Overview

- Interfaces
- Manufacturing
- Power

**Systems Engineering**

- Holistic
  - Finance
  - Customer needs
  - Lifecycle
- Interdisciplinary
- Project management
  - Manage complexity
  - Evolution
- Safety
  - Reliability
  - Redundancy


Important issues

- Requirements
- Manufacturability
- Maintainability
- Packaging
- Power
- Interfaces
- Testing

**Specifications (what the system must do)**

- Bandwidth, latency
- Accuracy (difference between measured and truth)
- Resolution (smallest change that can be detected)
- Repeatability (standard deviation of multiple observations)
  - same operator, conditions, day, machine
- Reproducibility (standard deviation of multiple observations)
  - different operator, conditions, day, machine

**Constraints (what the system must not do)**

- Power, size, weight
  - Must not stop running for within 24 hours on +9V
  - Must not be bigger than 5 by 3 by 1 inch
  - Must not weight more than 1 lbs
- Software development costs,
  - Must not cost more than $100,000
- Memory available,
  - Must not need more than 2 KiB RAM or 32 KiB ROM
- Time-table,
  - Must not take more than 1 month to produce
**Requirements Document.**

states what the system will do.  
serve as an agreement between you and your clients  
legally binding contract  
easy to read and understand by others  
unambiguous, complete, verifiable, and modifiable  
It does not state how the system will do it.

Sample Outline

1. **Overview**
   1.1. **Objectives:** Why are we doing this project? What is the purpose?  
   1.2. **Process:** How will the project be developed?  
   1.3. **Roles and Responsibilities:** Who will do what? Who are the clients?  
   1.4. **Interactions with Existing Systems:** How will it fit in?  
   1.5. **Terminology:** Define terms used in the document.  
   1.6. **Security:** How will intellectual property be managed?

2. **Function Description**
   2.1. **Functionality:** What will the system do precisely?  
   2.2. **Scope:** List the phases and what will be delivered in each phase.  
   2.3. **Prototypes:** How will intermediate progress be demonstrated?  
   2.4. **Performance:** Define the measures and describe how they will be determined.  
   2.5. **Usability:** Describe the interfaces. Be quantitative if possible.  
   2.6. **Safety:** Explain any safety requirements and how they will be measured.

3. **Deliverables**
   3.1. **Reports:** How will the system be described?  
   3.2. **Audits:** How will the clients evaluate progress?  
   3.3. **Outcomes:** What are the deliverables? How do we know when the system is done?

**Interfaces**

- Connector
- Voltage/Current/Capacitance
- Format
- Synchronization

**DB25/RS232**

**DB9/EIA-574**

**RJ45/EIA-561**
Robust systems
Add timeouts to wait loops
Add periodic check of proper operation
COP
Periodic interrupt watch dog

Handshake methods
Synchronous, tied to clock
Partially asynchronous
Consumer can slow down/stop
Interlocked

From Target to Initiator

From Initiator to Target

Jonathan W. Valvano
Standard values for 5% resistors range from 10 Ω to 22 MΩ. We can multiply a number in Table A3.2 by powers of 10 to select a standard value 5% resistor.

<table>
<thead>
<tr>
<th>Value</th>
<th>Table A3.2. Standard resistor values for 5% tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>11 12 13 15 16 18 20 22 24 27 30</td>
</tr>
<tr>
<td>33</td>
<td>36 39 43 47 51 56 62 68 75 82 91</td>
</tr>
</tbody>
</table>

Energy storage for typical AA-sized batteries (50 mm tall by 14 mm diameter).

<table>
<thead>
<tr>
<th>Battery</th>
<th>Voltage (V)</th>
<th>Energy (mAh)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline</td>
<td>1.5</td>
<td>2000</td>
<td>Primary</td>
</tr>
<tr>
<td>Lithium</td>
<td>1.5</td>
<td>3000</td>
<td>Primary</td>
</tr>
<tr>
<td>NiCad</td>
<td>1.2</td>
<td>1200</td>
<td>Secondary</td>
</tr>
<tr>
<td>NiMH</td>
<td>1.2</td>
<td>1800</td>
<td>Secondary</td>
</tr>
<tr>
<td>Li-ion</td>
<td>3.6</td>
<td>1900</td>
<td>Secondary</td>
</tr>
</tbody>
</table>

Additional feedback
1) How was the mix between simulation and real microcontroller? Want more real 9S12 labs?
2) How was the TRobot competition?
3) How was the in-lab programming quiz? Was it fair?
4) Did the on-line HW help you understand the material?