

Raytheon

Customer Success Is Our Mission



The Emerging Profession of Software Engineering

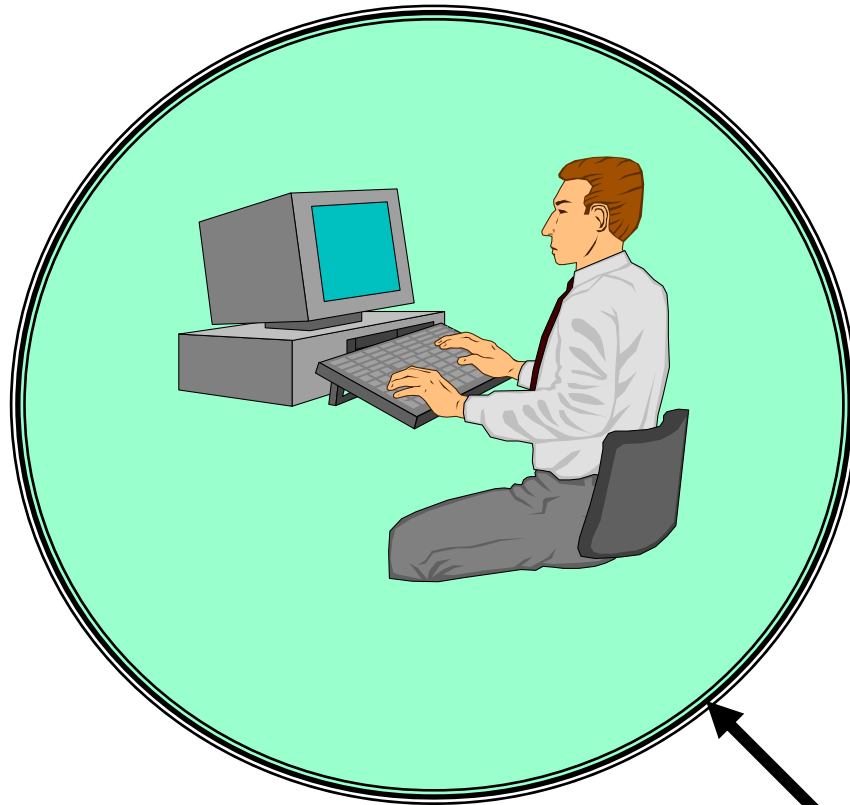
Dennis J. Frailey

April 7, 2008

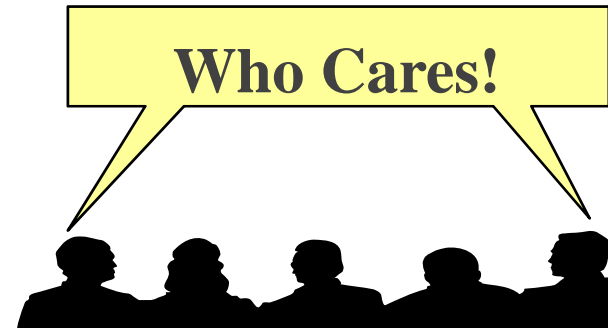
Presented at ITNG 2008

Computer Software Development -- The Way it Was

Software Developers



The Public



Protective Cloak of Technology

Major Disasters Attributed to Software

- **Therac-25** - Radiation therapy unit **killed five patients** by administering massive overdoses of radiation due to a software control issue. Hundreds of others were maimed.
- **2003 Northeast Blackout** – Caused partially by a software flaw in a widely-deployed General Electric energy management system, **affecting approximately 50 million people**.
- **2004 Los Angeles Air Traffic Control Failure** – LAX Airport lost air traffic control due to improper maintenance of a software system. **Over 400 flights were in the air when it happened**. The back-up system also failed within seconds of being activated.
- **French Ariane 5 Launch System** – Rocket tore itself apart due to a malfunction in the control software. Cost **\$500 million**.
- **Mars Climate Orbiter**- Was destroyed when a navigation system error attributed to using English vs. metric units occurred. Cost **\$125 million** of US Taxpayer dollars.

Major Project Failures Attributed to Software

- **Cheyenne Mountain Upgrade** – Project to replace five main computer systems in the NORAD command center was reported by the General Accounting Office to be 11 years behind schedule and **\$1 billion over budget**.
- **California DMV Drivers License and registration system** - Cancelled in 1994 after **\$45 million** spent.
- **FBI Virtual Case File** – Deemed a failure and abandoned after five years of effort, wasting at least **\$100 million**.
- **Washington D.C. City Payroll System** - Abandoned in 2000 after deployment, costing **\$25 million**.
- **Ford Motor Company Purchasing system** - Abandoned after deployment costing approximately **\$400 million**.
- **Hewlett-Packard Enterprise Resource System** – Problems contribute to **\$160 million** loss in 2004.

The Way it Is Becoming

Why does this software crash all the time?

My pacemaker has a computer!

Who should we sue for this fiasco?



What Do These Words Mean?

**PROCESS
DISCIPLINE
PROFESSION**

**Regulation
Loss of Creativity
Meddling
“Police”
Doom and Gloom
End of the World**

**Software
Engineering?**

**Order
Safety
Responsibility
Organization
Consistency
Reliability**

Terminology

Engineering: The application of science and mathematics by which properties of matter and the sources of energy are made useful to people.

(Merriam-Webster's New
Collegiate Dictionary, 10th Edition)

Terminology

Software Engineering. The application of a systematic disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.

(IEEE Std 610.12)

David Parnas's List of 9 Tasks a Software Engineer Should Know How to Do

- Analyze the intended application
- Participate in the design of the computer system configuration
- Analyze the performance of a proposed design
- Design the basic structure of the software
- Analyze the software structure for desired characteristics
- Implement the software
- Integrate new software
- Perform systematic and statistical testing
- Revise and enhance software systems

Parnas, D. (2001) "The Professional Responsibilities of Software Engineers", Software Fundamentals: Collected Papers by David L. Parnas, MA: Addison-Wesley. pp. 540-541.

Programmer vs Software Engineer

Programmer

Writing *code*

Using techniques learned from individual *experience*

Building products that *work*

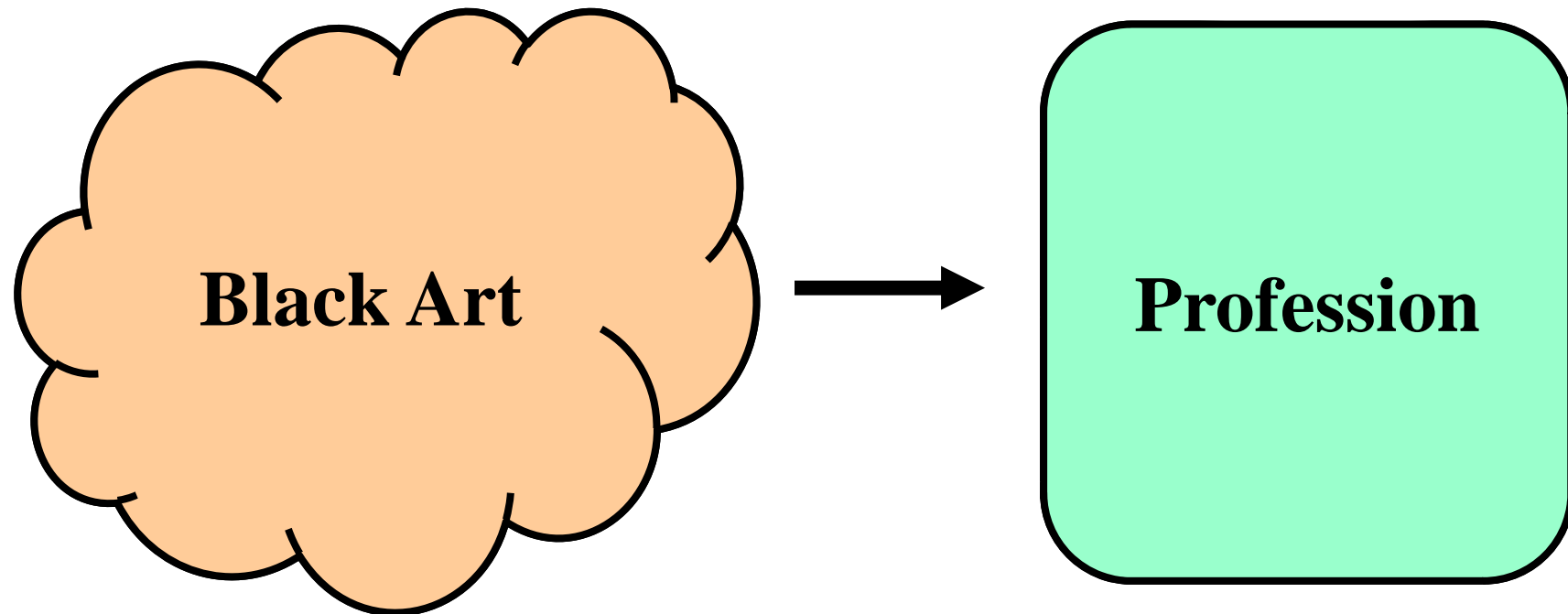
Software Engineer

Developing *systems*, often large and highly complex

Applying widely accepted techniques based on *proven knowledge*

Building products that *you can depend on*

Software Engineering is Growing Up



Terminology

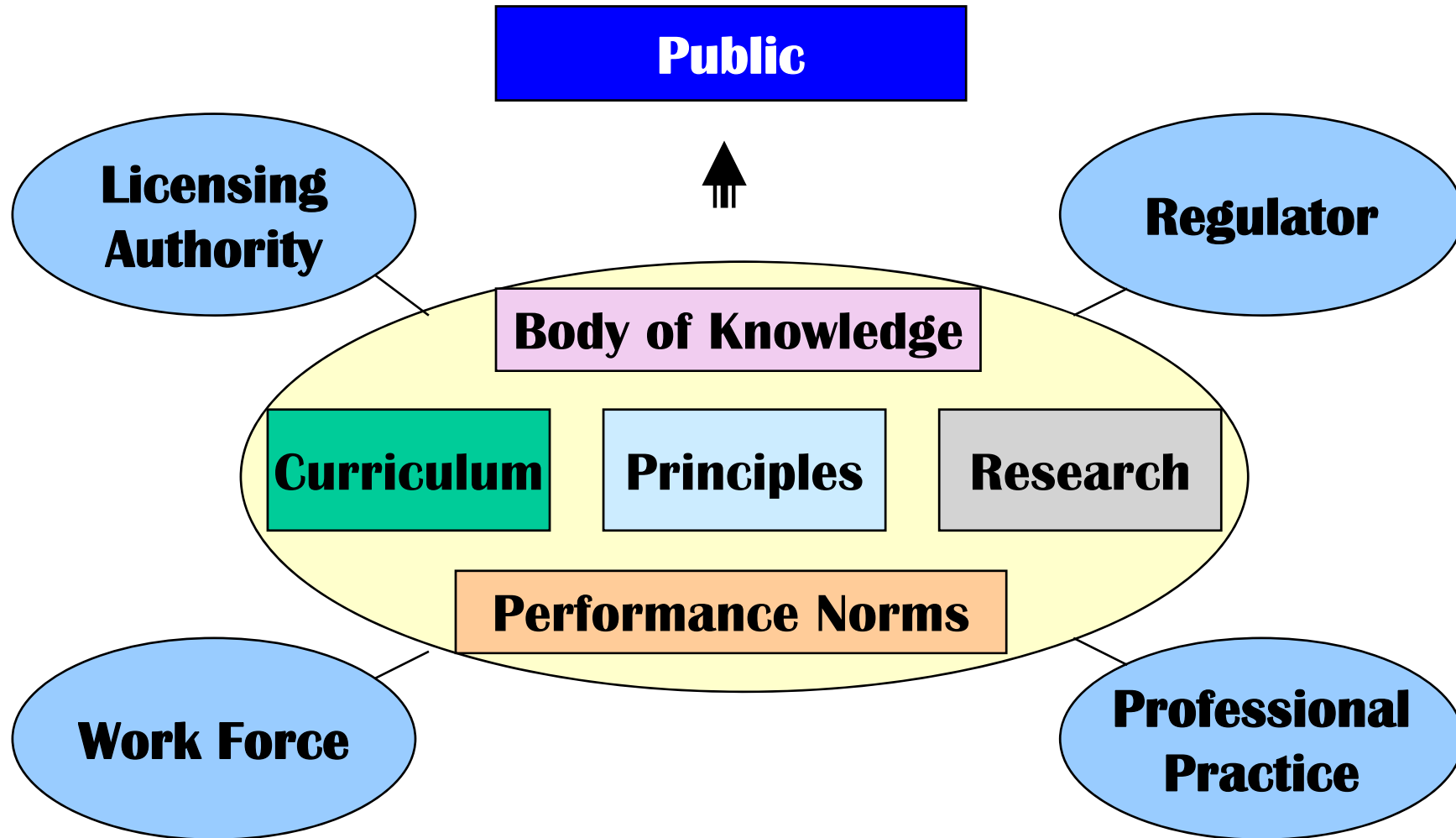
Profession. A calling requiring *specialized knowledge* and often *long and intensive academic preparation*; a principal calling, vocation or employment; the whole body of persons engaged in a calling.

Professional. (1) Relating to or characteristic of a profession; engaged in one of the learned professions; characterized by or *conforming to the technical or ethical standards of a profession.* (2) *participating for gain or livelihood* in an activity or field of endeavor *often engaged in by amateurs*; engaged in by persons receiving financial returns.

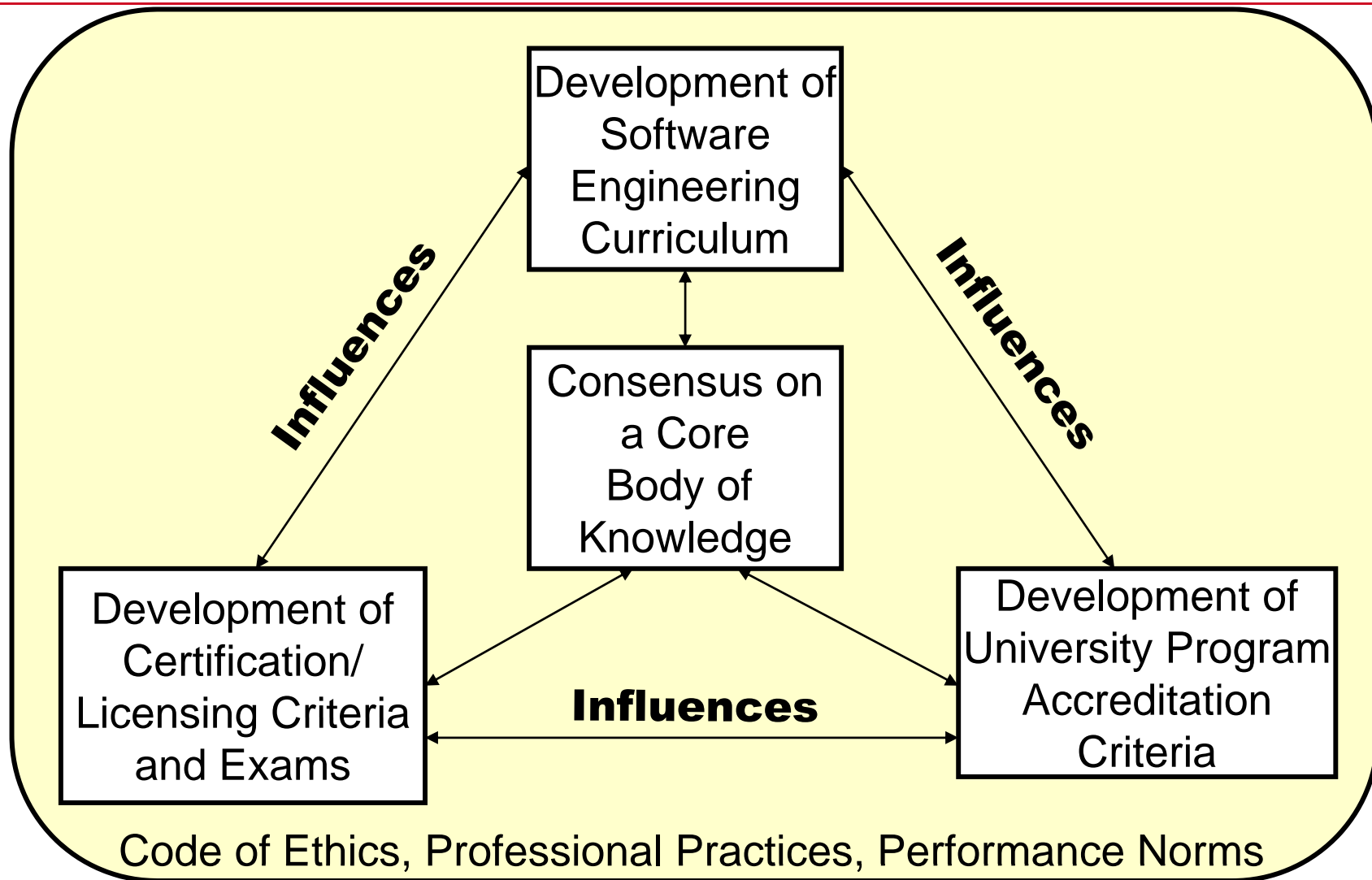
Professionalism. (1) The conduct aims or qualities that characterize or mark profession or a professional person. (2) The following of a profession (as athletics) for gain or livelihood.

(Merriam-Webster's New Collegiate Dictionary, 10th Edition)

Elements of a Profession



Key Interrelationships



Software Engineering Has Been Emerging as an Engineering Profession

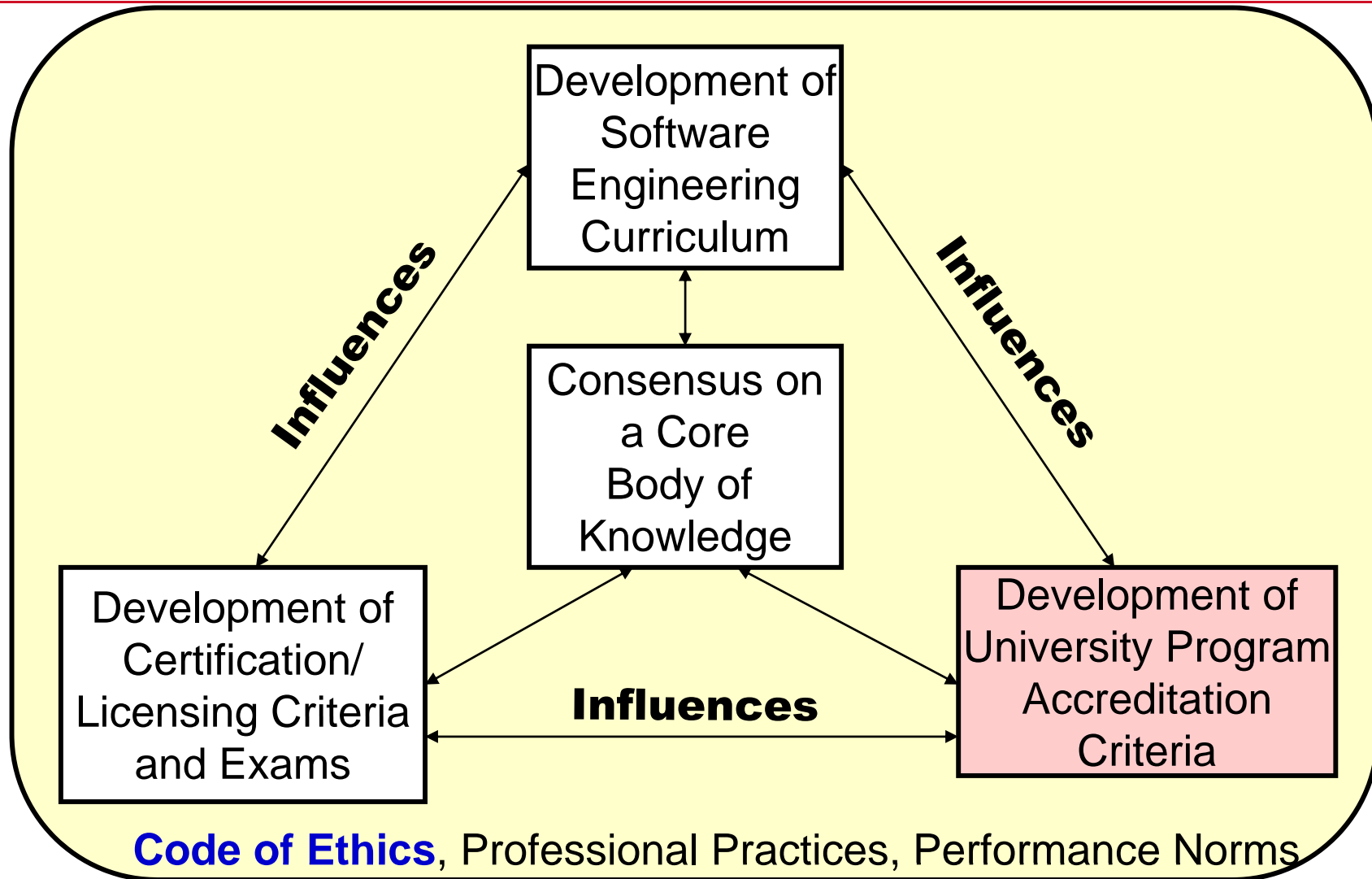
- 1968 -- NATO conference introduces the term *Software Engineering*
- 1970-present – Textbooks, Masters Degrees, Tools, Techniques, and Standards
- 1980-2000 -- *Licensing for software engineers* is recognized in Texas, BC, Ontario, Australia, United Kingdom
- 2001 -- Rochester Institute of Technology grants the first-in-US *Software Engineering bachelor degrees*. (Degree requires five years, including co-op work.)
- 2003 -- Four university BS programs in software engineering were *accredited by ABET*.
 - The total was up to 15 by 2007 and more are being considered for 2008
 - There are over 50 masters programs in software engineering in the U.S. alone

ABET Accredited Software Engineering Programs in the US, as of 2007

- Auburn University
- Clarkson University
- Embry-Riddle Aeronautical University - Daytona Beach
- Fairfield University-School of Engineering
- Florida Institute of Technology
- University of Michigan-Dearborn
- Milwaukee School of Engineering
- Mississippi State University
- Monmouth University
- Pennsylvania State University, Behrend College
- Rochester Institute of Technology
- Rose-Hulman Institute of Technology
- University of Texas at Arlington
- University of Texas at Dallas
- University of Wisconsin-Platteville

www.abet.org

Key Interrelationships



Other Signs that Software Engineering is Becoming an Accepted Profession

- 1998 -- ACM/IEEE-CS *Software Engineering Code of Ethics* was completed.
- 2001 -- ACM/IEEE-CS *Computing Curriculum* 2001 is completed - *includes a SW engineering component.*
 - 2004 – Release of *specialized curriculum for SW engineering*
- 2002 – “Strawman” version of IEEE-CS *Guide to the Software Engineering Body of Knowledge* published in book form.
 - Trial usage 2002-2004.
 - Several universities are using it to rationalize curriculum, e.g. SMU, NTU, NJIT.
- 2002 -- IEEE-CS instituted the **Certified Software Development Professional** (CSDP) Program
- 2004 – “Ironman” version of IEEE-CS *Guide to the Software Engineering Body of Knowledge*

Software Engineering Code of Ethics



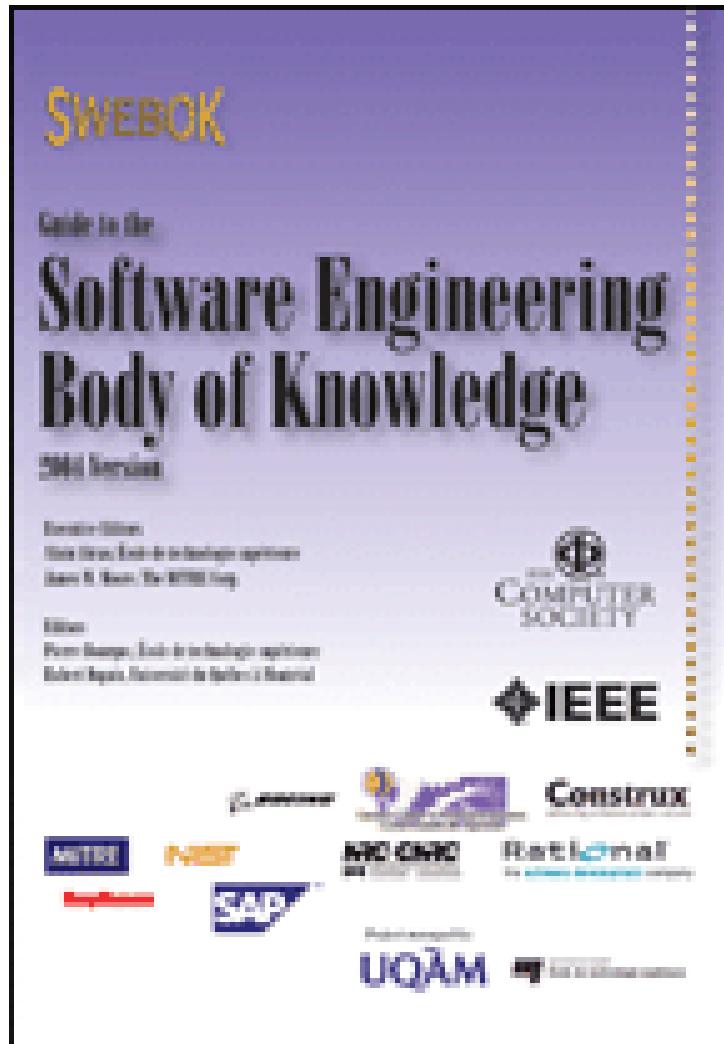
Software engineers shall commit themselves to making the analysis, specification, design, development, testing and maintenance of software a beneficial and respected profession. In accordance with their commitment to the health, safety and welfare of the public, software engineers shall adhere to the following Eight Principles:

<http://www.acm.org/serving/se/code.htm>

Eight Ethical Principles

- 1. PUBLIC - Software engineers shall act consistently with the public interest.
- 2. CLIENT AND EMPLOYER - Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.
- 3. PRODUCT - Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.
- 4. JUDGMENT - Software engineers shall maintain integrity and independence in their professional judgment.
- 5. MANAGEMENT - Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.
- 6. PROFESSION - Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.
- 7. COLLEAGUES - Software engineers shall be fair to and supportive of their colleagues.
- 8. SELF - Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

Body of Knowledge



- Software Requirements Analysis
- Software Design
- Software Construction
- Software Testing
- Software Maintenance
- Software Configuration Management
- Software Engineering Management
- Software Engineering Process
- Software Engineering Tools and Methods
- Software Quality

www.swebok.org

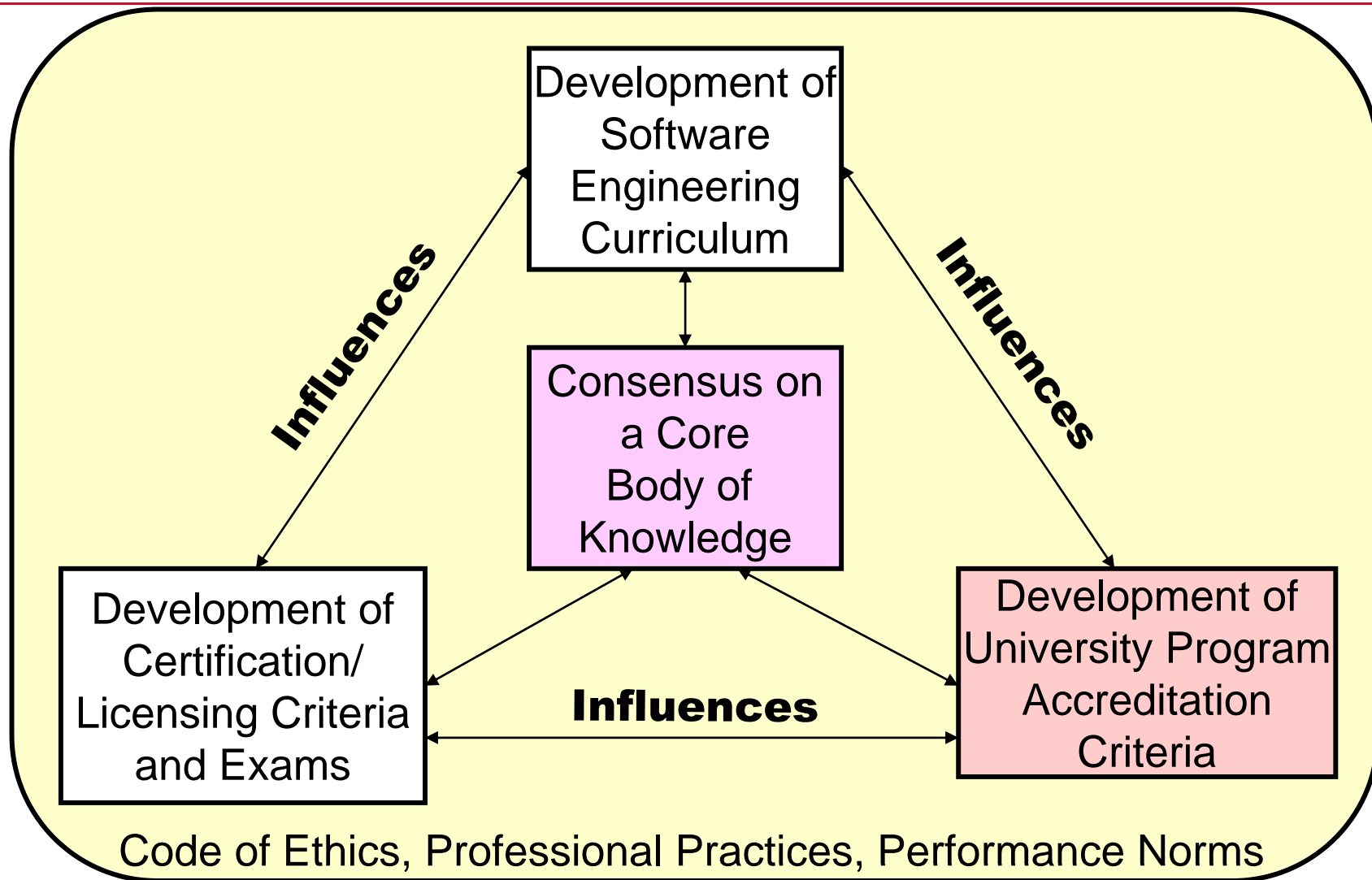
Other Body of Knowledge Efforts

- Australian Computer Society core body of knowledge

www.acs.org.au/index.cfm?action=show&conID=cbok

- British Computer Society
 - BOK under development
- Many others are adopting the SWEBOK
 - Rather than developing their own BOKs for software engineering

Key Interrelationships



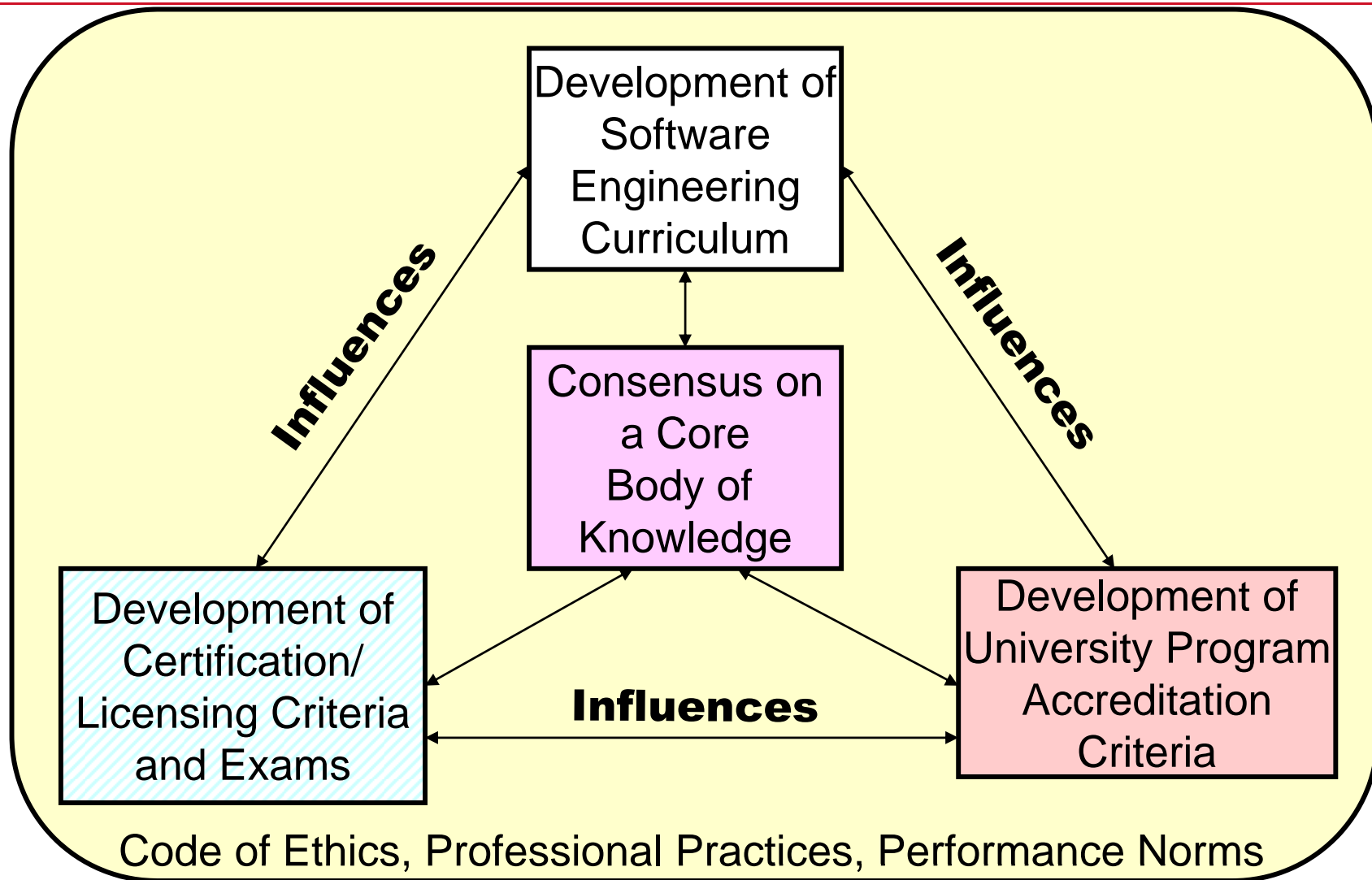
IEEE Certified Software Development Professional (CSDP)

- Formal recognition of demonstrated proficiency within and comprehension of a specified body of knowledge at a point in time.
- Peer recognition
- Not registration or licensure.
 - Registration: listing by and with a body of individuals or organizations that are certified
 - Licensure: authorization granted by government body for an individual or organization to practice a business or occupation
- Certification is voluntary.



<http://www2.computer.org/portal/web/certification>

Key Interrelationships



Software Engineering Curriculum Model



Software Engineering 2004

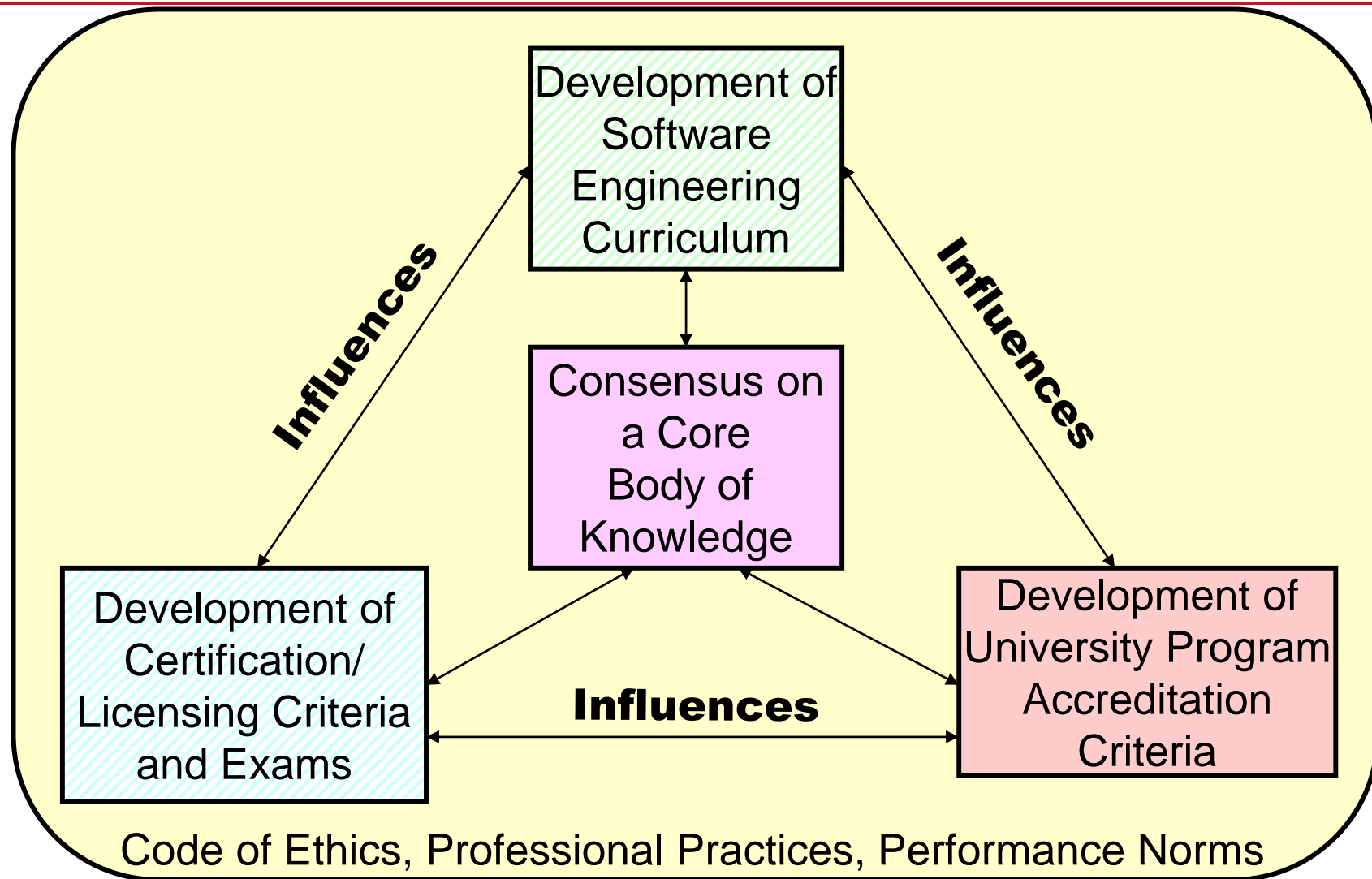
Curriculum Guidelines for Undergraduate
Degree Programs in Software Engineering

A Volume of the Computing Curricula Series

August 23, 2004

<http://sites.computer.org/ccse/SE2004Volume.pdf>

Key Interrelationships



Recent Activities

- 2007 - iSSEc Project to establish a model *Graduate Curriculum in Software Engineering*
 - Will establish recommended links to systems engineering (systems analysis, etc.)
- 2007 – *Software Engineering Licensing Consortium*, dedicated to making software engineering eligible for licensing in the US
 - Will not change how licensing works, but will advise on the qualifications for software engineers who wish to be licensed
- 2008 – IITP – *International IT Professional*

iSSEc - Software Engineering Reference Model for Graduate Curricula (in progress)

- **Worldwide, most of the value in new products and systems is delivered through software.** Much of the complexity of those products and systems resides in and is addressed by software. Most of the "surprises" that occur after product shipment and system deployment can be traced back to software being implemented incorrectly. Software is the underlying technology to advance mobile phones, automobiles, and aircraft. The ability of any large company or government agency to manage its projects and organization depends heavily on sophisticated software that supports its business and technical processes, ranging from logistics systems to manufacturing systems to customer relationship management systems. Software is everywhere. Yet, reports ... have painted the same story for years - - that creating and evolving large-scale software on schedule, on budget, with expected functionality, is uncommon.

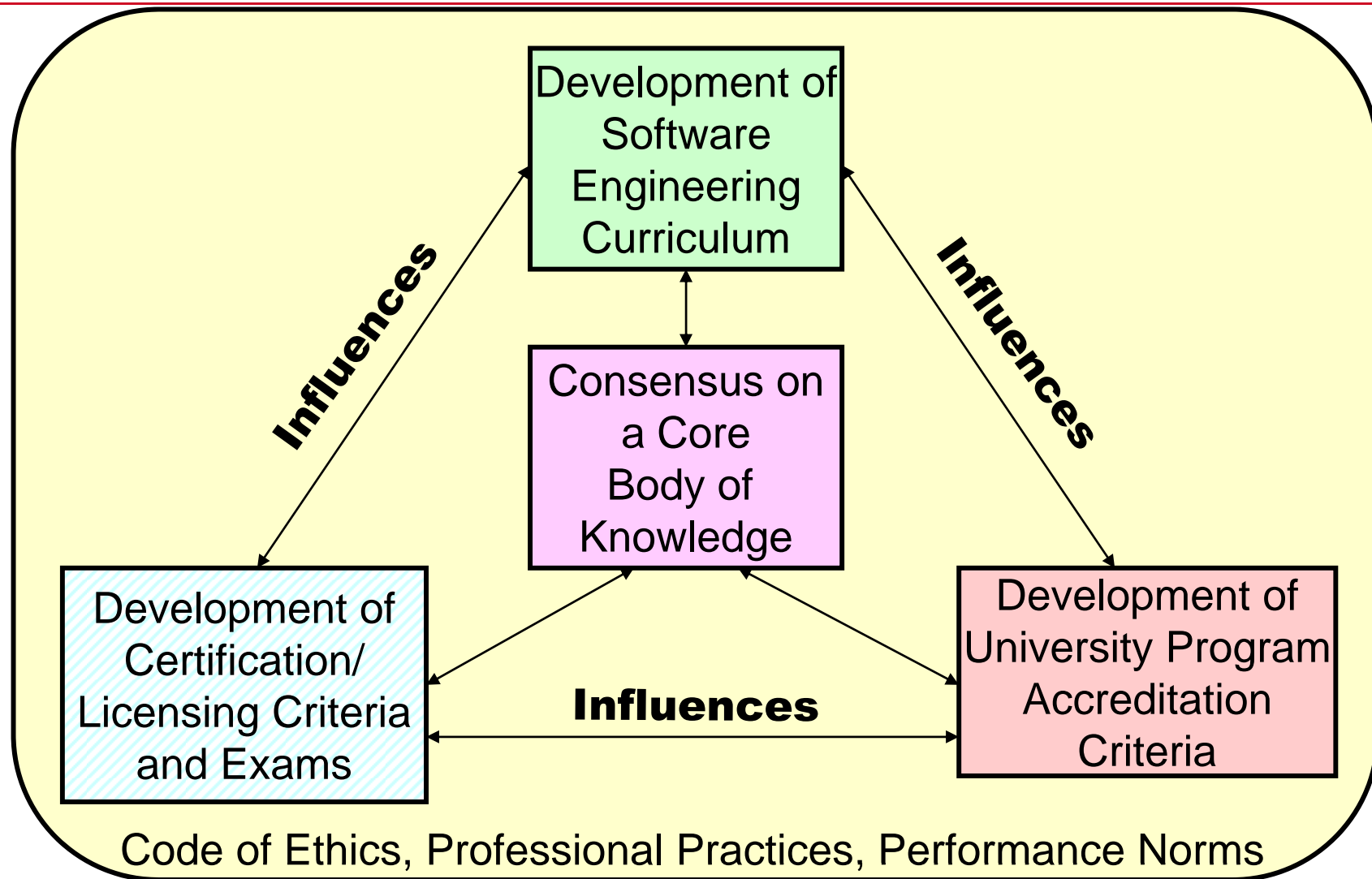
<http://www.asysti.org/issechome.aspx>

iSSEc - Software Engineering Reference Model for Graduate Curricula (in progress)

- **Software engineering is the acknowledged discipline by which large-scale and complex software is developed.** Many universities teach software engineering at the undergraduate level. ... The lack of a current model graduate curriculum is dismaying considering the reliance of the world economy on the quality of senior software engineering professionals.
- **The iSSEc (integrated Software and Systems Engineering curriculum) Project is creating a new model graduate software engineering curriculum** that reflects new understandings in how to build software, how software engineering depends on systems engineering, and how software engineering education is influenced by individual domains, such as telecommunications and defense systems. The resulting curriculum will be suitable for a university education leading to a Masters Degree in SWE.

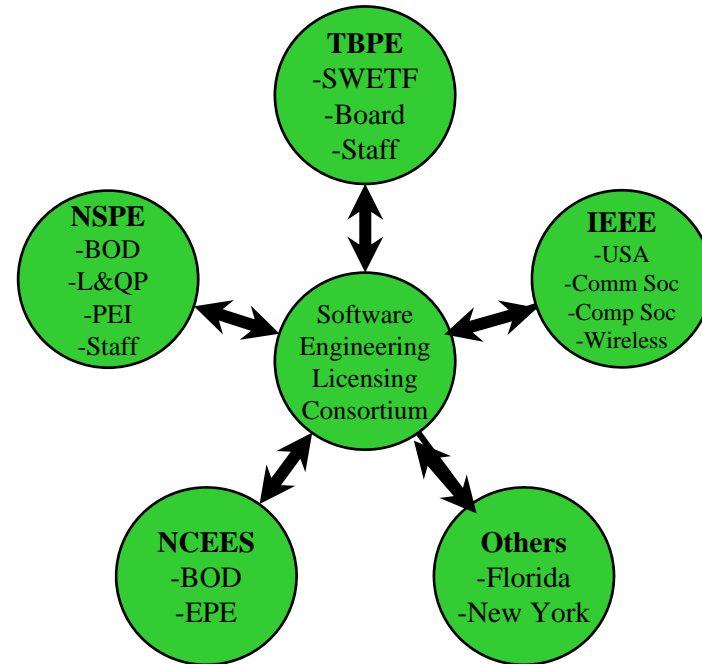
<http://www.asysti.org/issechome.aspx>

Key Interrelationships



Software Engineering Licensing Consortium

- IEEE (USA, CS PPC, CS Wireless)
- NSPE (PEI, L&QP, BOD)
- TBPE (Board, Staff, SWETF)
- NCEES (Exam Development)



“Software engineers are engaged in a significant role in evaluating, designing, developing, deploying, operating, and maintaining critical software systems. In order to protect the public health, safety, and welfare, such practices should be regulated ... in the same manner as other engineering practices are regulated.”

Examples of Software Applications that affect Health, Safety and Welfare

- **Infrastructure**: emergency dispatch services, fire alarms/sprinklers, emergency shut down systems, electrical grid, public water supply
- **Medicine**: heart lung machines, ventilators, medical infusion pumps, medical dispensers, implant devices, robotics, and medical records
- **Energy**: nuclear reactors, override systems, electrical grid systems, petroleum pumps
- **Recreation**: amusement park rides
- **Transportation**: railway signals/controls, auto; airbags, brakes, seatbelts, aviation; air traffic control, avionics, air crew life support, emergency evacuation equipment, automated traffic control
- **Financial**: banking systems, accounting, online financial systems, information security
- **Government**: taxation, licenses, criminal systems legislative support, public policy tools
- **Communications**: switching, transmission multiplexing, network management
- **Military**: GPS satellite, radio communications, artillery controls, aircraft systems

IITP (International IT Professional) Background Information

- I3P (International Professional Practice Program)
 - is a new organization that will award the International Information Technology Professional (IITP) credential
 - will be organized in early 2008, under the auspices of IFIP
 - IFIP (International Federation for Information Processing)
 - a UNESCO Consultative Committee, founded in 1958
 - IFIP members are computing societies
 - one member society per country
 - US is an exception: both IEEE-CS and ACM are IFIP members
 - I3P members will be IFIP member/affiliate societies

- Microsoft has committed \$1-1.5M to this effort
 - Negotiations with other potential sponsors are under way

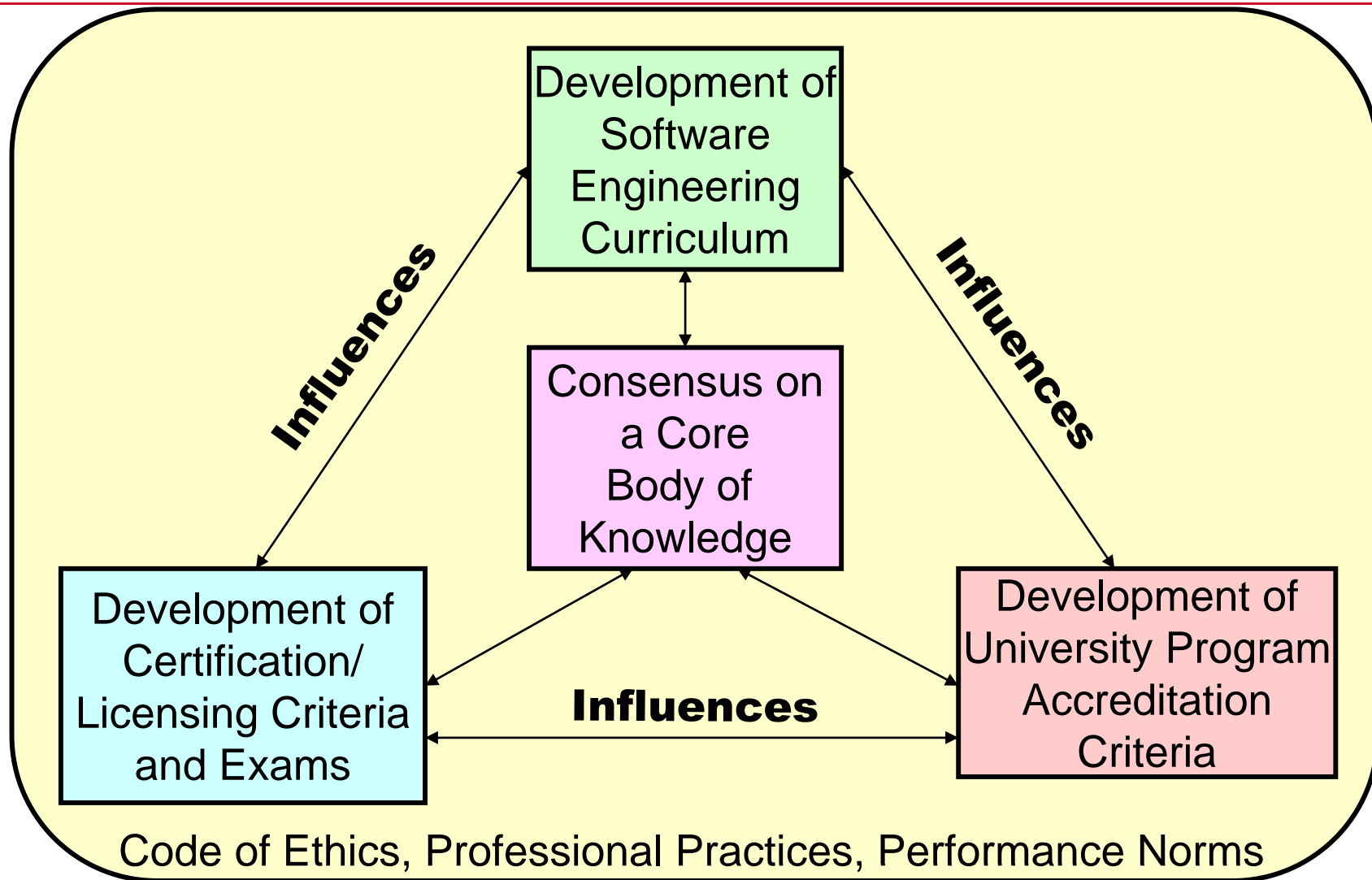
IITP (International IT Professional) is ...

- an “umbrella” (meta-)credential designed to increase the international recognition of society-offered professional computing credentials
- an I3P member society will be able to submit a professional credential for IITP accreditation (anticipated to take place in Summer 2008)
- society members who currently hold IITP-accredited credentials will also receive the IITP credential

I3P Participants

- Current participants in the I3P effort, and their certifications:
 - British Computer Society
Chartered IT Professional (CITP)
 - Australian Computer Society
Computer Professional (CP)
 - Canadian Information Processing Society
Information Systems Professional (ISP)
- Proposed future participants
 - IEEE and others in the US
CSDP
 - IT organizations from other countries around the world
- Note:
 - This is an effort of professional societies.
 - The target audience is industry, not individual professionals.

Key Interrelationships



Good Things I Have Seen with a Focus on Professionalism, Discipline, and Process

- More Accurate Estimates
- Software that does Not Crash (at least not often :-)
- Higher Productivity
- Employees Like it
 - They often return after Leaving for Greener Pastures
 - Because we do not have such a zoo in our software development organization

Reports indicate that young software engineers are especially eager to see their profession recognized

Bad Things I Have Seen with the Same Focus

- Overly Prescriptive Interpretations
- People wanting a Cookbook instead of a Model
- “Dehumanization” of Software Development
- Process and Discipline are Blamed because the Software Still Isn’t Perfect or it takes a while to produce it
- ...
- Employees Leaving because they Don’t Like the Climate
 - Some see it as too rigid – and sometimes it is!

Most of this results from individuals who apply rules without fully understanding the underlying principles

Observations

- Education and Understanding are the Keys to Effective and Proper Use
 - True professionals in any field always have good processes and disciplined practices
 - Even if they don't use that terminology
 - They know how to make effective use of good processes and practices
 - And *they know when the processes and practices do not apply*
- There will always be differences of opinion about these topics
 - How mature must a field be before standards of practice are put in place?
 - How do you balance the need for discipline with the need for innovation?

Excuses

“Professional practices cannot guarantee safety, so insisting on those practices is not justified.”

“We’ve done it the old way for 40 years, so why should we change?”

“The Perfect is the Enemy of the Good”



Processes, Discipline and Professionalism help
us stand on the shoulders of giants
–Instead of standing on each others' feet

Apologies to Richard Hamming, ACM Turing Lecture, 1969.

Appendices

Reference Material

- <http://www.swebok.org> -- SW engineering body of knowledge project
- <http://computer.org/certification> -- IEEE-CS certified software development professional
- <http://www.acm.org/serving/se/code.htm> -- Software Engineering Code of Ethics
- <http://sites.computer.org/ccse/> -- ACM Software Engineering curriculum info
- <http://www.abet.org> – ABET accreditation information
- <http://www.abet.org/criteria.html> -- Accreditation criteria (includes SW engineering)
- <http://www.tbpe.state.tx.us/> -- Texas PE Board

Additional References

- <http://www.acs.org.au/index.cfm?action=show&conID=cbok> -
- Australian Computer Society body of knowledge
- <http://sites.computer.org/ccse/SE2004Volume.pdf> -- SE2004
Software Engineering Curriculum Model
- <http://www.asysti.org/issechome.aspx> -- Integrated Systems
and Software Engineering Curriculum web site

ABET Accredited Computing Programs in the US, as of 2007

- Information Technology:
 - 3 programs
- Information Systems:
 - 24 Programs
- Computer Science:
 - 230 Programs
- Computer Engineering:
 - About 200 Programs
- Other Titles:
 - 4 Programs

Software Engineering Defined for Licensing

Software engineering is the application and/or study of a **systematic, disciplined, quantifiable approach** to the **development, operation, and maintenance of software**, that has an impact on the lives, property, economy, or security of people or the national defense; that is, the application of engineering to software.