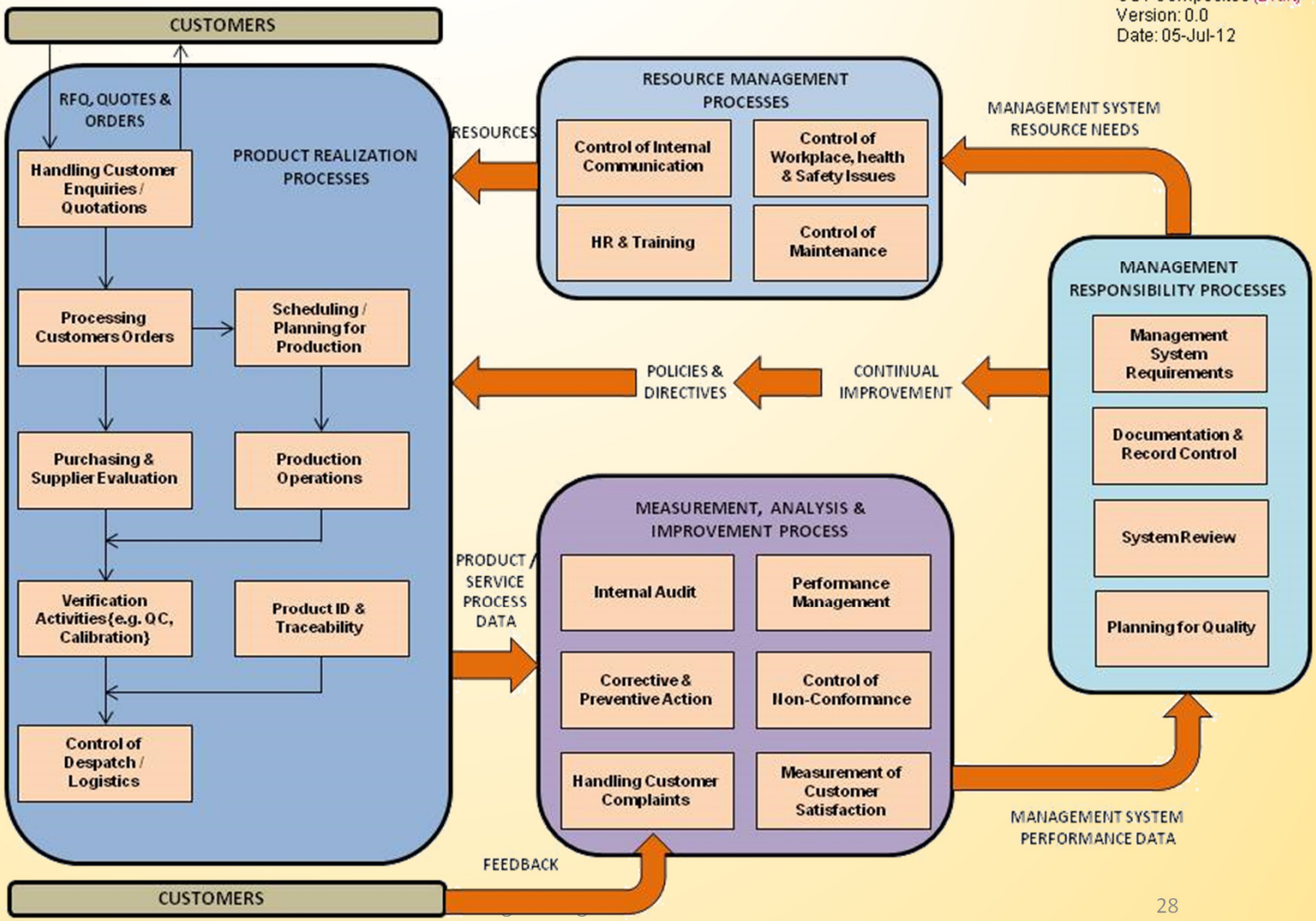
Software Development Life Cycle



Systems Management Process Model

CST Composites (Draft)
Version: 0.0
Date: 05-Jul-12

Note the feedback mechanism



How does a software engineer fit all of this in?

- Typically, by taking less options and more required courses (typically 127 – 135 hours)
- Many (most) courses in the Software Engineering degree replace corresponding “General Engineering” courses (except Engineering Physics)
- **Or – by not having an accredited Software Engineering degree**
- **There are only 21 accredited Software Engineering programs at the present time**

Accredited SE programs

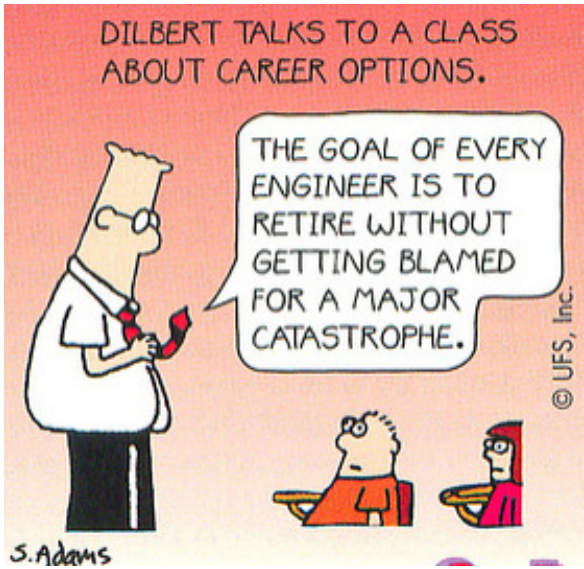
- Auburn University
- California Polytechnic State University, San Luis Obispo
- Fairfield University-School of Engineering
- Embry-Riddle Aeronautical University - Daytona Beach
- Florida Institute of Technology
- Rose-Hulman Institute of Technology
- University of Michigan-Dearborn
- Mississippi State University
- Montana Tech of the University of Montana
- Monmouth University
- Clarkson University
- Rochester Institute of Technology
- Drexel University
- Gannon University
- Pennsylvania State University, The Behrend College
- South Dakota State University
- University of Texas at Arlington
- University of Texas at Dallas
- The University of Virginia's College at Wise
- Milwaukee School of Engineering
- University of Wisconsin-Platteville

What to do with this knowledge

- Be very careful about degree titles.
- Those who claim to be a “software engineer” – determine their credentials and background. Do they have the experience to show they know the trade?
- Software engineering is a relatively new discipline, only given since the late 1990s. There are only 21 accredited programs. Accreditation shows that both CSAB and IEEE are happy with the program.

THANK YOU!!!

If you have questions…..
comments…..
or want to express a differing opinion…..



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