ETLS 509 - Validation & Verification
University of St. Thomas

John Engelman

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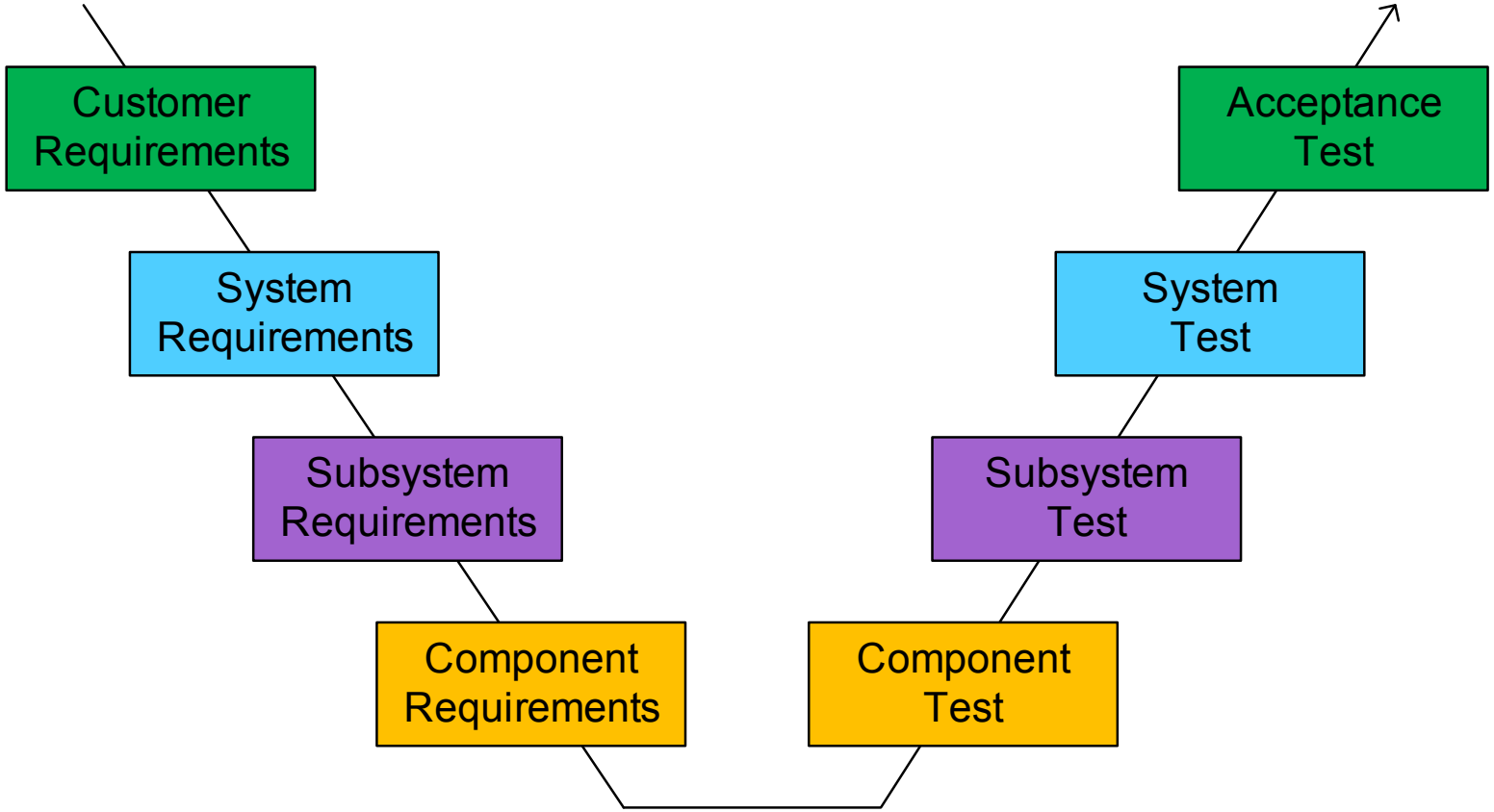
ETLS 509 - Session 11

- **Producibility, Disposability, and Sustainability**



Outline

- Review
- Producibility, Disposability, and Sustainability
- Update on project – paper & presentation

Definition

- Related to each other in *bringing into being (making)* and *ceasing to be (sustain / dispose)*.
- New market opportunities for environmentally friendly or “green” products
- Factories want things that are easy to produce, Operators and Maintainers what things that are easy to service – not all products can be both
- Everyone wants things that are easy to dispose

Numbers are staggering

- 10,328,884 automobiles produced in the US in 2012
- 12-15 million cars reach end of life in US per year
- Currently, 75% of the materials from each car are able to be recycled
- Airbus delivered 295 aircraft in the year's first six months - 2013
- Boeing delivered 477 aircraft in 2011
- Average age at leaving service for commercial passenger airliner = 25 years - Boeing analysis
- The "service life of 20 years" is as generalization that figures 51,000 flight hours and 75,000 pressurization cycles for most aircraft - wiki answers

Priorities in System Design

- **Priorities between producibility, sustainability and disposability in system design are usually –**
  - Producibility
    - Optimization of system design around the ability to produce the system is essential for a cost effective design and general maximization of profits
  - Sustainability
    - Covers the entire utilization lifespan of a system and is a principal factor in the user experience of a product or system
  - Disposability
    - Has been growing in importance as a design consideration for a long period time. In part, disposability has been driven by government regulations thereby imposing requirements that must be met on the system design.

Disposability

- **This covers not only the disposition of a system or product no longer in service**
  - Covers disposal of waste from all aspects of the manufacturing processes
    - This can have significant impacts on the design of a system, for example,
      - in the manufacturing of lenses for telescopes the glass will be doped with a number of different compounds that effect the speed of different wavelengths of light differently
        - » This is needed if you want light of all wavelengths of light from a single light spot source to end up the same point of a focal plan array
        - » Due to disposal issues the use of lead as a doping material has essentially ended. This has major impacts on the design of high-end optical telescopes as this was a principal doping material

Environmental Impacts

- **How we dispose of items is having a major impact on the environment**
  - Fish were found to be spontaneously changing sex from male to female in the Potomac river in the Washington, D.C. area.
    - Fundamental cause has been hypnotized to be female hormones that have been discharged into the river via "treated waste water"
    - http://news.nationalgeographic.com/news/2007/01/070122-sex-change.html
- **The environment has justifiably become a major item in the design of many systems and products**
  - Part of this is driven by regulation, e.g. federal and state regulations on increasing fuel economy
    - Regulations are aimed to accomplish a dual function
      - Reduce the demand on fossil fuels
      - Reduce the amount of CO_2 created through the combustion of fossil fuels
  - Environmental regulations effect a much wider swath of industries than the above example. Many of the most obvious regulations are in the manufacturing area; however, focus on other aspects has been dramatically increasing
    - Cities outlawing the use of plastic bags in retail stores

Producibility, Disposability, and Sustainability - Blanchard - CT 16

- **Need for sustainability of the system that produces, supports, maintains and disposes of products increasing:**
  - Technological and Ecological Services – substitute energy for human effort
  - Factors promoting green engineering – what does it mean to be "green"?
    - Reduce environmental impact of products, production operations, utilization, and disposal practices, i.e. bead blasting aircraft vs chemical paint strippers
    - From Marrian – Webster: tending to preserve environmental quality (as by being recyclable, biodegradable, or nonpolluting)
  - Ecology based manufacturing – harmonization of manufacturing activities with global ecology / processes that do not result in hazardous waste – additive technologies vs subtractive technologies – 3D printing.

Design for Producibility

- **Not only includes ease of manufacture, but also ability of the manufactured entity to be packaged, transported, and delivered to point of use in timely manner.**
- **A characteristic of design – therefore a requirement**
- **Designing for Producibility needs to include the full set of manufacturing processes as well as anticipated improvements in the processes**
  - Manufacturing a product of system will include predications on learning curves that anticipate the reduction of labor required.
  - Level of automation
    - In many cases the cost for producing a product is a function of the level of investment in special automation – consider products manufactured in “lights out” factories. This also applies to shipping, consider how Netflix ships its products

Manufacturing Measures

- Manufacturing is an engineering discipline and as such things are measurable and quantifiable.
- MLT – Manufacturing Lead Time
- T_O - Average operational time of a machine
- T_{SU} – Time to setup machine
- T_{NO} – Non-operational time of a machine
- T_P – Average production time per unit
- Learning curves

Sample Learning Curve

- An 80% learning curve implies that when you double the number of units produced the labor will be 80%.
- Learning curves can be an percentage; however, they are usually in the 70-95% region

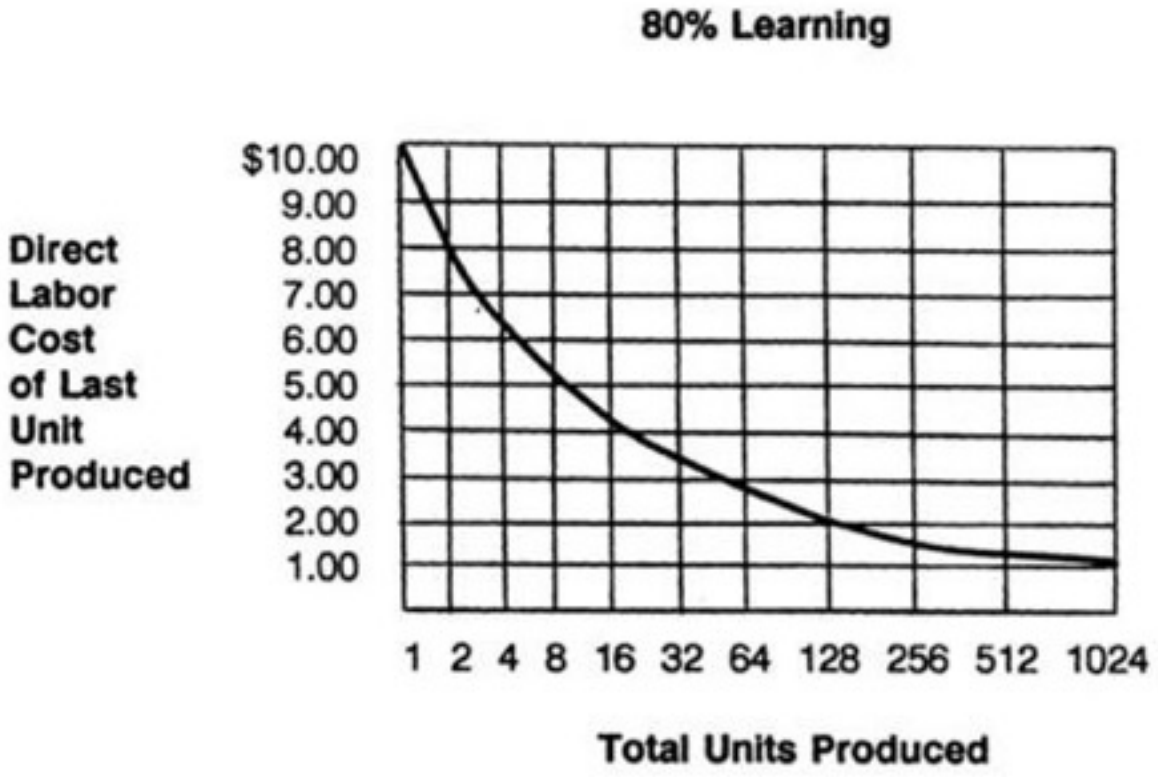


Figure from: http://decodemba.wordpress.com/strategy/

A Production System with Demanufacturing and Disposal

- **Dealing with sustainability and disposal has led to a modified view of a product/systems life cycle**

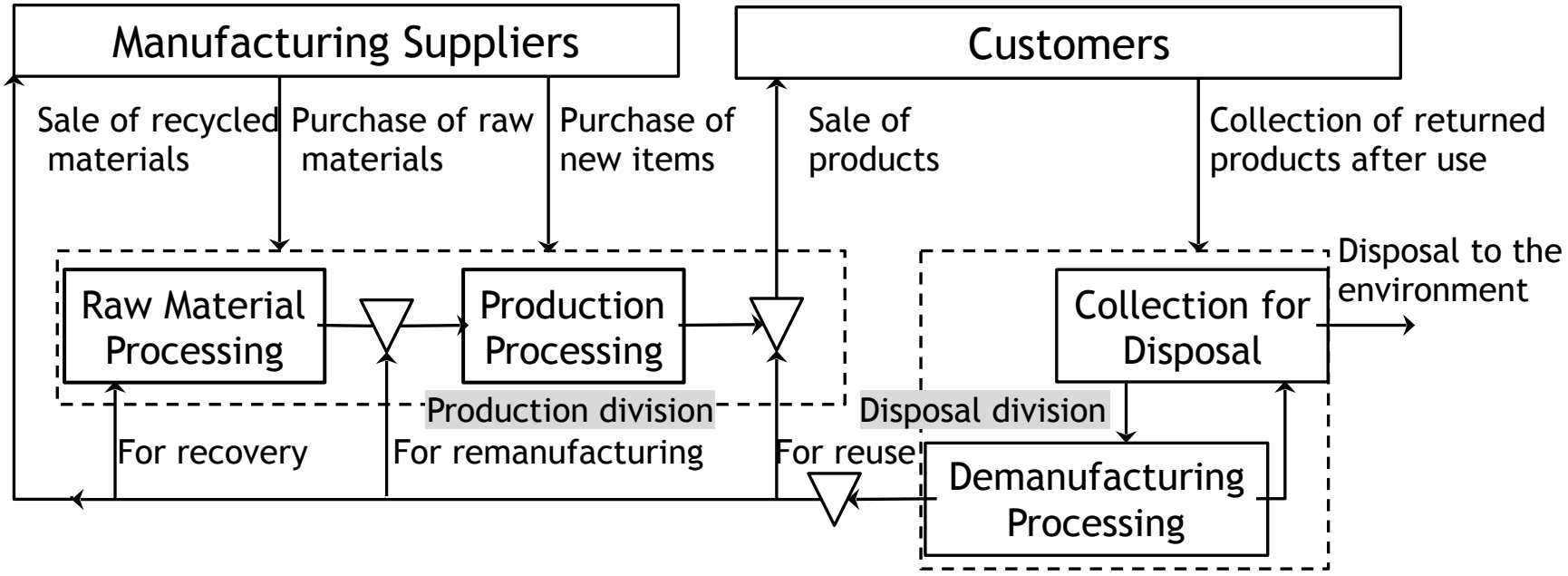


Figure 16.4 Blanchard

Design for Disposability

- Reuse of materials – recycling oil, metal, concrete, asphalt, lumber, glass
- Remanufacturing – products returned from service and returned to new condition
- Recovery – of materials or reusable components to reduce disposal volume and cost.
- Proper disposal methods for all things, including medications.

It's not easy being GREEN

Green Product Criteria – State of Minnesota

- **From state of MN: http://www.nextstep.state.mn.us/res_detail.cfm?id=1393**
  - **Low-Impact Living**: environmental and social impacts can be reduced by using a product or service or adopting a behavior that:
    - Reduces energy use & uses renewable energy
    - Contains recycled material
    - Reduces packaging
    - Is less toxic
    - Is durable, reusable
    - Conserves & protects water
    - Is derived from plants
    - Is organically grown, sustainably produced
    - Is locally produced
    - Is socially responsible

The 5 Rs

- The "5Rs", from the green design group o2-USA/Upper Midwest Chapter (http://www.o2umw.org/5Rs-GreatDesign.html),
  is one snappy way to condense and summarize these eco-product criteria:
- RESTORE
  - Use materials (and support firms) that help reverse damage or -- add -- to natural capital.
- RESPECT
  - Examine impacts the item will have on stakeholders, as well as eco-systems -- social plus environmental justice, look for the win-win-win scenario (triple bottom line).
- REDUCE
  - Reduce the materials needed to do function, including: less materials used, less weight to transport (reduce fuel demands), less energy to manufacture, less energy to store (aseptic pack vs. refrigerated milk), less energy to use (compact fluorescent bulbs vs. incandescent), reduced toxicity (reduce to ZERO).
- REUSE
  - Reuse something already manufactured, and make item easy to BE reused with minimal remanufacturing (Like wine barrels that get turned into taiko drums when they retired from wine making).
- RECOVER
  - Create item to be fed BACK into the resource loop (includes Cradle to Cradle), have a robust and easy to use system to RECOVER materials, and USE RECYCLED substrates to make the item (100% PCW paperboard) wherever possible. Under this clause we would naturally tuck the old favorite -- RECYCLE the things you recovered.

Metrics for Sustainability

- **Resources includes**
  - Depletion, degradation, and, utilization efficiency
- **Product includes**
  - Design, durability, useful life, and packaging
- **Employment includes**
  - Health, safety, security, and worker satisfaction
- **Economic includes**
  - Value added by investment and production ethics
- **Society includes**
  - Community Development and social impacts
- **Environment includes**
  - Waste production, emissions, and acoustics
- **Infrastructure includes**
  - Transport ease and communications

Blanchard 16.6.2

“Green” Example

- **777 vs 787**
  - 787
    - 50 percent composites
    - 20 percent aluminum
  - 777
    - 12 percent composites
    - 50 percent aluminum
  - Sure composites provide increased strength at lighter weight, but how do you dispose of composites?
    - http://www.sciencedirect.com/science/article/pii/S0255270111002029

An Example

- 2015 Camry LE 2015 Camry LE Hybrid
- Compare cost / sustainability of standard vs hybrid models
- Standard gas milage = 25 City / 35 Hwy
- Hybrid gas milage = 43 City / 39 Hwy
- Standard purchase price = $23,795 (LE no options)
- Hybrid purchase price = $27,615 (LE no options)
- Hybrid battery replacement cost = $3,541 warranted for 8 years/100,000 miles
- Comparative cost of ownership = cost to drive vehicle 75,000 miles? Cost to drive vehicle 150,000 miles? Assume gas at 3.50 per gal. All other costs comparable (oil change, tire replacement, etc)

Summary

- Like every thing else we have discussed in this course, producibility, disposability, and sustainability are designed in characteristics to meet customer demands.
- That means there are requirements that describe these characteristics.
- And if there are requirements, they can be validated and verified.

777 Project

- What are the Producibility, Disposability, and Sustainability requirements for the 777?
- 21st Century Jet - Making the Boeing 777 3-2