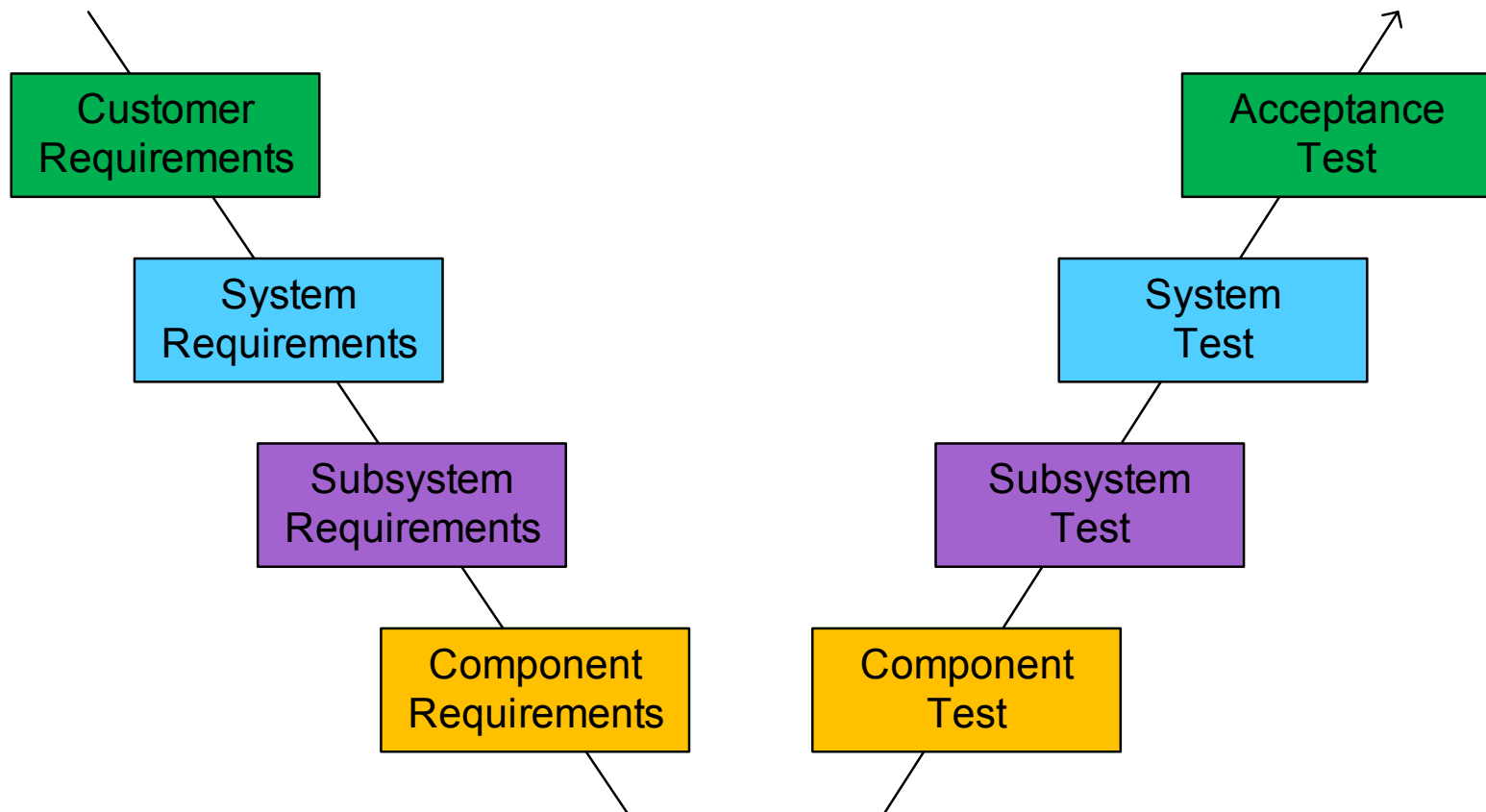


ETLS 509 - Validation & Verification
University of St. Thomas

John Engelman
Fall 2016

ETLS 509 - Session 12

- Requirements Definition Affordability (Life-Cycle Costing)



Outline

- Review/questions
- Product Life Cycle & Life Cycle Costs

Product Development Life Stages

- **Product Development**
 - Comes in response to solving a problem to satisfy a need
 - Typically no revenue/profits (rare exceptions)
- **Product Introduction**
 - Typically characterized by slow sales growth. Think introduction of Blu-Ray players, hybrid autos, personal PCs (1980), VCRs (late 1970's)
 - Frequently initial high costs - in 1981 IBM PC was \$1,565 (in \$4,087 in 2014 \$), no hard disk and 16KB of memory expandable to 256KB. VCR price in 1977 ~\$1280. In 1995 VCRs<\$100.
 - High costs are accompanied by low profits (if any)
- **Growth (assuming a successful product)**
 - Rapid sales growth
 - Price stabilization/reduction
 - Profits & competition
- **Maturity**
 - Stability in sales
 - Declining profits - changes in business strategy (e.g. IBM sells PC line to Lenovo in 2005)
 - Significant price competition
 - Think commodity products, pens, DVD players, PCs (next chart)
- **Decline**
 - Declining sales
 - Declining profit margins
 - Examples - VHS players, pagers
 - Products such as pagers may maintain “niche” market; however, sales are continuously going down

Common Product Life Curves



(a) Growth-Divide plateau



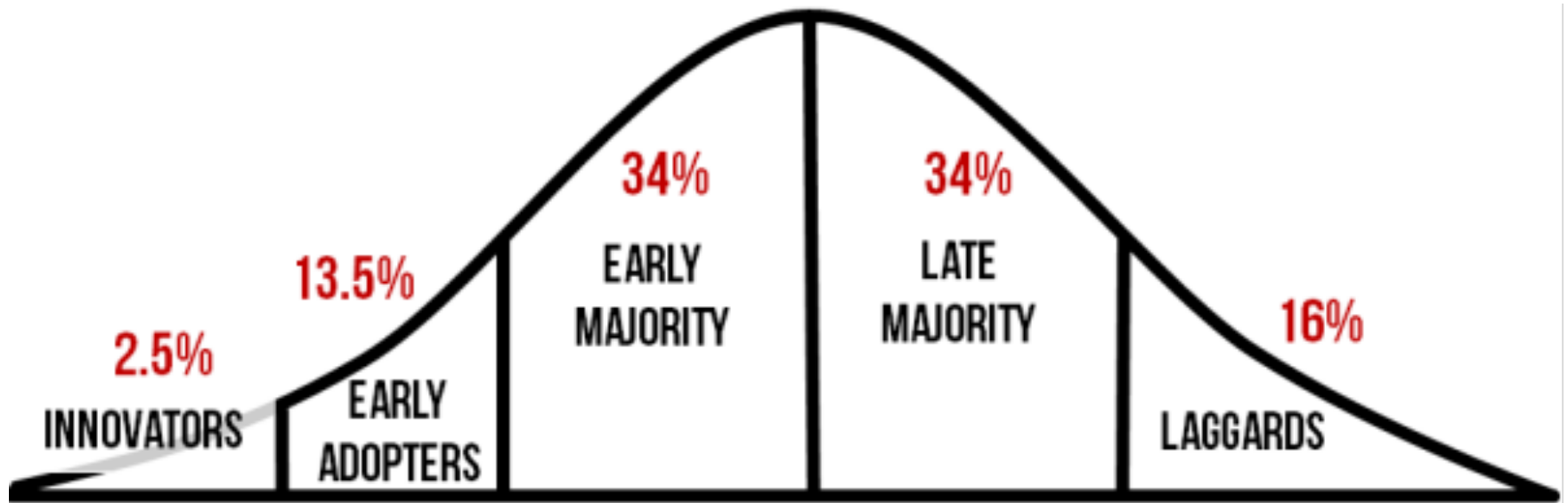
(b) Cycle-Recycle Pattern



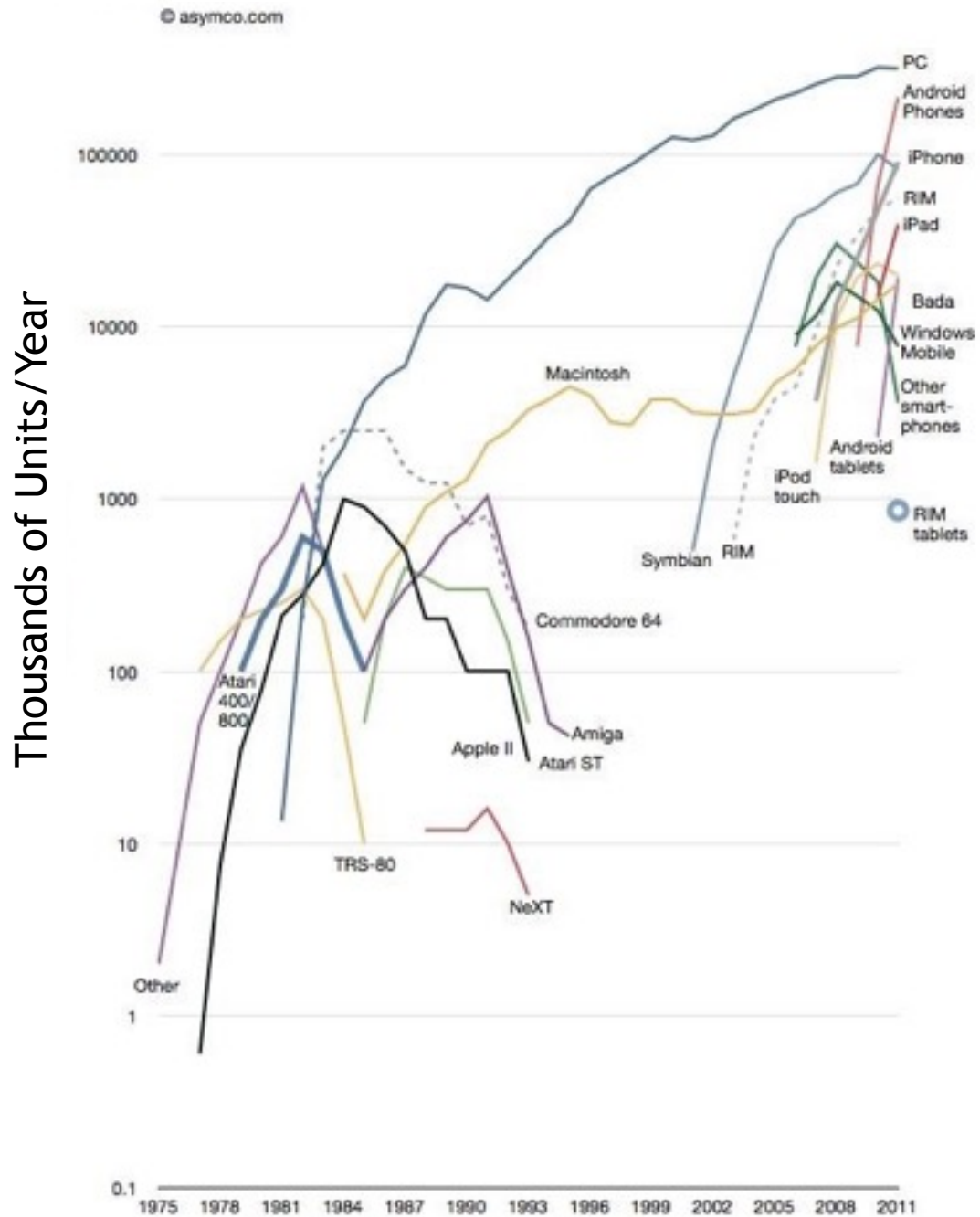
(c) Innovative Maturity or Scalloped Pattern

Technology Adoption Curve

- In 1962, Everett Rogers, made observations about how technology is adopted that have influenced product development. Viewing technology adoption via a normal distribution -

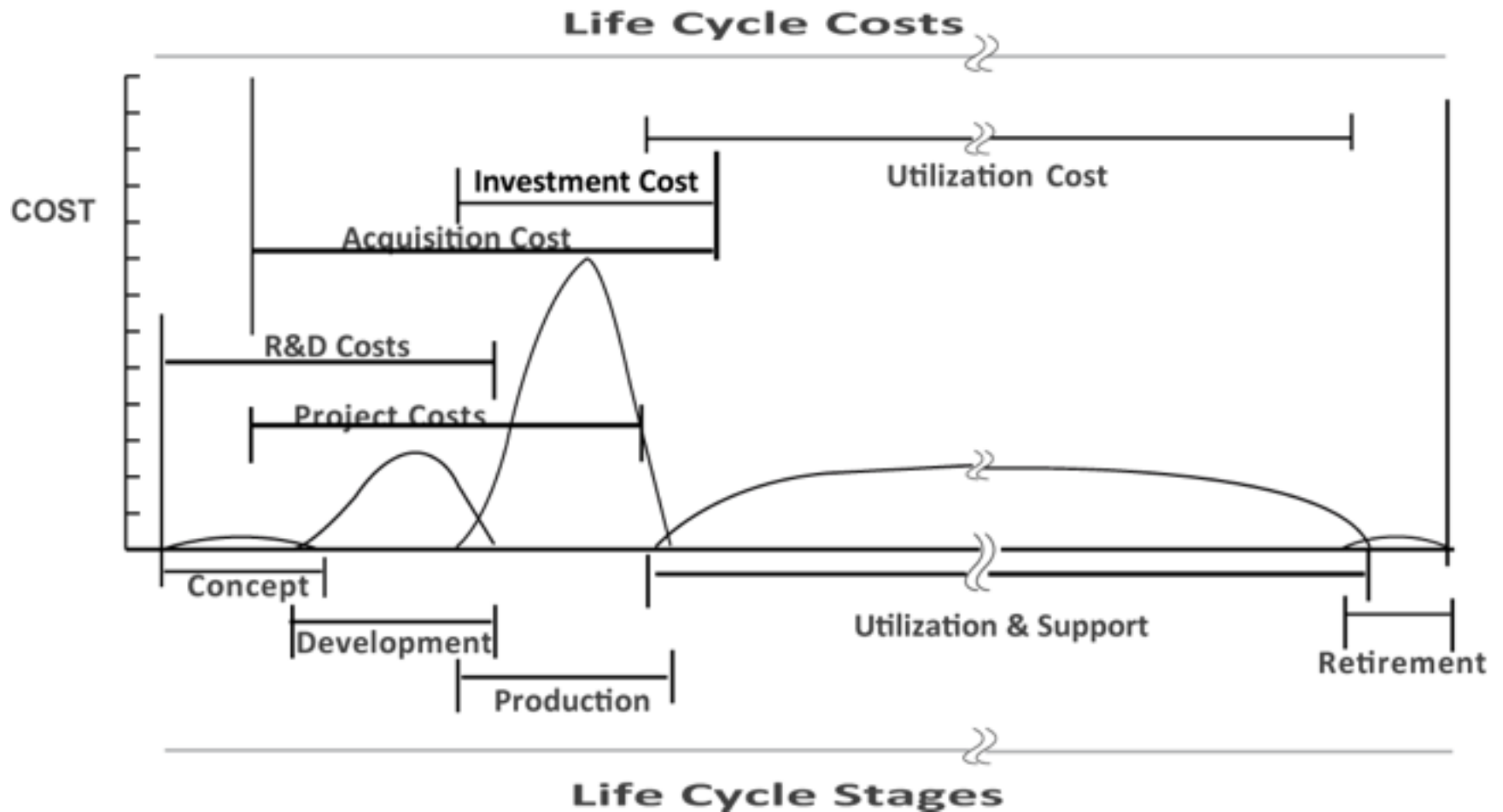


PCs & Gadgets Shipped Per Year (Log Scale)

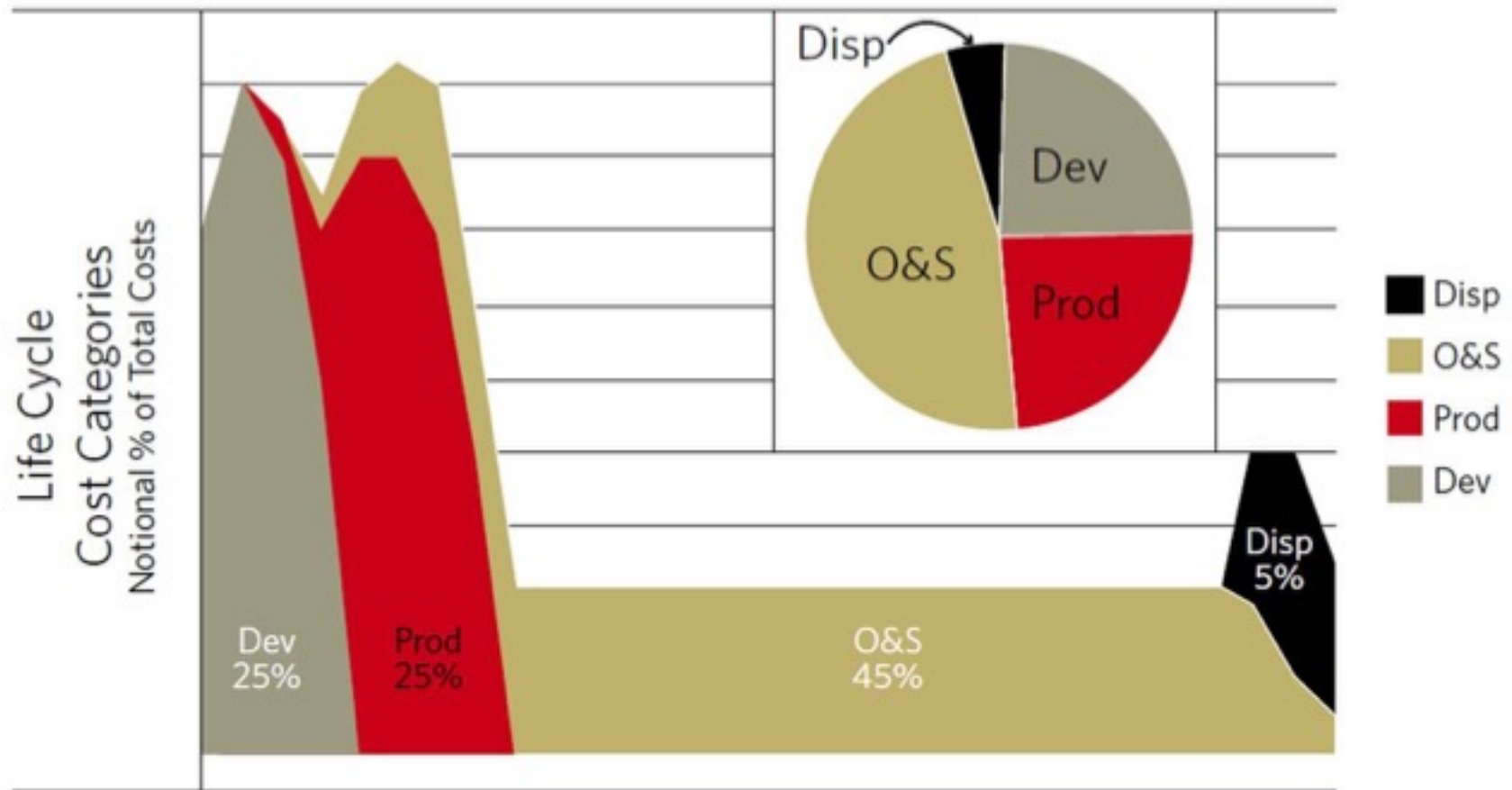


From:
<http://simplepimple.com/2012/01/the-history-of-pc-and-gadget-sales-from-1975-in-one-chart/>

Where are the Costs Across the Life Cycle?



Weapon System Life Cycle Cost Categories and Phases



Disp - Disposal

Prod - Production

O&S - Operation and Support Dev - Development

Life-cycle Cost Breakdown

- **Research & Development**
 - Program Management
 - Advanced R&D
 - Engineering Design
 - Equipment Development & Test
 - Engineering Data
- **Production**
 - Manufacturing
 - Construction
 - Internal Logistic Support
- **Operation & Support/Maintenance**
 - Operations
 - Maintenance
 - System Equipment Modifications
 - System Phase-out and Disposal

Research & Development Costs

- **Research & Development**
 - Program Management
 - Advanced R&D
 - Engineering Design
 - System Engineering
 - Electrical, Mechanical Design
 - Reliability, Maintainability
 - Human Factors
 - Producibility
 - Logistic Support Analysis
 - Equipment Development & Test
 - Engineering Models
 - Test & Evaluation
 - Engineering Data

Production Costs

- **Production**
 - Manufacturing
 - Manufacturing Engineering
 - Tools & Test Equipment
 - Fabrication
 - Assembly
 - Inspection & Test
 - Quality Control
 - Material
 - Packing & Shipping
 - Construction
 - Manufacturing, Test, Operational, Maintenance Facilities
 - Internal Logistic Support
 - Program Management
 - Provisioning
 - Initial Spares / Repair Parts
 - Initial Inventory Management
 - Technical Data Preparation
 - Initial Training and Training Equip
 - Test & Support Equipment Acquisition
 - First Destination Transportation

Operations & Maintenance

- **Operations**
 - Operating Personnel
 - Operator Training
 - Operational Facilities
 - Support & Handling Equipment
- **Maintenance**
 - Maintenance Personnel & Support
 - Spare / Repair Parts
 - Test & Support Equipment Maintenance
 - Transportation & Handling
 - Maintenance Training
 - Maintenance Facilities
 - Technical Data
- **System / Equipment Modifications**
- **System Phase-out & Disposal**

Life-Cycle Costs

- **Determining life-cycle costs is an essential part of systems engineering**
 - Cost is one of the most important variables in trade-off in designing a system
 - Cost optimization that may minimize initial system design costs may result in significantly larger total cost of ownership
 - Estimating the total cost of ownership can dramatically influence the business models associated with acquisition
 - Consider fuel cost verses aircraft weight

Some Life-cycle Cost Models/References

- Blanchard, B (2004). Logistics Engineering & Management, 6th Ed. Pearson / Prentice Hall (Appendix D).
- Price Systems
 - True Planning
 - <http://www.pricesystems.com/>
- Isograph
 - <http://www.isograph-software.com/2011/software/availability-workbench/life-cycle-cost-analysis/>
- PTC / Windchill
 - <http://www.ptc.com/product/windchill/lcc>
- Defense Acquisition Guidebook
 - <https://acc.dau.mil/CommunityBrowser.aspx?id=289207&lang=en-US>

777 Project

- **What are the life cycle cost considerations for the 777?**
- **21st Century Jet - Making the Boeing 777 1-2**