Module 2

Project Organization/Planning

Readings

- Lecture 2
- Chapter 2 in *Engineering project management*
- Project Management Institute. (2017). Part 1: A guide to the project management body of knowledge (PMBOK® guide): 3. The role of the project manager. In *A guide to the project management body of knowledge® (PMBOK® guide)*. (6th ed.). (pp. 51-68). PMI Publications.

Lecture

▼ What are system engineers?

The systems engineer often serves as the project manager's right hand; the two work in tandem to focus on requirements for the project.

The systems engineer is likely a subject matter expert, that individual will have a considerable amount of autonomous work and leeway to ensure that the project keeps on pace and on schedule.

▼ What is systems engineering?

Encompasses integration management, risk management analysis, quality management, lifecycle cost and disposal, as well as interface specifications, standards, and alternatives analysis for the project.

Enables the successful realization, use, and retirement of engineered systems.

Requires technical and non-technical knowledge.

▼ What are risk factors?

Systems engineers collaborate and inform the project manager regarding risk factors.

These can range from technical requirements to supplier risks that could affect the overall risk profile for the project.

▼ What is systems thinking?

Evaluating system functions as a whole is known as a systems approach or systems thinking.

▼ What are specific systems functions?

System engineers manage the manufacturing, construction, funding, and general management processes associated with the system.

▼ How do system engineers approach requirement solution development?

Systems engineers collaborate with experts and ensure that every advantage is pursued while mitigating risk factors and apprising the project manager of progress within the system.

▼ How are requirements obtained?

- brainstorming
- document analysis
- interface analysis
- focus groups
- stakeholder or customer interviews
- observations
- prototypes
- requirements workshops
- reverse engineering
- survey/questionnaires

▼ What is requirements management?

The process of analysis based upon information elicited from stakeholders or the customer.

These methods and activities are all ways of eliciting information to gain knowledge about the project and what will be required to bring it from idea to reality.

▼ What is project design methodology?

The framework by which the team can follow and execute all phases of the lifecycle and systems development process.

Has a critical impact on the success rate of the project.

▼ What goals can be achieved with design methodologies?

- Appropriate cost estimates are accurate, reliable, and complete.
- Stakeholders' desires and essentials are appropriately defined.
- All tasks are completed with a standardization and procedural approach.
- Common terminology and a process framework are established, allowing the team to have a shared expectation of process.
- Lessons learned are made part of the knowledge management database, and solutions are rapidly deployed.
- Conflicts are spotted early and resolved quickly.
- Deliverables are created and handed over according to project timelines and scope.

▼ What are some other project management frameworks?

Six Sigma, Prince 2, ITIL, and SCRUM

▼ What are technical project management skills?

Some of the biggest skills required include the ability to appropriately manage time, the ability to effectively communicate ideas and philosophies, strong decision making, and the ability to negotiate or problem solve in a manner that is effective and collaborative.

Strategic planning and forecasting are skills that are necessary for a technical project manager.

- ▼ What is forecasting?

  Businesses use forecasts and data analysis to look at the viability of certain trends, find the performance history of a product, and determine how profitable a venture may be in the future.

  Projects may be either given the green light or canceled depending upon how available data is used to successfully forecast processes.

- ▼ What is trend analysis?

  A standardized forecasting activity that looks at historical patterns in order to determine future risks or benefits.

- ▼ What is cost-benefit analysis?

  Assists project managers in finding an expected benefit for performing a task or function, especially when faced with multiple options.

- ▼ What is strategic planning?

  It combines forecasting, risk management, and a great deal of scrutiny to navigate unforeseen challenges and opportunities to arrive at a successful project inception.

  It decides where and how funding is allocated during projects.

  It allows the project manager to evaluate the current performance of the project.

  It produces questions like where are we now, where should we go, and how do we get there?

- ▼ What is SWOT analysis?

  Evaluates environmental analyses, industrial analyses, and company analyses.

Chapter 2 in *Engineering project management*

- ▼ What is the system method?

  Increases the likelihood of successful system development by putting the focus on the behavior of the system as a whole rather than on its components.

- ▼ Why use the system method?

Why? We want to accomplish something that is greater than what is provided directly by each part; we want some emergent behavior, i.e. gears + screws + metal = bike.

Behavior emerges from union of parts. "The whole is greater than the sum of its parts."

Note: goal is desired not unplanned emergent behavior.

- What is the role of the systems method?

  The role is to figure out what are all the parts we must have.

- The systems method uses decomposition to do what?

  The system is broken down into segments for analysis: the requirements, design, test program, etc.

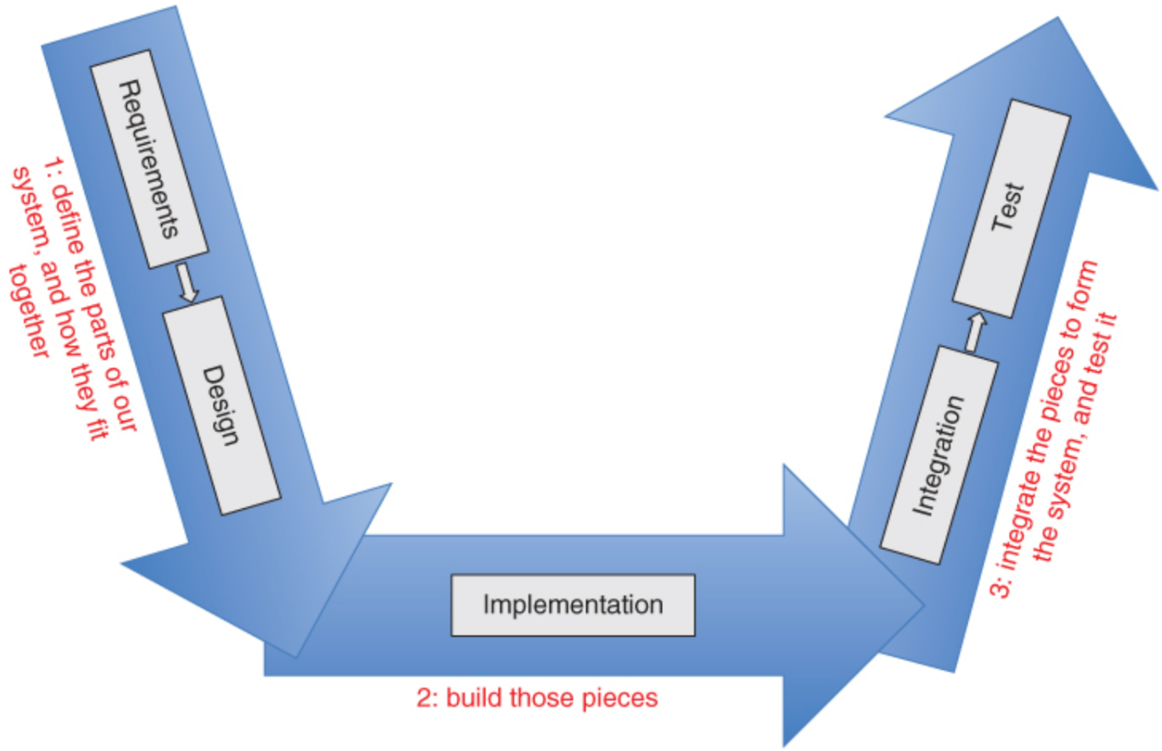
  We can also decompose into a hierarchy.

- Parts of a system must?

  Match and be in balance. Another reason to use systems method.

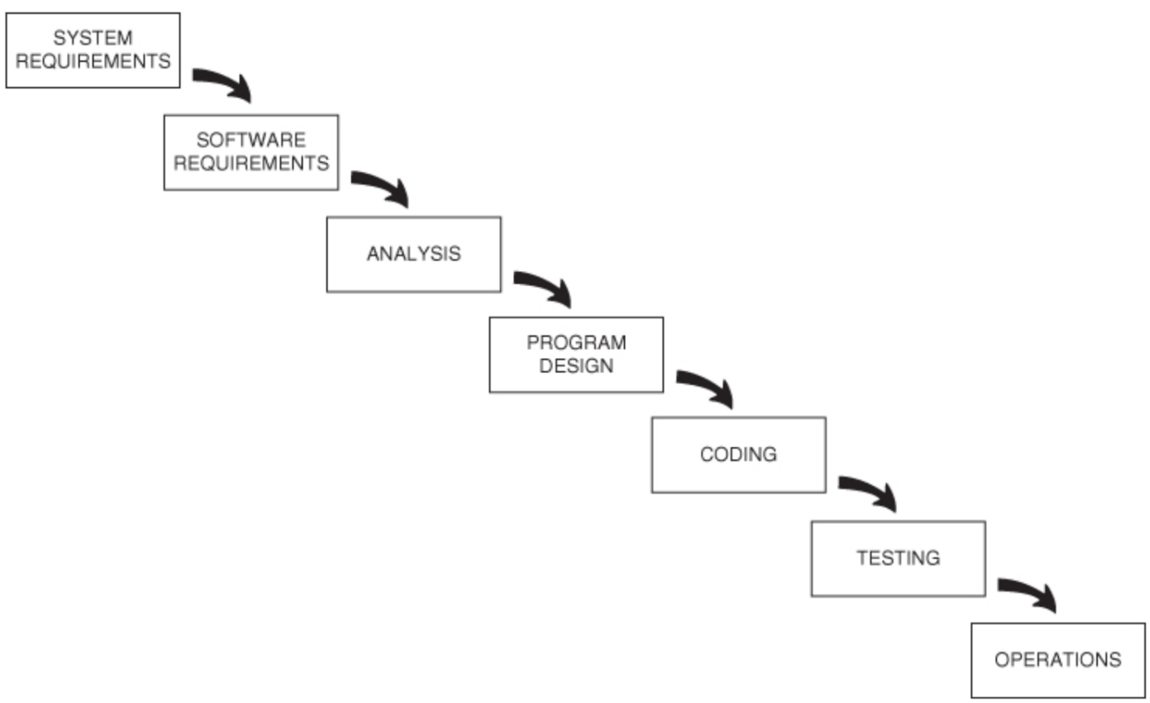
- "U" Life-Cycle shape

  activities proceed in hierarchy



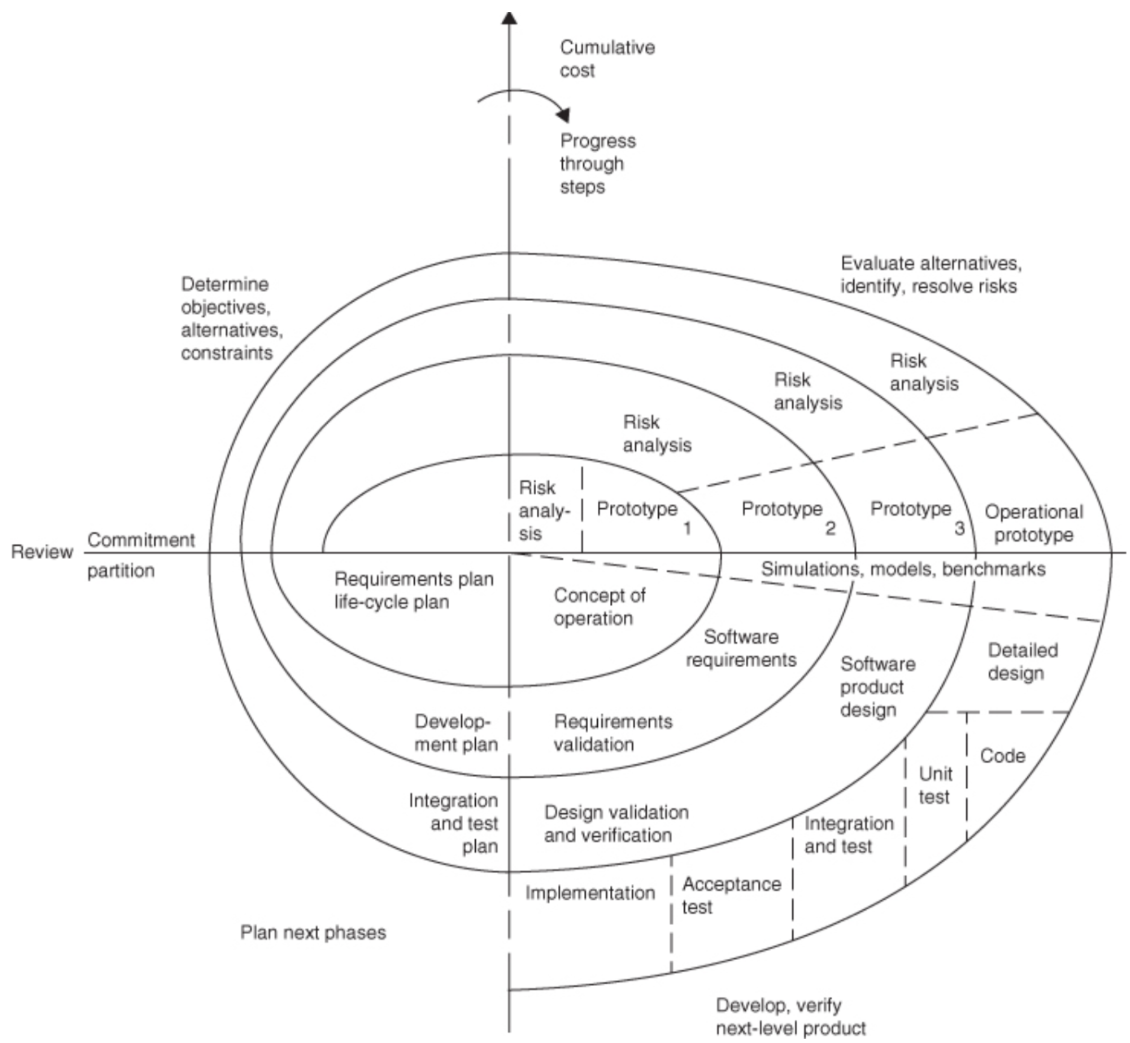
- Waterfall Life-Cycle shape aka waterfall method

  series of steps to be taken in a particular order



- Spiral model for life-cycle

  starting with a prototype each increment of system development develops a "partial" system so necessary fixes can be added along the way



- What are life-cycle decision gates?

  A review or formal decision-process: are we ready to move to the next stage of the life-cycle?

  Reviews provide an assessment of a project's maturity, technical risk and programmatic/execution risk.

- Engineer's vs. Customer's coordinate system of value?

The *customer's* coordinate system of value	The *engineer's* coordinate system of value
Usually non-technical in nature	Usually technical in nature
Characterizes something about the *mission*	Characterizes something about the *technology that implements the system*
Captured in what I call *operational performance measures*	Captured in what I call *technical performance measures*
Measures the *goodness* of the design for the users	Measures whether or not the design is *feasible*, and helps us estimate the *schedule* and *cost* needed to build the system
The two types of metrics should be *linked*; that is, we need to credibly and transparently show how changes in design (which change the *technical performance measures*) cause changes to the *operational performance measures* Our *degrees of design freedom* are located in the engineer's coordinate system of value, but we *measure the goodness of the resulting design* in the customer's coordinate system of value	

▼ How to align engineer's and customer's coordinate systems of value?

You need to make the effort to socialize your ideas for operational performance metrics with your customers, users and other stakeholders. Achieve transfer of emotional ownership to the customers. Make the metric theirs not just yours.

▼ What are guidance processes?

Written guidance processes for every aspect of an engineering project.

▼ What are the range of processes we can use in an engineering project?

Planning	Written guidance for how each aspect of our project will be performed
Contracting	Written guidance for how all aspects for making and documenting binding, legal commitments with our customers is performed
Acquisition and Purchasing	Written guidance for how we acquire materials and services from outside organizations, whether by subcontract (usually used for items that involve invention or adaptation) or by purchase order (usually used for items that are being purchased without any adaptation)
Finance	Written guidance for how we will allocate budgets and funding to people and tasks, keep financial records, and all other financial aspects of the project, including compliance with customer requirements, laws, regulations, and company standards
Project Start-up	Written guidance for how we will get the project started, including acquisition of necessary facilities, equipment, people, cash, intellectual property, and so forth
Technical Management	Written guidance for how we will oversee the engineering, development, integration, testing, production, and other technical aspects of the project
System Requirements	Written guidance for how we will create and validate the design for our system
System Design	Written guidance for how we will create and validate the design for our system
System Implementation	Written guidance for how we will build the components of our system, including hardware, software, and data
System Integration and Test	Written guidance for how we will assemble the components of our system into a functional whole, and how we will then check that the system complies with the requirements and incorporates other desired features

Making Decisions	Written guidance for how we will make decisions, and keep records about them
Delivery	Written guidance for how we will deliver, install, and bring into actual operation the completed system
Property Management	Written guidance for how we will keep track, protect, and utilize material objects on the project, with particular emphasis on items that belong to our company, that belong to our customer, and to those items that must be delivered to the customer at specified time points in the project
Technical Evaluations / Quality	Written guidance for how we will achieve the levels of quality specified in our contract, our requirements, and in our organization policies
Safety	Written guidance for how we will keep our employees, our users, and our community safe while we perform the work on our project
Configuration Control	Written guidance for how we use control changes to items (documents, parts, subsystems, data, and so forth), and ensure that we know what is the state of each item, and that we are always using the correct version of each item
Human Resources	Written guidance for how we will acquire, motivate, and retain the people we need to do the work entailed in the project, make appropriate plans about the time-phasing of needed personnel, and provide for the orderly transition of people to another project when their contribution to this project is complete
Project Termination	Written guidance for how we will ensure that all items specified are delivered to the customer at the conclusion of the project; that all contractual obligations are fulfilled and documented appropriately; and that people, materials, facilities, and other resources are properly handled and accounted for as the project comes to a close

▼ What is systems method planning?

Writing plans on how to perform each aspect of the project, e.g. how to validate technical requirements, how to acquire specialized personnel, how to maintain safety etc.

▼ Why use requirements?

To understand a problem then write down what you have decided.

▼ What is a requirement?

A requirement is a formal written statement of the problem we are trying to solve by building an engineered system. Is a statement of *what the system should do* and *how well* it should do it.

▼ How to get customer's coordinate system of value?

Talk to and listen to customers if necessary watch how they work. Why? Engineers need to know

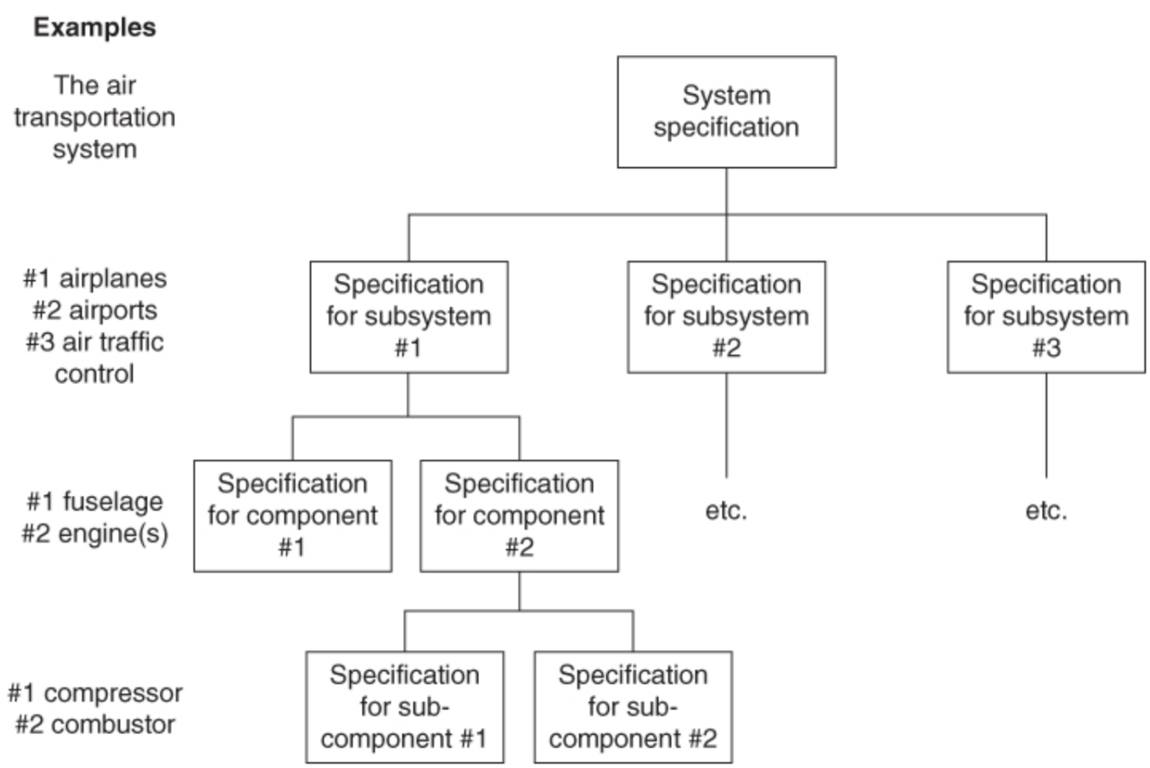
▼ What are specs?

Written requirements

▼ What is hierarchy of specs?

Includes spec for system as a whole and specs for subsystems/components.

▼ What is a specification tree?



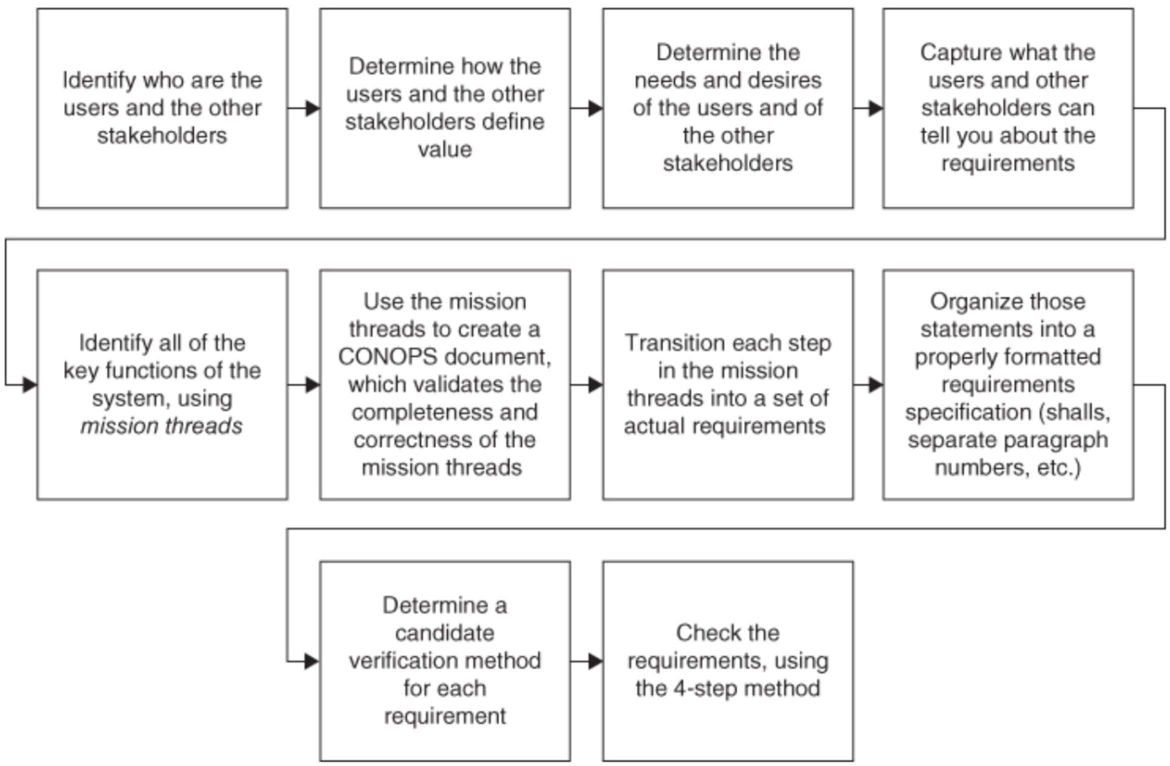
▼ What do requirements define?

The what and how well for a system

▼ What includes a contractually binding commitment?

Specifications

▼ How to create the requirements?



▼ What are mission threads?

The major operational sequences of our user's mission.

▼ What is a CONOPS document?

Concept of operations document.

Describes the mission threads, the inputs, and the outputs, but also summarizes how often each mission thread is likely to be exercised during actual operations, identifies any timing constraints for a thread, identifies other constraints imposed by outside authorities, etc.

▼ What are candidate methods?

Inspection, analysis, demonstration, simulation, and assessment by operation

▼ What is a SMART requirement?

Specific, Measureable, Achieveable, Realistic, Testable

▼ What environment does alignment create?

Many people are aware of the non-routine problems that must be solved to build a system.

Many people understand that the project manager believes that thinking about these non-routine problems are a part of their job.

People understand that the project has provided tools, data and other helpful infrastructure to help them refine their thinking and to experiment/tinker with solutions.

▼ How can a project manager contribute to alignment?

- Motivating team members with shared vision
- Making sure the problems are identified. All the PM has to do is create an initial version of the problems and then listen for feedback
- Creates supportive environment
- Creates a culture for people to step forward with their ideas
- Creates a reward system for good work - must provide recognition

Ch. 2: - *2.3 Design*

▼ What is a design?

Tells us how the requirements are going to be accomplished.

▼ What is a trade study?

Helps create a set of candidate alternative designs.

▼ How to measure the goodness of candidate alternative designs?

operational performance measures

technical performance measures

why: we need to make sure that increased technical performance also improves operational peformance. And we need to explain that it does to non-technical stakeholders.

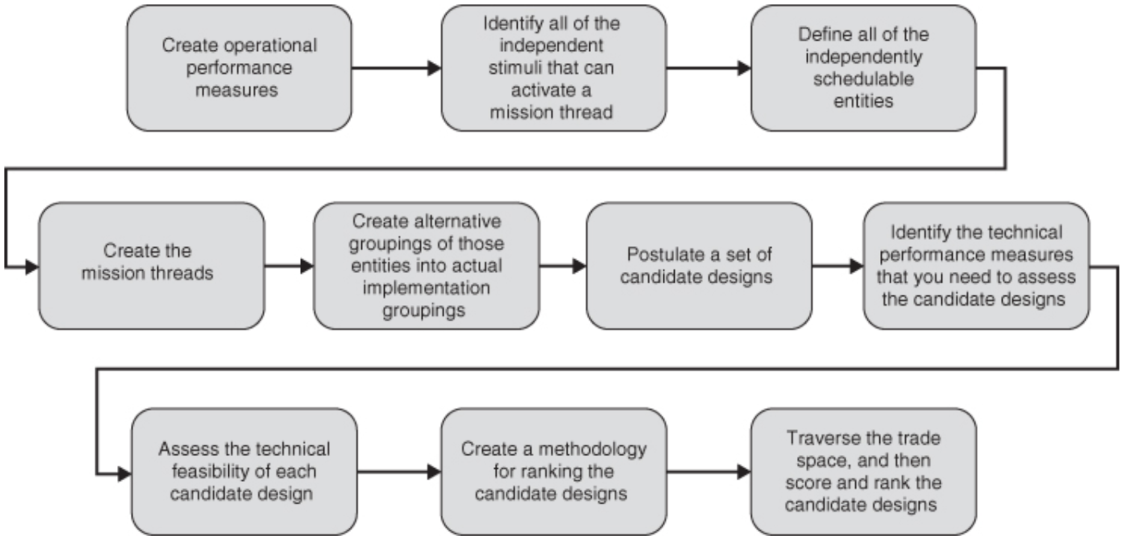
▼ What are the steps to create a design?

1. Understand the *pressure points* that the design must actually address
2. Perform the actual *trade study*: create alternatives (each of which address every requirement), create measurement methods, assess the alternatives (and adjust the alternatives, as is usually necessary), select the preferred candidate, and gather the rationale showing why that is in fact the right candidate design to select
3. For the selected design, assess in some detail various important features of that design: the *performance* and *capacity* (via modeling and benchmarking), *stability* (that is, we want the design to be relatively insensitive to small errors in inputs and assumptions), *design margin* (we want the design to be relatively insensitive to small errors in implementation, e.g., some part weighs a small amount more than planned, etc.), and *avoidance of known design pitfalls*
4. Verify the *completeness* of your selected design; that is, make sure that it actually addresses every requirement. This is accomplished through a *traceability* analysis, where we map every requirement to a section of the design that implements that requirement
5. Finalize your selection of a candidate design, perhaps with alternative designs for a few selected features. Prepare a thorough description of the design itself (which should be detailed enough to serve as a guide to those who will build each of the pieces called for by the design), as well as of the assessment findings, including the rationale for the selection. Archive all materials, so that the process can be reconstructed and rerun. It is not uncommon later on in a project to have to reopen the trade study, add a new design candidate, and rerun the assessment

▼ What is a pressure point?

Something the design must actually address. Use your knowledge of the users and the mission to understand what the actual design drivers are.

▼ What are the steps needed to perform a trade study?



▼ What are some candidate analysis methods for assessing the goodness of a design?

Quality functional deployment	Diagrammatic method to relate user goals to requirements, and requirements to design candidates
Pareto analysis	Diagrammatic method for finding the dominant influences in a situation
Functional analysis	A method of decomposition that enables the definition of various system descriptors, such as states and modes, system functions, sequential dependencies, external interfaces, assigning quantifiable performance requirements to functional groupings, analyzing timing, analyzing off-nominal behavior and types of errors, analyzing how to detect faults and how to recover from error conditions, and so forth
Optimizing across multiple parameters	A quantifiable method for creating mathematically optimum combinations from pairs of parameters
Modes and states	A method to analyze and define operational segments within the systems operational sequence and operational life-cycle (modes), and the conditions of existence of a system (states); these start us thinking about the dynamic behavior of our system
Timeline analysis	A method to define a specific time dimension to functional relationships, where sequence and/or concurrency are important; again, this helps us think about the dynamic behavior of our system
N^2 chart	A graphical depiction of a set of elements and their interfaces
IDEF-0 analysis	A graphical depiction of a function, showing its *inputs*, *outputs*, *enablers*, and *constraints*
Swim-lane methodology (activity diagram)	A graphical depiction that assigns functions and tasks to people and/or organizations, (e.g. who among the users performs each of the depicted elements of a mission thread)
Schematic block diagrams	A graphical depiction of the functional decomposition down to the level of modular units, that is, small pieces of a candidate design that (a) perform a single, independent function, (b) have a single entry point and a single exit point, (c) display low external coupling, and (d) can be separately tested
Functional / physical matrix	A graphical map between the functional architecture (requirements) and the candidate physical architectures (design), intended to aid in the identification of gaps and conflicts
Decision tree	A graphic technique for finding an optimized choice between specific alternative decisions (including design decisions) that mathematically accounts properly for conditional probabilities
Pugh method	A tabular method for assessing alternatives against a baseline, against multiple assessment criteria that may be weighted differently
Constraint theory	A formal mathematical / graphical method for identifying and resolving conflicts (in the form of *over-constraints*) in the definition or characterization of a system
Modeling	A computer program that is designed to simulate selected aspects of the behavior of the eventual system. We use such a model to make predictions about how well the candidate design will work, and therefore, hope to make better design decisions. Using such a model can both help you improve each design candidate, and also help you select the final design

▼ What are design pitfalls?

- Systems are ***dynamic***; that is, they change over time:
  - Processing happens in defined sequences
  - Steps happen within defined time frames
  - Various stimuli (both asynchronous and synchronous) cause processing to occur
  - . . . and so forth
- Such dynamics have implications:
  - Physical parts move, get hot or cold, vibrate, etc.
  - Software parts get started and stopped
  - Data gets passed from one place to another
- You *design* how these interactions are to proceed, hence they constitute your *planned dynamic behavior*
- However, your system can have dynamic behavior for which you did *not* plan; things go awry during the dynamic execution:
  - Steps get out of sequence
  - The wrong activity gets started in response to a stimuli
  - Timing requirements are not met
  - Control signals get lost, or associated with the wrong data
  - . . . and so forth
- This is very common!
  - In fact, there is an entire vocabulary for such problems (e.g. "deadlock," "race conditions," etc.)
- The major design pitfall: most designers realize that their design must implement the dynamic behavior *they want*, but they do not realize that their design must also *prevent* the dynamic behavior *they do not want* (see Figure 2.19b)
  - Designing to prevent the dynamic behavior that you do not want is hard; you must first *envision* all of the ways in which your system's dynamics could go wrong, and then *create a corrective* to each
  - Understanding all of the implications of dynamics is hard; but most designers don't even try
  - I have invented a design methodology and design pattern to accomplish this; see https://cpb-us-e1.wpmucdn.com/sites.usc.edu/dist/a/54/files/2018/01/98909-vak73m.pdf for a description

▼ Design vs Requirements Hierarchy

Requirements grouped by functionality

Design: items grouped by steps that must be executed in sequence

▼ How to prove the credibility of a model?

- *Analytic validation*. We check that the algorithms are coded correctly within the model.
- *Calibration against benchmarks*. We use the model to make predictions about things for which we already have actual measurements of a real system; we then believe that we can rely on the predictions of the model for additional situations.
- *Assessment of the accuracy and risks of extrapolation beyond the benchmark data*. Obviously, using the model to make predictions for situations where we do not have actual measurements is one of the primary purposes of employing a model. But such extrapolation necessarily entails some *uncertainty*; if you were doing an experiment where you were measuring the viscosity of water as you cooled it, and you made measurements at 60, 50, and 40 °F, you would conclude that cooling the water did not change the viscosity very much. You might therefore be tempted to extrapolate, and make a prediction about what would happen if you cooled the water to 30 °F.[11] Since such extrapolation is a major purpose of our models, we must make explicit efforts to look for the non-linearities, phase changes (such as the fact that water will freeze if cooled to 32 °F!), turbulence, queuing, and other major disruptions that would limit the range of validity of such extrapolations.

▼ What is an error budget analysis?

Specify the degree of accuracy for each step in a system

Then combine all individual errors to arrive at estimate for overall accuracy.

▼ What is benchmarking?

Making system measurements in lab or controlled env.

Why? To re-benchmark the model against the actual emerging system.

▼ What's an example of a nested model?

- A physics model of radio-frequency propagation, which feeds …
- A model of an antenna, which feeds …
- A model of the antenna mast height, which feeds …
- A model of the received signal quality, which feeds …
- A model of successful packet completion rate, which feeds …
- A model of message completion delay (average and variance), which feeds …
- A model of end-to-end completion time and accuracy for a specific capability, which feeds …
- A measure of some system operational performance measure!

▼ What is a federated model?

If the model is nested and feeds automatically from one sub model into another sub model

▼ What is a design pattern?

A portion of a larger design that has been codified by an authority under appropriate conditions. e.g. HADOOP data storage architectures

▼ Advice: design the hardest/highest risk portions of a system FIRST.

▼ What to do if error prone system?

Assign isolated segments to experts on your team.

Ensure team members prevent undesirable dynamic/emergent behavior

▼ What does the design process look like?