January 2016

Functional & Design Specifications

“For every problem, there is a solution that is simple, plausible, and wrong.”
– H.L. Mencken

Learning Objectives

By the end of this module, you will have a basic understanding of the following:

- Differences between functional and design specifications
- Problem analysis for functional specifications
- Organization of specifications
- Style in specifications
- Content for specifications
- Post-mortem preview

Your Roles in Project Docs

Document	→	**Your Role**
➢ Proposal	→	Salesperson
➢ Func. Specs.	→	Lawyer
➢ Design Specs.	→	Designer
➢ Building	→	Technician
➢ Post-Mortem	→	Royal Commissioner
➢ Web Site	→	Sales/Technician/Entrepreneur
➢ User Manual	→	Educational Psychologist

Sum these together and you get an **Engineer**

The Seen and the Unseen

- A technician knows how to deal with the seen: the known risks and problems.
- An engineer knows how to anticipate the unseen: the potential risks and problems.

- unknown known → ignorance
- known known → obvious information
- known unknown → psychology: economics, market, users
- unknown unknown → disaster

-- Donald Rumsfeld, *Secretary of Defense* (for George W. Bush) -- So take this with a very large "grain of salt"

Difference between FS and DS

Functional Specs = **WHAT**

Example → *Rigid external case*

Design Specs = **HOW**

Example →	**Sheet steel**	→	**Plexiglass**
WHY →	Readily available	→	Readily available
→	Inexpensive	→	Expensive
→	Difficult to fabricate	→	Easy to make
→	Temp. resistant	→	Melts
→	Conductive	→	Non-Conductive
→	Opaque	→	Transparent

Some FS & DS Considerations

- Normal Operating Conditions (Temperature, Altitude, Humidity, Interference)
- Power
- Heat Dissipation
- Size
- Weight
- Response Times
- Packaging (Device Protection, Aesthetics)
- Reliability
- Standards (ISO, IEEE, CSA, MilSpec, medical, etc.)
- Compatibility with Other Systems
- Known System Limitations
- Sustainability Considerations
- Safety Considerations
- Documentation (e.g., User Manual)
- Test Plan (DS only)
- Training of Users
- User Interface/Ergonomics
- ***Et cetera***

Exercise

What are the functions and the corresponding design for an all-in-one eating implement to be used by a person who only has the use of one hand?

Parkinson's Spoon

- https://www.youtube.com/watch?v=WiVQcgmIi08

Problem Analysis for FS #1

- Collect **all available information** about the project (RFP, RRFP, client or user notes, RESEARCH, etc.)

- Identify and **meet with the *real* user** of the proposed system
  - Minimal requirements of the user
  - Ideal requirements (wish list)

  Also meet with the decision makers and determine their requirements (costs and benefits). But watch out for *Analysis Paralysis*

Analysis Paralysis

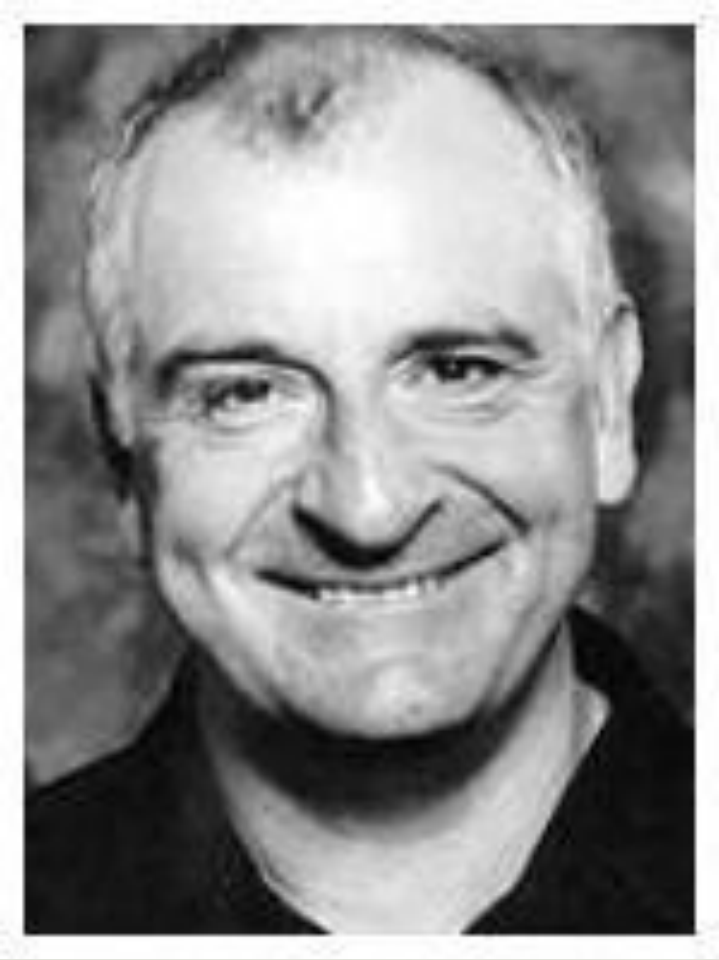
"You could spend an infinite amount of time gathering data to help optimize something that refuses to be optimized any further."

– *Darrell Mann*

"The usual approach to problem-solving is to identify and remove the cause of the problem. Sometimes this is not possible because the cause cannot be found; because there are too many causes; or because the cause is human nature and cannot be removed. In such cases we are usually paralyzed."

– *Edward De Bono*

Hmmm . . .



"A common mistake that people make when trying to design something completely foolproof is to underestimate the ingenuity of complete fools."

-- Douglas Adams, author of *A Hitchhiker's Guide to the Galaxy*

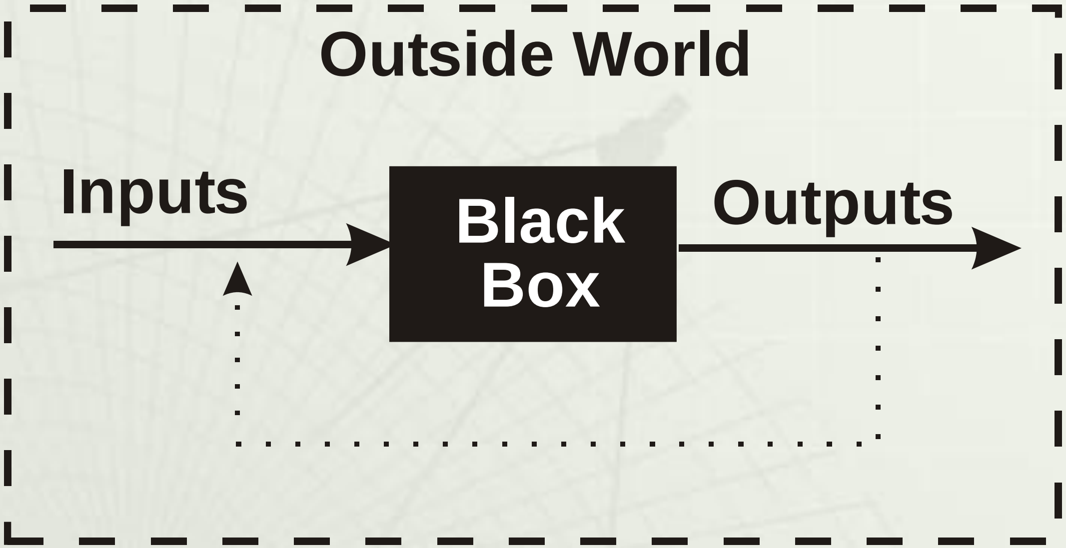
Problem Analysis for FS #2

- Analyze the **physical and theoretical phenomena involved in the performance characteristics** of the idea/product.
- Analyze the practicality of the idea to **see if it is marketable** and if you have the facilities and expertise to develop/produce the product.
- Examine **the system currently being used** to complete the task(s). This will help provide insight into the “real” (rather than the stated) problem and needed functions.

Problem Analysis for FS #3

- Analyze the collected information and define the issues which need to be resolved. During this process, create a **list of questions which need to be answered**.
- **Collect answers to those questions** through surveys, interviews, meetings, tours, observation, and research, and then analyze those answers.
- **Define the system or device conceptually** by working backwards from the output through the functions and processes in order to determine what inputs are required.

Problem Analysis for FS #4



- **Review the definition of the problem and the functions** with the users of the system.

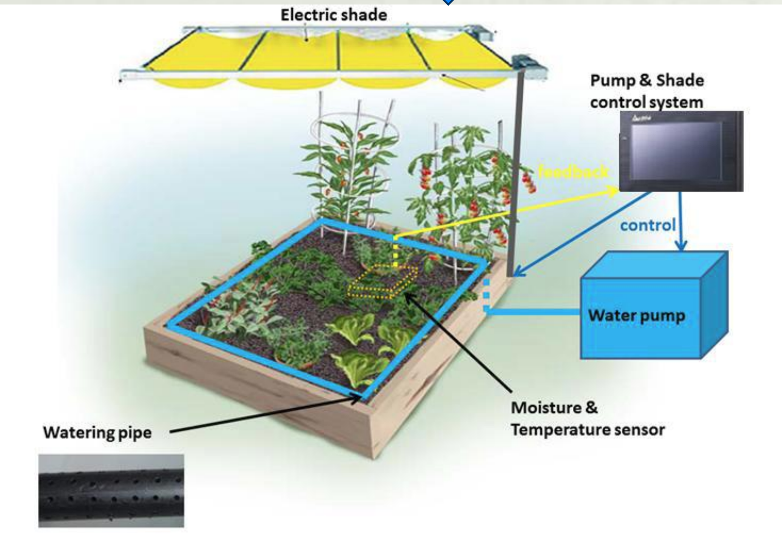
- **Negotiate any changes required and obtain approval**.

Structure of Specifications

- Letter of Transmittal
- Title Page
- Abstract (FS and DS)
- Table of Contents
- List of Figures
- Glossary
- Body of Document
- Conclusion
- References
- Technical Appendices

Organization of Specifications

- System Overview (What and Why)
- Cloud-Shaped Drawing (FS) or Block Diagram (DS)



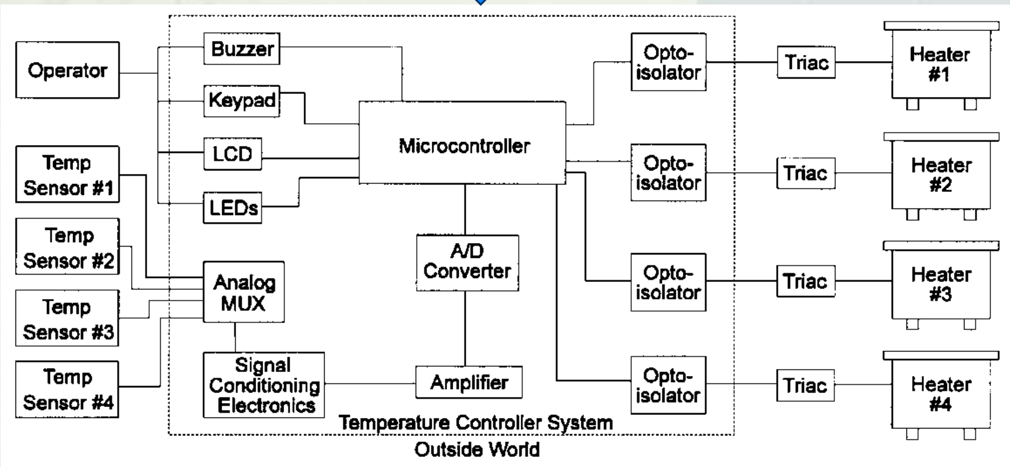


Figure 1: Temperature Controller Block Diagram

Organization of Specifications

- In FS, describe functions that apply to entire system (usually one paragraph per function); in DS, present design choices, and explain **why** you made the choices you did
- Subsections detail subcomponents of system:
  - In FS, describe functions that apply to subcomponents
  - In DS, explain choices that apply to subcomponents
- Headings numbered and (ideally) match each other:
  - In FS, *2.2.1 Temperature Sensor* outlines the needed requirements
  - In DS, *2.2.1 Temperature Sensor* details a sensor meeting those requirements
- Provide any physics, equations, and theoretical detail that are necessary to support your choices
- Provide description of device limitations (and rationale)

Style of Specifications

- Typically written in passive voice (although sometimes written using 1st person – “*We*” or “*Acme Inc.*”).
- Critical functions listed using “*must*” (“*The device **must** have an MTTF of 6 years*”). **Please don’t do this for 305W/440W.**
- Use lists, tables, and figures rather than text where possible (see your stereo spec sheet for an example). We do not want text-heavy specs. **Be concise here.**
- In FS, avoid jargon and technical terms as much as possible (Steve should be able to understand it). The FS often forms the basis for a legal contract.
- In DS, include a glossary for the specialized terms.

FS & DS Content

- Normal Operating Conditions (Temperature, Altitude, Humidity, Interference)
- Power
- Heat Dissipation
- Size
- Weight
- Response Times
- Packaging (Device Protection, Aesthetics)
- Reliability
- Standards (ISO, IEEE, CSA, MilSpec, medical, etc.)
- Compatibility with Other Systems
- Known System Limitations
- Sustainability Considerations
- Safety Considerations
- Documentation (e.g., User Manual)
- Test Plan (DS only)
- Training of Users
- User Interface/Ergonomics
- ***Et cetera***

❖ Distinguish between proof-of-concept, prototype, and production versions.

❖ **Failure to address sustainability and/or safety issues will result in a 20% reduction in grade for the Functional and/or Design Specification.**

Sustainability & Safety Issues

- A section (about 1 page each) in both the Functional and Design Specifications **must** deal with sustainability and safety issues related to your device:
  - Covers “cradle to cradle” cycle for your **proof-of-concept/prototype** device (i.e., how do you intend to recycle, reuse, or repurpose the materials in your project).
  - Outlines major sustainability and safety considerations for **production** device.

Sample Acceptance Test Plan

- We want you to provide a high-level acceptance test plan NOT a detailed characterization of the circuit or components
- Design one to fit the specifics of your project.
- Must include a copy as an appendix in your DS.
- Submit a separate copy to me along with the DS.

Team XXXXX

Test Sheet

Date:

Mechanical Parts			
1- Wheel :			Comments:
Max RPM: 10	☐ Yes(pass)	☐ No(fail)	
2- Brake:			Comments:
Max force: 20 N	☐ Yes	☐ No	
Deceleration: 1.2 m/S^2	☐ Yes	☐ No	
Stopping distance: 2 m	☐ Yes	☐ No	
3- Movement of link			Comments:
From 0 to 90 degree	☐ Yes	☐ No	
...			
....			

Electrical Parts			
1- Circuit Output :			Comments:
Volt: 120 V	☐ Yes	☐ No	
Frequency: 60 Hz	☐ Yes	☐ No	
2- Laser Output:			Comments:
Power: 300 mW	☐ Yes	☐ No	
Range: X m	☐ Yes	☐ No	
Detection of movement by sensor	☐ Yes	☐ No	Comments:

Post- Mortem Preview

- Title Page
- Introduction (general background, need for system, etc.)
- Description of how system works and problems you encountered
- Comparison of estimated and actual budgets and timelines
- Description of group dynamics and problems encountered
- Work breakdown (who did what)
- What you would do differently if you were to undertake a similar project again
- One-page, individually written, descriptions of contribution to project and what was learned
- Conclusion (future plans for the system, recommendations)

Student Perspectives

“There were several times (usually during conflicts) where we would pull out either our functional or design specifications and verify how we would implement a certain feature and when we could consider the feature completed.” – Shane Schneider, 1999

“Never underestimate the worth of a finalized design before construction.” – Jeff Robinson, 2000

“My advice is to have each group member read, under-stand and search for inconsistencies in the design spec.” – David Boen, 2001

A Couple More Aphorisms

“If it’s stupid but works, it ain’t stupid.”
– Major Ambler Furry, USAF

“Not everything worth doing is worth doing well.”
–Tracy Kidder

Conclusion

- Your functional specification is due on Monday, February 15 by 11:59 PM.
- Your design specification is due on Monday, March 07 by 11:59 PM.
- Please send them as .pdf attachments.
- **Hasbro has made the nearly perfect 305W/440W project: sizable market, useful social purpose, uses sensors, an embedded system, actuators, a simple user interface, and attractive packaging – the WOW factor. BBC Video: Robo Cat**