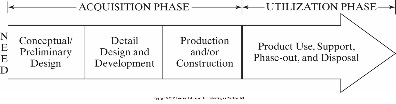
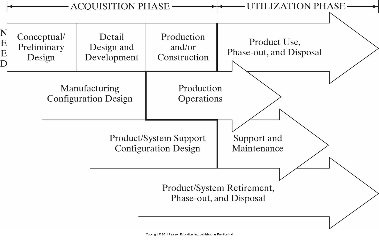
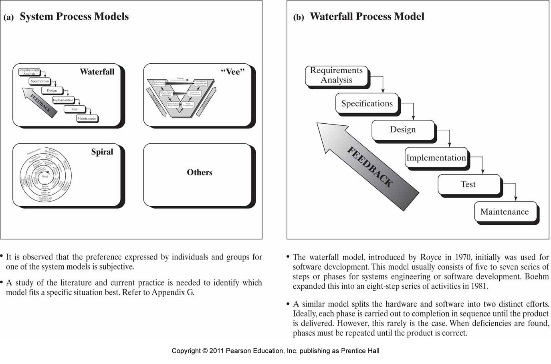
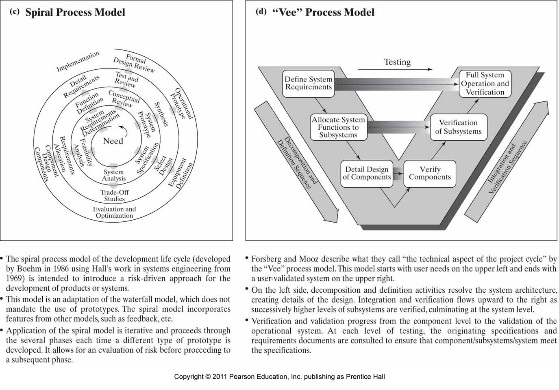
**System**

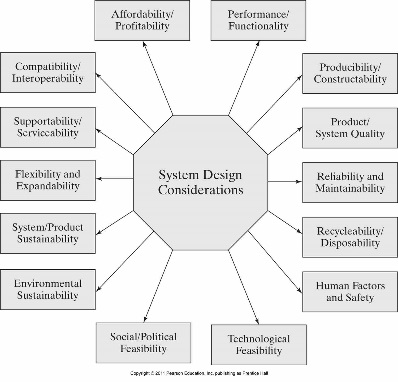
* elements are: a) *components*, b) *attributes*, and c) *relationships*; *alter* either energy, information or materials; can be either *natural*, or *man-*made; can be either *physical* or conceptual; are typically *static* or *dynamic*; set of interrelated components











**Problem statement**

* [relatively] non-technical
* Uses “language” of customer
* Non-complex

**Q’s to get well-made prob. stmt.**

* Q the customer
* Differentiate their needs and wants
* Explore project boundaries
* Do I/O analysis
* Preview user interface
* Survey design attributes
* Identify conflicting needs
* Prepare draft operations manual

**Sections of prob. stmt.**

* Background/overview
* Overall design [not detailed]
* Deliverables

**Prob. stmt. defines**

* Who, what, why (insight)

**Chars. of good prob. stmt.**

* Short, avoids defining soln., not short list of reqs.
* Captures essence of prob./ need, includes qual. & quant.

**Needs analysis**

* When, what (sys. do & primary & secondary functions), where, how often?

**Operational Requirements**

* Mission def, environ. factors, oper. lifetime/deployment, utilization reqs. (freq. of use, hrs. of oper., capacity), perf. params. (mass, volume, range, velocity), effectiveness (MTBM, MDT, MTBF)





**Identifying Technical Measures (TMPs)**

* *Quantitative* values describe performances that stem from op. reqs., are Design Dependent Parameters (DDP) [e.g., MTBF, MTTR, MDT, MTBM, etc.], include weight, envelope, availability to perform/function as designed

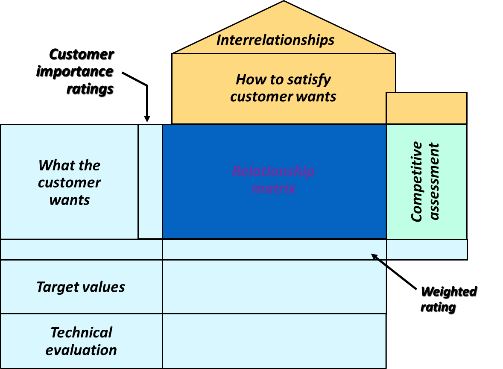
**Quality Function Deployment (QFD)**

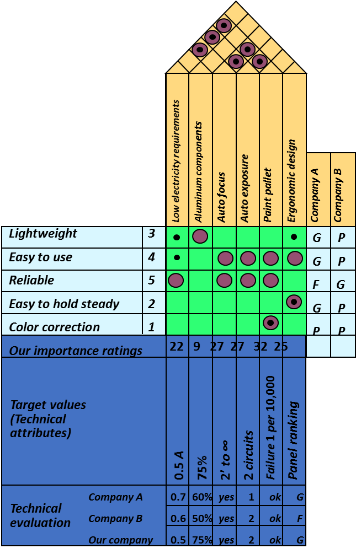
* (Dated) method to identify & capture prime desires of customer
* Uses cross-referenced matrices to perform comparisons of technical & design features resulting in weighted values for TMPs
* *Goal*: identify what customer wants, *predict*: how good/service/process will satisfy customer wants, *relate*: cust. wants to sys. hows, *evaluate*: importance ratings/values, *compare*: performance to desirable TPMs
* *Leads* designers into *preliminary design phase*, *paves* way for functional req. devel. (FFBDs), *allows* for functional allocation by partitioning major sys. elems., *permits* ident. of HW & SW items that multiple functions -> simplify overall sys. arch.

**System Design Flow**

* Abstract notion -> systemic form/function -> repeatable, producible system/product
* 4 design stages: concept.; system; prelim; critical (w/reviews)
* Design revs.: formal method of checking proposed design, provide common baseline for all project stakeholders, permits solving of any interface issues, creates record of design decisions & rationale, leads to greater prob. of a mature design for when production starts
* Reduces risk associated w/prod. phase w.r.t. meeting reqs.

**QFD “House of Quality”**





**Requirements**

* Statement that identifies a capability or function that is needed by a system to satisfy its customer’s needs
* Customer’s needs: solve prob., achieve obj. (cntrct, stanrd, spec)
* 3 sys. eng. Tasks: get reqs; design; verify
* No two sys. are alike but uniform & identifiable process for logically discovering reqs.
* *Process is iterative*: reqs. emerge throughout sys. life cycle and change, customer: “I’ll know it when I see it”, stakeholder priorities change, low-level -> other reqs. become priority

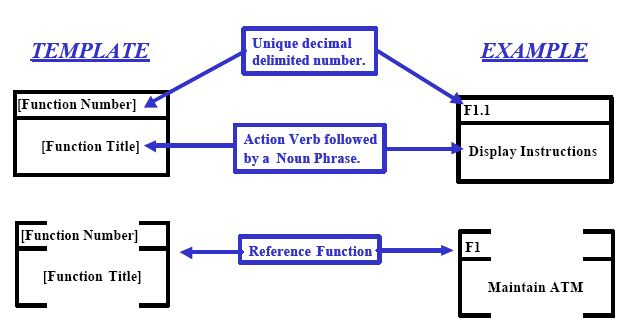


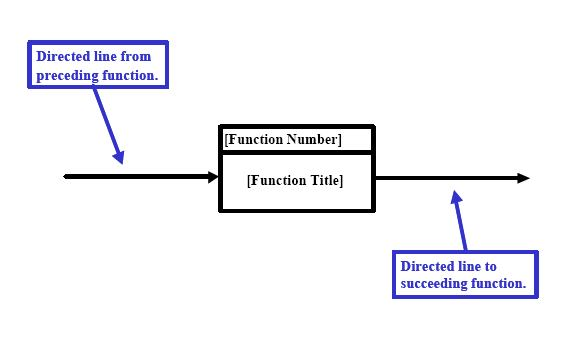
**Functional Requirements**

* What, how well, under what conditions one or more inputs must be converted to one or more outputs @ boundary in question to satisfy customer’s needs. Top-level reqs., basis for reqs. mgmt., the “what” of the system, organic/living, increases in complexity/detail as reqs. decomp. progresses

**Functional Flow Block Diagram (FFBD)**

* Captures functional reqs., time-seq. of operational & support seqs., organized by order of execution, can use Boolean logic
* Benefits: ident. pot. areas for trade study (AOO); dev., analyze, & flow down reqs. to lower levels; provide better pic. of how sys. under dev. is intended to function/work; ident. possible areas for oper. simplification w/in overall system







Typical spec. tree/hierarchy

**Key Specification Terms**

* **Hierarchy**: order of prec. or import. of each spec. in entire compliment of spec. docs. (us. in tree format); **flow down**: act of distributing reqs. from higher prec. docs. to lower level -> greater req. detail; **traceability**: ability to follow interconn. between reqs. w/in partic. spec. & other specs. either higher or lower in prec.; **config. mgmt.**: process of maint. accurate records & current vers. of all of a prog’s specs., drawings, & key docs.

**Standard Specification format**

* **1.0**: intro, purpose, scope of spec.; **2.0**: applicable docs., stds., reference docs; **3.0**: spec. reqs.; **4.0**: verif. of reqs.; **5.0:** packaging/notes, etc.

**Example of System Spec. Req.**

* GPM **shall** enable accountants to generate following financial reports:

Feedback summary; fees summary; invoice summary; listings summary; user summary

* GPM **will** provide following capabilities

**Example of Development Spec.**

* End-User Characteristics, & General Constraints

**Product Specification Example**

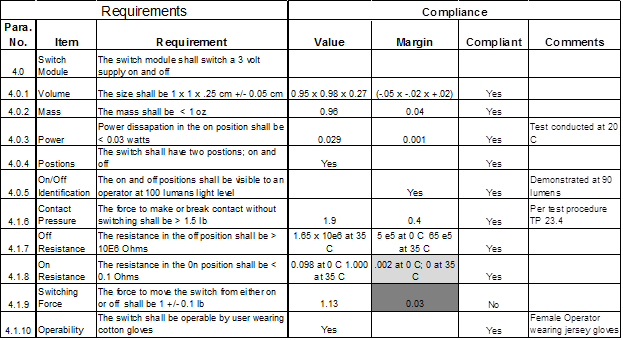
* Physical and Operational Characteristics:

*Performance Reqs*.; *Safety*

**Process Specification Example**

* Product Mgr.; Project Mgr.; Reqs. Eng.; Developer

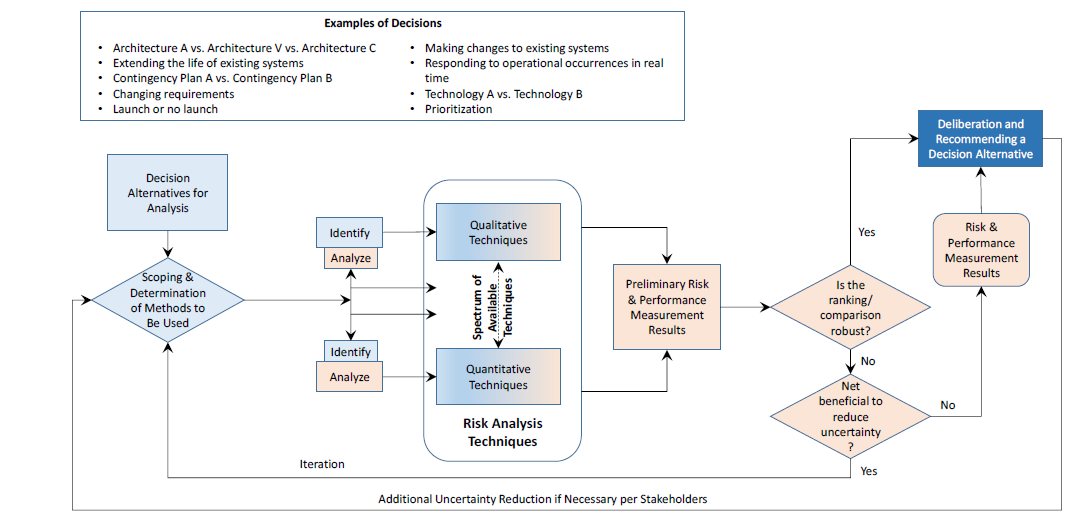
**Sample Verification Cross-Reference Matrix**



**Why Perform a Trade Study?**

* **Gather & assess** possible design sols. for new sys. that one is creating; **determine** whether to make/buy needed asset/tool/SW app.; **methodically eval.** attributes & chars. of each pot. design in light of sys.-level reqs.; **reduce** uncertainty & risk assoc. w/sys. dev.; **arrive** @ decision as to which pot. design sol. will provide “balanced” approach that results in sys. that’s both realizable & functional

**Decision Process Map**



**Examples of How Trade Studies Can be Applied**

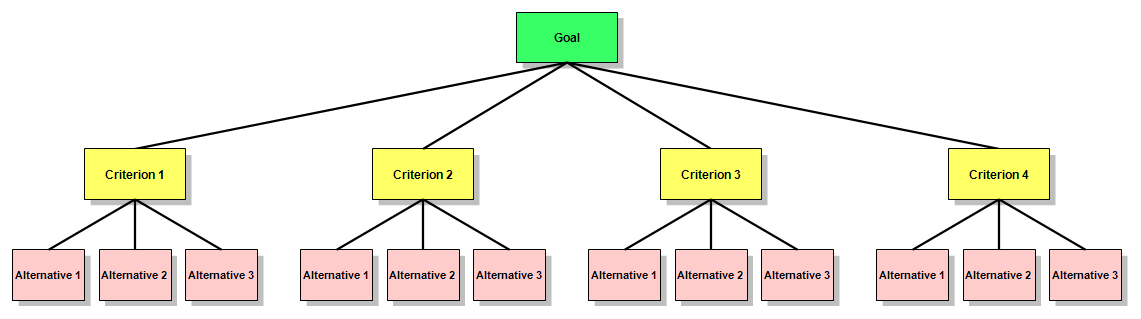
* **Choosing** how/where to allocated limited resources/budget w/in project; **decide** whether to proceed to next checkpoint/gate in sys. dev. process; **what time** to conduct required sys. project revs. (SRR, PDR, etc.); **select** which risk mgmt. methodology to apply to sig. proj. risks to sys. creation while considering costs, schedule, & tech. perf. of the emerging threat

**Means to Conduct a Trade Study**

* *Qualitative*: simplest, easiest; uses ling. descriptors to compare alts./attrs.; downside is possible subjective bias when making comparisons
* *Quantitative*: pairwise comparisons, decision trees, or AHP; advantage is less prone to analyst bias

**Analytic Hierarchy Process (AHP)**

* Pairwise comparisons of attr./chars.; uses matrix/lin. alg. to arrive @ opt. choice when considering (Mult.-Crit./Mult.-Alt.) MCMA descisions
* *Objective*: sits at head of hierarchy; *criteria*: upon which analysis will be performed (each has weight/importance factor as % & add up to 1); *alternatives*: different choices
* Info decomposed into *hierarchy of alts. & dec. crit.* -> *rel.* rank of alts.; quant. & qual. data can be compared; derive weights & priorities



**Handling Costs – Diff. From Economic Evaluation Method(s)**

* Dangers of including cost as another criterion: political & emotional response? *Separate* benefits and costs into different hierarchical trees.
* Cost/Benefit eval.: choosing alt. w/best bens./cost ratio. Use RoR/BEP to properly consider decision from a cost POV

**System Verification**

* *Validation*: process of confirming that a set of reqs., design, or sys. *meets the intent* of dev. or cust. (does the *sys*. meet its req.?). *Verification*: process of confirming that a req. or sys. is *compliant* (does the sys. meet *this particular req.?*).