Elec 4309 Senior Design

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The "Mystery" of Standards

*"**Standards generally go unnoticed.***

*They are mostly **quiet, unseen forces**, such as specifications, regulations, and protocols, **that ensure that things work** properly, interactively, and responsibly.*

***How standards come about is a mystery to most people** should they even ponder the question."*

John Gibbons, Forward to U. S. Congress Office of Technology Assessment TCT-512, *Global Standards: Building Blocks for the Future,* March 1992

What is a “Standard”?

A simplistic but idealized working definition…

Standard - a ***document***, developed and used by consensus of the ***stakeholders***, which describes how a ***product*** is to be ***obtained or used***.

document - can be electronic or paper
stakeholders – includes anyone with an interest without restriction
product - can include hardware, software, analysis result, test result, protocol, definition, *etc.*
obtained or used - can mean designed, built, procured, calculated, tested, *etc.*

Features of an Ideal Standard

- ***Relevant and necessary***, by providing specific value to benefit development of a product.
- ***Singular***, by focusing on a specific concept.
- ***Unambiguous***, by not being subject to multiple interpretations.
- ***Consistent***, by not conflicting with other documents within its family of standards.
- ***Auditable*** (measureable), with a quantitative exit criterion showing that the standard was followed.

What Does (and Doesn't) Go Into a Standard?

- ✓ **Best practices** (things that have worked well)
- ✓ **Lessons learned** (things that haven't worked well)
- ✓ **Recent research** results
- • Able to stimulate further research in related areas
- ✘ Standards cannot be created for every situation
- ✘ Sometimes necessary in real practice for a subject matter expert to extrapolate from one or more existing standards and design principles to solve a specific need

Example: Types of Standards (for Composites)

- Technical terminology
- Material specifications
- Process specifications
- Test methods (and practices and guides)
- Test fixtures
- Data reduction methods
- Data reporting formats
- Test matrices
- Statistical procedures
- Analysis methods

and more…

Standards and Engineers

Standards a mystery? Sadly, it isn't only the man on the street - **standards are also a mystery to most engineers**

Why?

Because standards are a mystery to many engineering faculty!

Standards are not well-taught in engineering schools

Standards – Who Cares?

- Few engineering students are introduced to standards in school, and even fewer are given an understanding of the standards development process
- Too few engineering professors understand the utility and purpose of standards, the process of origin and maintenance, or their importance and application in the workplace
- ABET is only ***starting*** to recognize the issue

ABET Guidance (from 2008-2009)

ABET now requires a design project that

"…incorporate[s] appropriate engineering standards…"

*But ABET **does not** yet require any specific instruction in*

- *Standards development processes*
- *Major standards development organizations (SDO), their scopes, and varying approaches*
- *How, when, why of appropriate use of standards*

**Criteria for Accrediting Engineering Programs, Effective for Evaluations During the 2008-2009 Accreditation Cycle, November 3, 2007, ABET , Inc*

Benefit of Standards

The engine of national and global commerce is driven by standards

Good standards – those with credibility, integrity, and marketplace acceptance – reduce procurement costs, improve products, expand markets, and/or lower risk

Standards do this by…

- *Reducing duplication of effort or overlap and combining resources*
- *Bridging of technology gaps and transferring technology*
- *Reducing conflict in regulations*
- *Facilitating commerce*
- *Stabilizing existing markets and allowing development of new markets*
- *Protecting from litigation*
- *…And more*

Practicing Engineers Need Standards

Why?

To Produce Their Products Efficiently

- *Deliverable products must be designed and built - they make use of procured items and must themselves be **procured***
- *Each of these phases, procurement especially, requires **specification***
- *Effective specification requires **standards***

Engineering Managers Need New Standards

For Knowledge Capture and Transfer

- *Massive retirements of "boomer" engineers have begun – those with 25+ years of experience obtained during the most productive and creative years of US industry*
- *Significant loss of engineering experience is occurring*
- *Add to that – engineering schools are not producing students at the expected needed replacement rate – a significant shortage of engineers will occur over the next few years*

Capture of knowledge as standards, and training of junior engineers in their use, can ease the generational transition

Engineering Hiring Mgrs Need Students that Know Standards

Those new graduates without standards knowledge may:

- unnecessarily need elementary instruction in their first jobs
- have a higher propensity for operating outside of best or accepted industry practices
- waste resources by "reinventing the wheel," or
- even simply fail in duties to align their products or services with desired markets.

Center for Global Standards Analysis

Formed at Catholic University of America (CUA) in 1999 to:

1. develop education and research programs that will facilitate the study of United States Standards Policies and global standardization;
2. provide a neutral forum in which students, universities, government departments and agencies, national, regional and global standards organizations, associations and corporations can meet to discuss United States Standards Policies, global standardization and develop creative strategies.

Why So Little Teaching of Standards in Engineering Schools?

- Denial of need
- Absence of trained faculty
- Absence of existing curricula resources

CUA CGSA, 2004 Standards Survey

Specific Conclusions of 2004 Engineering Standards Survey

- Standards education is **not a priority issue** among schools of engineering in the US
- Schools of engineering in the US **do not accept** the critical nature of standards in the current and future global economy
- Only a **handful of schools** of engineering in the US offer an on-going course on standards: *e.g.*, Catholic University of America, University of Colorado (Boulder), University of Pittsburgh
- When presented at all, the subject of standards is most often taught **within** larger design or engineering ethics courses

Importance of Standards

- Workforce needs to be prepared to understand and apply standards
- Engineers need greater exposure to standardization to position themselves competitively
- Curricula need to stay market-relevant, and standards education is a perfect medium to marry technical design to real-world issues.

Basic Standards Knowledge for Engineering Students

- **Purpose** of standards
- **Types** of standards
- **Sources** of standards
- **Standards Development Processes**
  - Who controls the standards
  - How to update/correct existing standards
  - How to create new standards
- **Most Important** standards for their discipline
- **Proper Use** of those standards

Types of Standards

ASTM currently recognizes five specific types:

1. **Specification** (in the sense of a procurement document)
2. **Test Method** (produces a test result)
3. **Terminology** (or definitions)
4. **Practice** (a protocol that doesn't produce a test result)
5. **Guide** (informational description of a number of options)

Specification vs. Standard

*The term **specification** has both a generic meaning and a targeted meaning:*

Generic – part of common compound term indicating **any** type of standard, as in **"standard specification"**

Targeted – a **specific** type of "standard," as per ASTM, which forms the basis for procurement of a product

Standards Development Organizations (SDO)

International SDO – An accepted set of principles by which an organization engaged in the development of international standards must comply has been adopted by the World Trade Organization (WTO), Committee on Technical Barriers to Trade*

ISO conforms to this definition, but – contrary to what ISO prefers to emphasize – ISO (and its sister IEC) is **not** the only International SDO

*G/TBT/ 1/REV. 8. Section IX, Decision of the Committee on Principles for the Development of International Standards, Guides and Recommendations with Relation to Articles 2, 5 and Annex 3 of the Agreement.

Differences in Standards Development Philosophies

- **US** has a unique stakeholder-driven standards development process, using a large number (~400) of decentralized, non-governmental (and often international) SDOs ranging in size from very large and broad-based, to very small and specific SDOs, with ANSI (not a standards producer) as the official US coordinator
- **Rest of world** uses a politically-driven, government-based, standards development process – with ISO/IEC at the top level of this

Let's Get Modern and Honest

ISO – "International," but Europe-driven, with a one-country/one vote approach that gives Europe a definite voting edge

US-based SDOs now advertise their globalness, and the major US SDO's meet the WTO definition of "international" equally well or better than ISO

ASTM International – largest US-based SDO, with substantial global participation, voting by individual stakeholders, and more inclusive definition of "consensus" than ISO

SAE International – US-based, but substantial global participation; and not just "Automotive"

Technical content from US-based SDOs has driven a disproportionate amount of standards development for the rest of the world, including the standards of ISO

Incorporating Standards in Engineering Curricula

- **Use standards in design assignments** and to corroborate lecture material
- **Exercise standard test methods in the laboratory**
- **Encourage intern/co-op experiences** to report on standards usage
- **Encourage "student member" participation** in SDOs
- **Obtain teaching resources from SDOs**
- **Utilize "capstone projects"** to challenge students in the use and application of standards. In these, students should:
  - report on the standards they used
  - how they were used
  - how their use impacted the project (time and cost savings)
  - if the standards met their needs as written, and
  - how they anticipate the standards will assist in penetrating markets for the product or service they undertook in the capstone project.

Relevant US Legislation

Enacted ***- The National Technology Transfer and Advancement Act of 1995****,* Public Law 104-113, (signed into law on March 7, 1996)

Requires federal agencies to use consensus based, voluntary standards as alternatives to specifications that had previously been developed only for government use

Proposed ***- Manufacturing Competitiveness Act of 2007*** (H.R. 255, Sec. 7, proposed amendment to Tariff Act of 1930, introduced to U.S. Congress 2007-02-16)

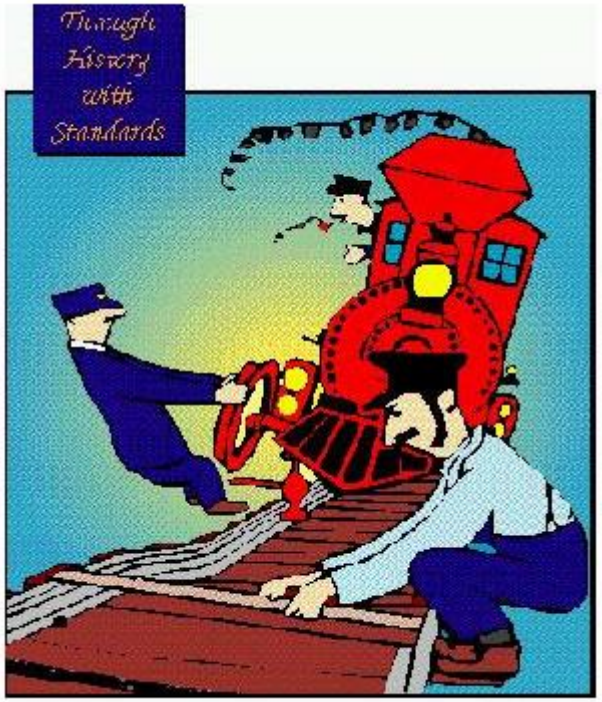
Director of NIST would be authorized to create grants to faculty and schools to develop curricula that advance the teaching of standards

History of Standards

- Differences in standards may be necessary for any number of reasons: cultural, political, legal or financial.
- The “Royal Egyptian Cubit” was decreed to be equal to the length of the forearm from the bent elbow to the tip of the extended middle finger . . . plus the width of the palm of the hand . . . of the Pharaoh or King ruling at that time.
- Though the method used to define a unit of measure was fixed, the measurement itself could change over time depending upon the height of the current Pharaoh or King and the lengths of his arm.

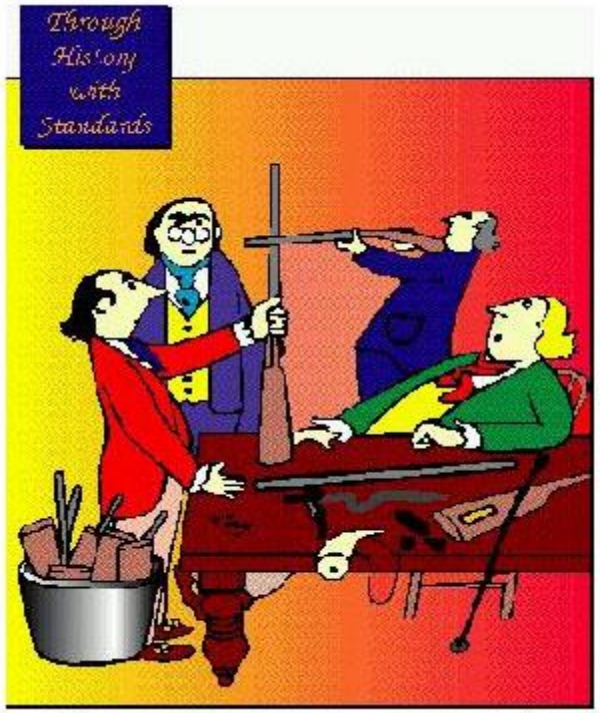
Railroad Tracks

- The development of a standard railroad track gauge (i.e., distance between the rails) made possible the interchangeability of railroad cars.
- Most early American railroads had their own gauges. Eventually, President Lincoln ordered that all gauges be 5 feet.
- Leaders in the railroad industry did not agree on this standard, eventually compromising on a measurement of four feet, eight and one-half inches (4’8.5”) throughout the nation.
- The U.S. measurements do not agree with the track gauge of some other countries, such as in South America where the distance between rails is five feet, six inches (5’ 6”) and in South Africa where the distance is only three feet, six inches (3’6”).



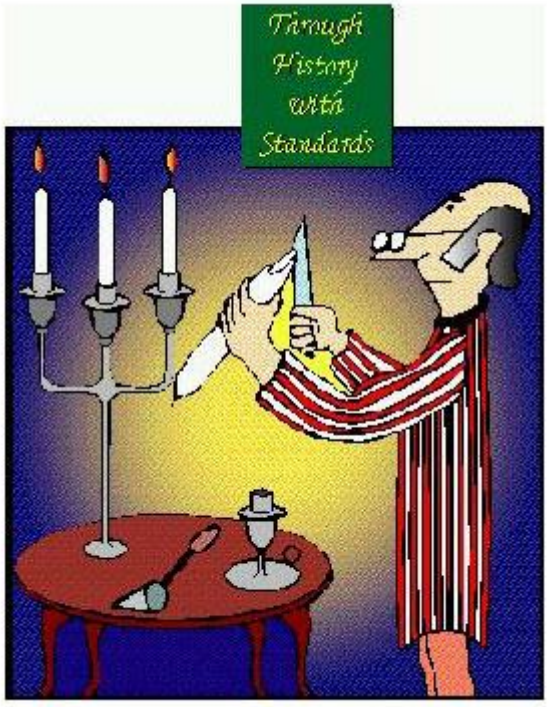
Eli Whitney

- Eli Whitney, the "father of standardization" at the end of the eighteenth century, received a contract from Thomas Jefferson to produce 10,000 muskets.
- To allow one of the first forms of mass production, Mr. Whitney divided his work into steps and put groups to work on each step, which was unprecedented from the traditional method of having each man by himself produce a part of the musket.
- Whitney even appeared before Congress with a pile of parts and assembled ten muskets by picking standard parts at random.



Screw

- Joseph Whitworth, an engineer and toolmaker in the nineteenth century, actively promoted standardization as a means of obtaining the interchangeability of parts.
- He introduced the system of "end measurements" and in 1856 exhibited a measuring instrument controlled by a screw which detected differences in length as small as one millionth of an inch.



Communication Standards

- For communications, interoperability can be defined as the condition achieved among communications – electronics systems or communications – electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users.
- Communications standards are extremely important for national defense and in responding to emergencies and disasters.

Child Safety Standards

- Each year thousands of children are injured from seemingly harmless products.
- Do cribs, toys, highchairs, playpens, toy chests, strollers, and playgrounds pose a danger? They can, according to the U.S. Consumer Product Safety Commission (CPSC).
- CPSC is an independent federal regulatory agency that works to save lives and keep families safe by reducing the risk of injuries and deaths associated with consumer products.
- They do this in a number of ways, such as developing voluntary standards with industry, issuing and enforcing mandatory standards, or banning consumer products if no feasible standard would adequately protect the public.

Standards and the Internet

- Internet users increasingly count on "being connected" for a number of reasons.
- The importance of the computer and the Internet to all segments of society continues to grow at a rapid pace.
- The backbone of the Internet is based on an open-architecture network that relies on standards and specifications for the technical requirements.
- These requirements have changed over time and they continue to change as technology evolves.
- The main organizations behind the development of Internet standards are the Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C).

Food Safety Standards

- Public concern over food safety has increased dramatically in the last decade. Both mandatory and voluntary standards address food safety, from alleviating problems caused by contaminated food to addressing the safety of equipment used to process food, and even the expertise of people that work with food.
- At the federal government level, the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) protect the safety and wholesomeness of food.
- The FDA makes sure that the medicated feeds and other drugs given to animals raised for food are not threatening to the consumers' health.
- The USDA has developed mandatory standards for meat, livestock, poultry, eggs, fruits and vegetables, dairy products, and other agricultural products.

Standards for Medical Devices

- In the United States, the federal Center for Devices and Radiological Health (CDRH) of the Food and Drug Administration (FDA) is responsible for regulating medical devices and radiation-emitting products.
- Many industry standards address aspects of safety and/or effectiveness relevant to medical devices.

Environmental Protection

- The public-private partnership in standards development is important to both the private sector and the federal government.
- Most standards are drafted by standard developing organizations, conforming to recognized procedures, and are for voluntary implementation.
- The government relies on these private sector voluntary standards.
- The U.S. Environmental Protection Agency (EPA) and industry effectively work together to protect our air, water, and environment.

Example: Fire Safety and Escape Standards

- Building codes reflect good practice in building design, construction and operation.
- Building codes cover all aspects of building design and construction, including structural integrity, mechanical and electrical system, sanitation and plumbing, and safety and fire prevention, and give special attention to aspects designed to protect lives in an emergency such as a fire.
- A major design consideration for engineers and architects is ensuring that the occupants of a building can be safely evacuated in the event of a fire.
- When a building code is adopted by a governmental unit, such as a state or city, the code, and the standards referenced in the code, become mandatory for design and construction in that jurisdiction.

Establishing Standards

- Standards are something that most of us accept as part of our everyday life.
- But they have become such an integral part of our existence that the average person gives little or no thought to everyday products and services and how they work.
- They make modern conveniences possible: light bulbs fit into lamps, electronic files are transferred over the Internet, trains move between states because the tracks are the same gauge, and the list goes on.

U.S. Standards System

- When the formal U.S. standards system was established nearly a century ago, standards were primarily developed to support manufacturing and mechanical processes.
- In the present day, standards offer benefits to all segments of business and industry, government and consumers.
- They simplify product development, reduce unnecessary duplication, lower costs, increase productivity, promote safety, and permit interchangeability, compatibility, and interoperability.
- They help to advance scientific discovery, and keep people safe by minimizing injuries and protecting key environmental resources.

Standards and Standardization

- A **standard** is "a recognized unit of comparison by which the correctness of others can be determined.”
- Another definition is "a set of characteristics or qualities that describes features of a product, process, or service."
- The term **standardization** actually encompasses a broad range of activities and ideas – from the actual development of a standard to its promulgation, acceptance and implementation.
- It also includes the methods of evaluating whether products, processes, systems, services and personnel comply with a standard – this evaluation is known as **conformity assessment**.

Voluntary and De facto Standards

- At the heart of the U.S. standards system are voluntary standards that arise from a formal, coordinated, consensus-based and open process.
- Developed by subject matter experts from both the public and private sectors, the voluntary process is open to all affected parties and relies upon cooperation and compromise among a diverse range of stakeholders.
- De facto (also known as *ad hoc*) standards are normally developed outside the traditional framework and usually appeal to a more narrow market than standards developed by voluntary-standards-focused organizations.
- These "marketplace" standards, though often developed more quickly than standards developed in a more formal process, do not always ensure a level playing field.

Standards Promote Efficiency and Economy in Business

- Standardization improves efficiency in design, development, and material acquisition.
- It also conserves money, manpower, time, facilities, and natural resources by minimizing the number of sizes, the variety of processes, the amount of stock, and the paperwork that largely accounts for the overhead costs of manufacturing and selling products.
- Designers can be confident that they are designing products that embody recognized practices and approved levels of safety. Technical risks are minimized by using components that are proven to work for the intended application.
- By making possible large-scale productions of standard designs, standards encourage better tooling, more careful design, and more precise controls, thereby reducing the production of defective and surplus pieces.

Standards Promote Efficiency and Economy in Business

- Efficiencies in manufacturing are achieved using standards.
- By using standardized parts, manufacturers are able to reduce their costs by being able to choose from multiple sources of supply, rather than having to rely on custom materials or parts.
- Standards make mass production possible, lower the cost of research and development, and speed up manufacturing.
- Standards reduce product costs and improve competition.
- When specifications for materials, fit, safety, performance, and dimensions have been standardized, manufacturers use them - it is good business.

Standards Affect Interchangeability and Interoperability in Business

- Products built using standards facilitate interchangeability and compatibility.
- This results in an increased number of supply sources, increased competition, reduced risk, reduced inventories, increased worker productivity and economies of large-scale operation.
- Standards to promote interchangeability and compatibility can increase the technical efficiency of the economy by increasing the ease with which products of one firm can be substituted for and combined with products of another.

Standards Provide U.S. Business Access to Global Markets

- International standards help to establish widely accepted common specifications for products, processes and services.
- International standards facilitate world trade by, effectively, removing technical barriers to trade, leading to new markets and economic growth.
- The widespread adoption of international standards means that suppliers can base the development of their products and services on reference documents that have broad market relevance.

Standards Provide U.S. Business Access to Global Markets

- Means that they are increasingly free to compete in many more markets around the world
- For customers, the worldwide compatibility of technology that is achieved when products and services are based on international standards brings them an increasingly wide choice of offers
- Benefit from the effects of competition among suppliers

The Rise of Microsoft

- In 1980, Microsoft didn't even have a personal computer (PC) operating system
  - the dominant operating system was CP/M.
- IBM's rush to bring a PC to market was a golden opportunity
  - IBM turned to Microsoft for an operating system and Microsoft produced a clone of CP/M called "MS DOS."
- Open architecture standard set by IBM established Microsoft dominance
  - The success of the IBM PCs (and clones of IBM PCs) resulted in the rapid spread of MS DOS
  - Even more rapid proliferation of software applications designed to run on MS DOS.
  - Microsoft's Windows was later bundled with (and eventually replaced) MS DOS.
- Software industry might look very different today!
  - Had Gary Kildall signed with IBM, or had other companies not been able to clone the IBM PC

Discussion Questions on Microsoft

1. What factors led to Microsoft's emergence as the dominant personal computer operating system provider?
   - Is Microsoft's dominance due to luck, skill, or some combination of both?
2. How might the computing industry look different if Gary Kildall had signed with IBM?
3. Does having a dominant standard in operating systems benefit or hurt consumers?
4. Does it benefit or hurt computer hardware producers?

Why Dominant Designs Are Selected

- **Increasing returns to adoption** occurs when a technology becomes more valuable the more it is adopted.
- Primary sources:
  - **Prior Experience and Technology Base**
  - **Learning Effects**
  - **Network Externalities**

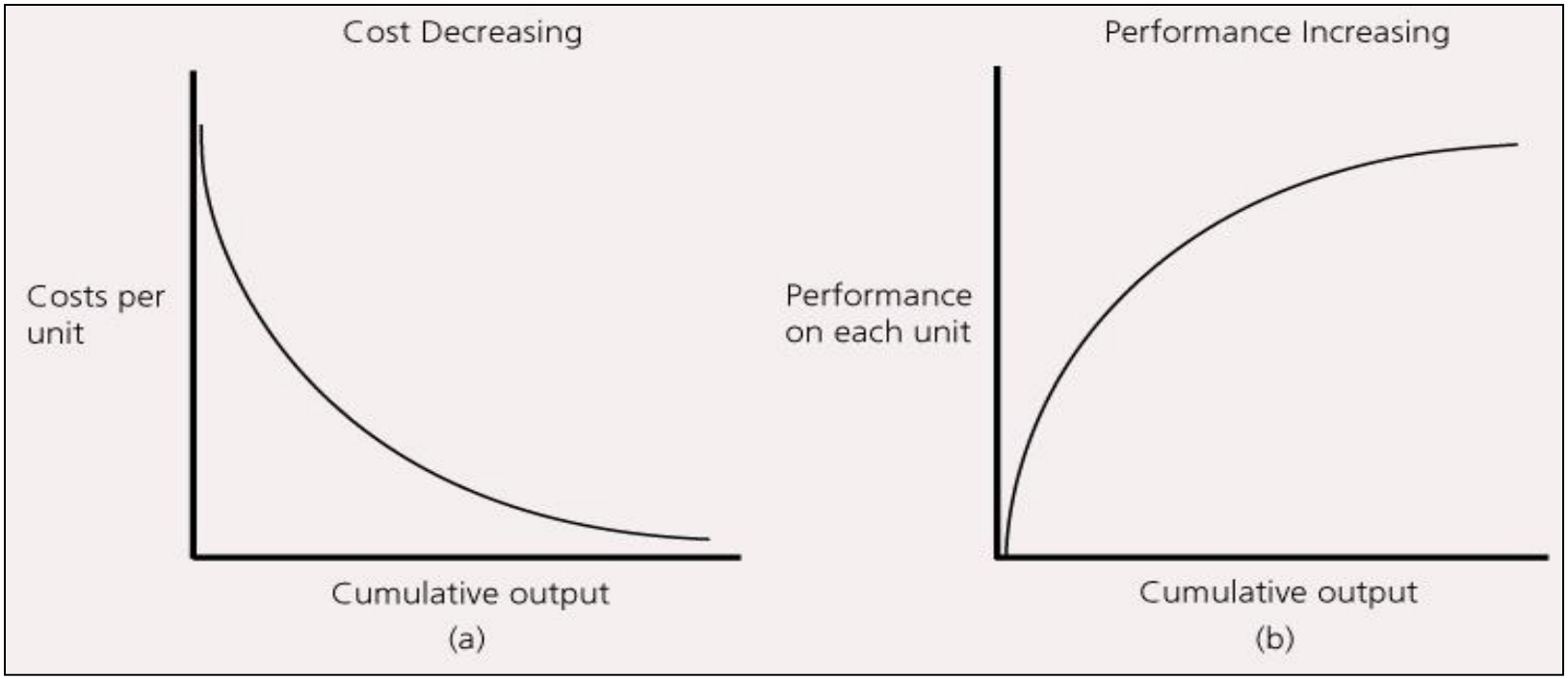
Prior Experience and Technological Base

- Most entrants come from related industries:
  - A firm's prior experience influences its ability to recognize and utilize new information
  - Their product introductions tend to be similar to their other operations
    - E.g. digital cameras from Sony resemble camcorders, while Kodak' s offerings look like traditional cameras
- Technological base of new industries:
  - Use of a particular technology builds knowledge base about that technology.
    - The knowledge base helps firms use and improve the technology

    → Suggests that technologies adopted earlier than others are likely to become better developed, making it difficult for other technologies to catch up.

Learning Effects

- **The Learning Curve**: As a technology is used, producers learn to make it more efficient and effective.

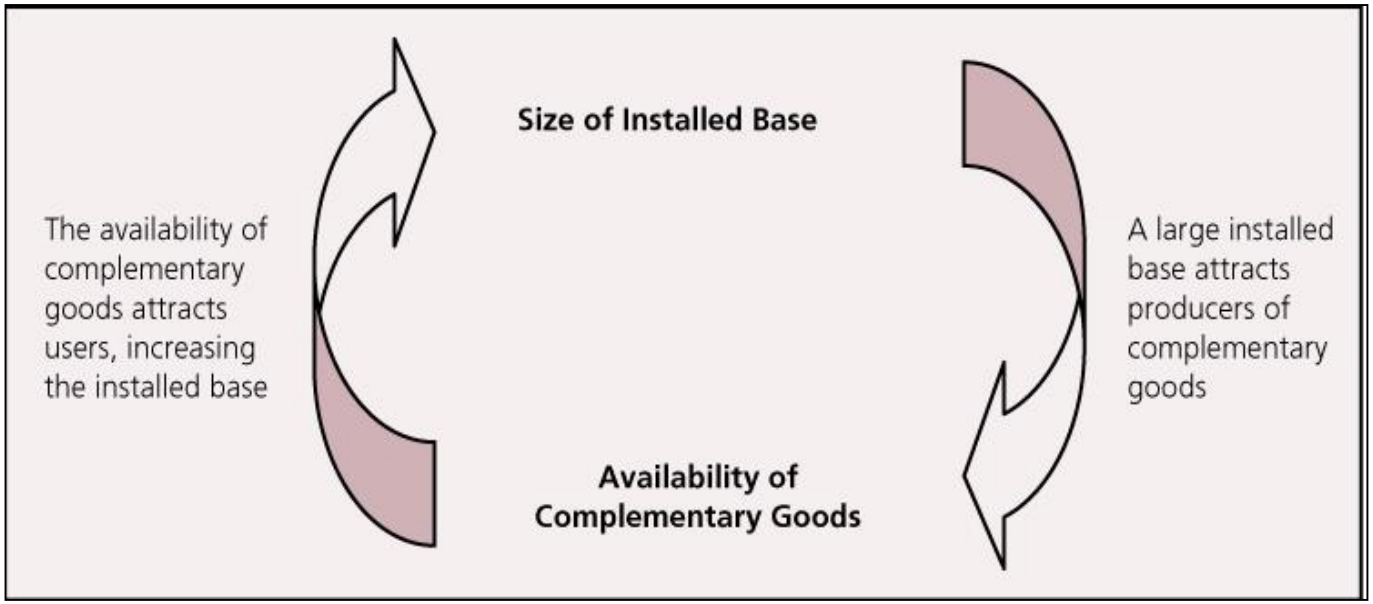


Network Externalities

- The value of a product to an individual increases with the number of other users of the same product:
  - Linkages between users
  - Complementary products
  - Switching costs
- Common in industries that are physically networked:
  - E.g., railroads, telecommunications
- Also arise when compatibility or complementary goods are important:
  - E.g., use of Windows maximizes the number of people their files are compatible with, and the range of software applications they can use.

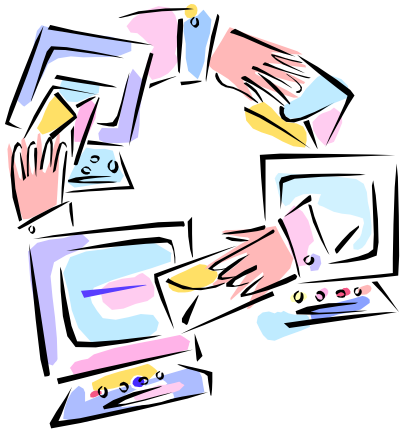
Why Dominant Designs Are Selected

- A technology with a large installed base attracts developers of complementary goods; a technology with a wide range of complementary goods attracts users, increasing the installed base.
  - A self-reinforcing cycle ensues:



Standards and Dominant Design

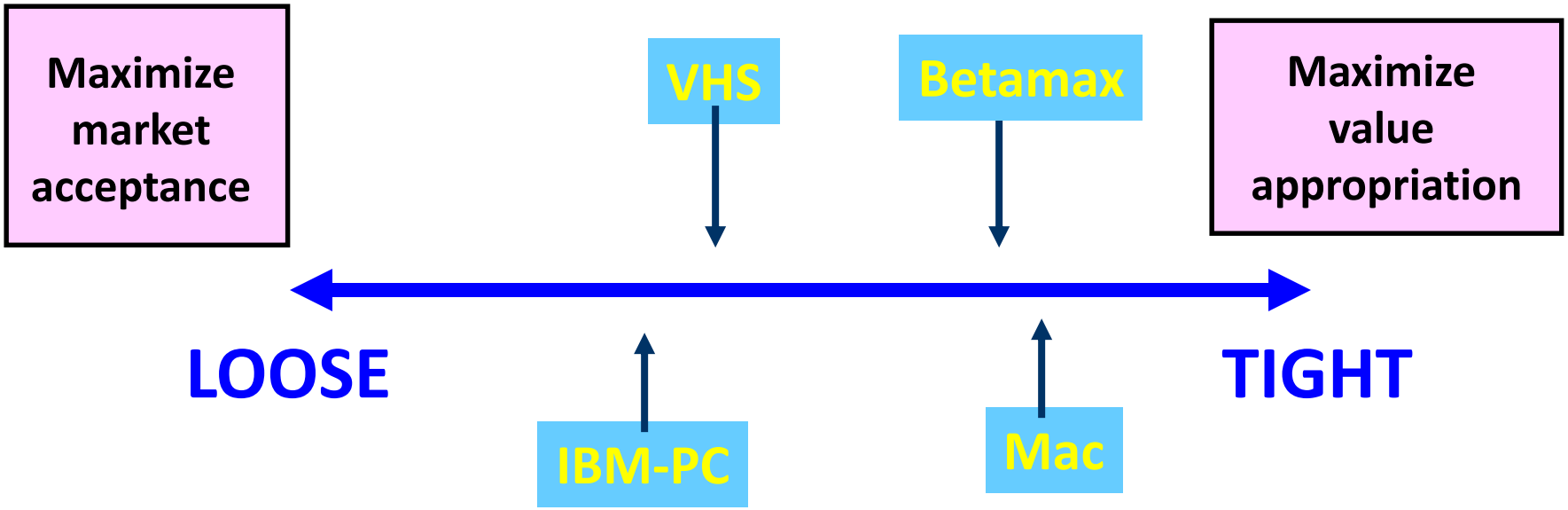
- Standards set by:
  - Government
  - Non-governmental voluntary groups
  - Companies
  - The market place
- Standards can be:
  - Open, e.g., Linux
  - Closed, e.g., Windows



Competing with Standards

- Open standards *decrease* profit appropriation:
  - Rival imitate easily
  - Increases buyer power and supplier power due to lower switching costs
  - Possible loss of control (Java and Microsoft)
- They also *increase* market acceptance:
  - Low switching costs for buyers increases demand
  - Less uncertainty for suppliers regarding design elements leads to more suppliers and lower costs
  - Can encourage innovation in your standards as opposed to rivals
  - Network externalities (requires critical mass)

How Should Companies Compete in Standards-based Industries?



Standards Summary

- Knowledge is captured as standards
- Standards ensure that things work properly, interactively, and responsibly
- Good standards reduce procurement costs, improve products, expand markets, and/or lower risk
- Practicing engineers need standards
- Conformity assessment is used for evaluations
- Tension between open and close standards affected by market acceptance vs. value appropriation