Applying Industrial Engineering to FIRST – Optimizing Your Team and Season

Ben Martin

Agenda

1) Operations Management
2) Standardization
3) Design for Manufacturing
4) Design of Experiments
5) Six Sigma

This will be a very high level introduction to each of these items.

About Me

- Purdue Industrial Engineering
- Carnegie Mellon MBA
- 15-year FRC participant
- Retired Senior Mentor

TEPPER CARNEGIE MELLON

PURDUE INDUSTRIAL ENGINEERING

IBM

IAM ROBOTICS

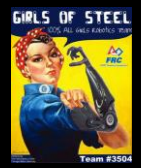
CUBEROVER

amazon

TECHFIRE 225

FIRST ROBOTICS COMPETITION

York, PA

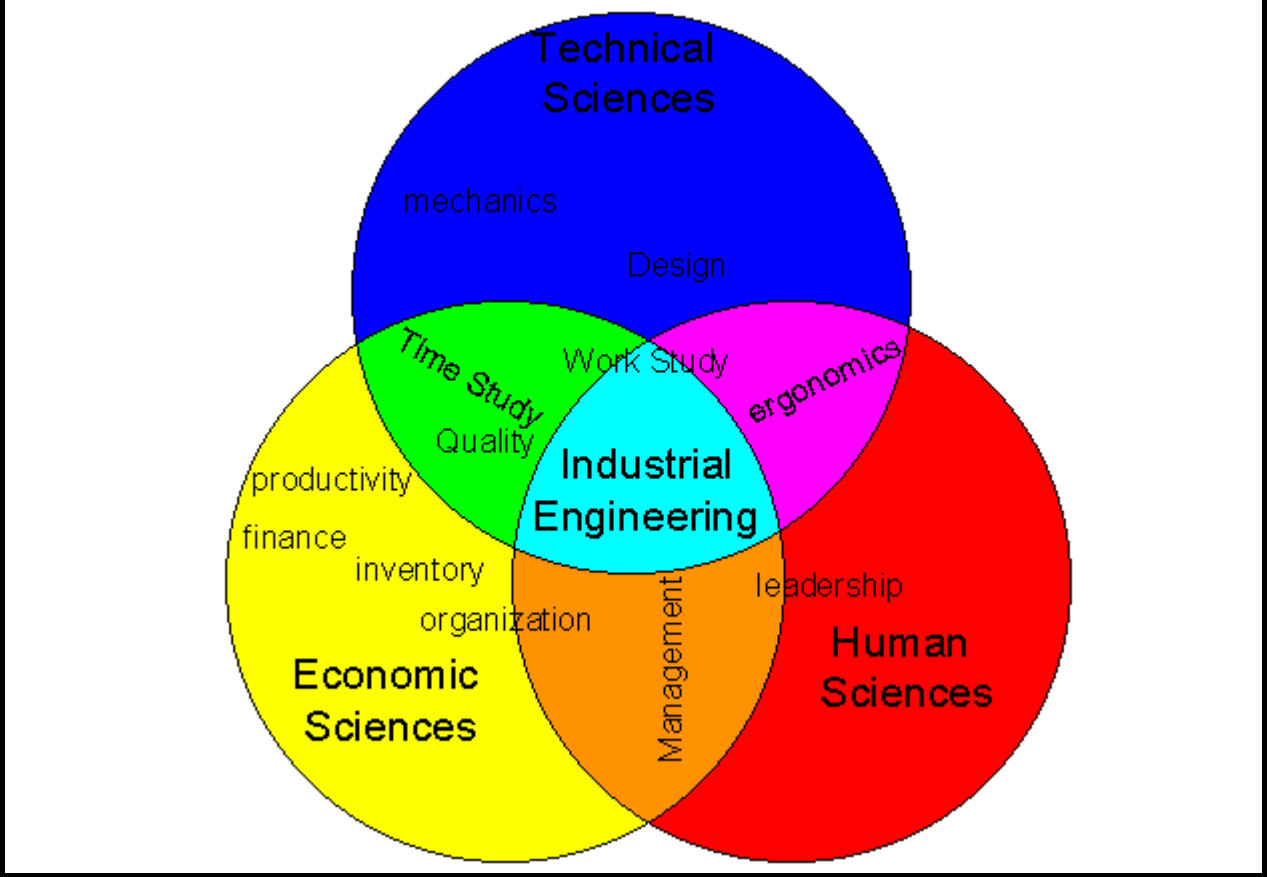


FIRST CAPITAL ROBOT IN 3 DAYS

CAT

St. Onge Supply Chain Engineering Company

What Is Industrial Engineering?



Operations Management

What is your goal?

Most teams want to:

1) Win competitions/awards

And

2) Win in the right way

The definition of the right way varies from team to team.

For TechFire 225, to satisfy #2, every student needs to be engaged & enriched through the process.

Who owns what?

Is there trust?

Most Important Resources for Teams

1) Program-Specific Knowledge
2) Time
3) Money/Inventory

Hierarchy of Robot Needs (FRC/FTC) --

Are you focusing on what is important?

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Maslow's Hierarchy of Needs

HIGHER LEVEL NEEDS
    Self-Actualization
    Esteem
    Love/belonging
    Safety
    Physiological
FUNDAMENTAL NEEDS
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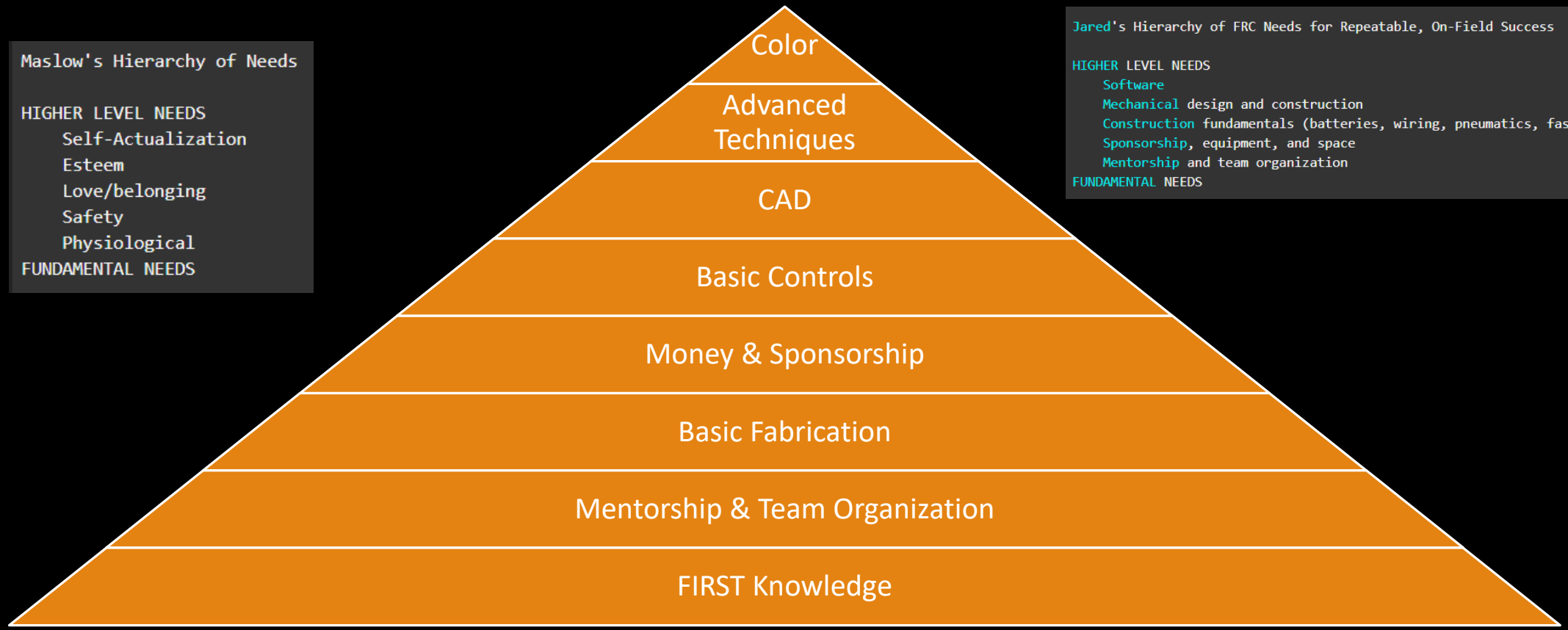


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Jared's Hierarchy of FRC Needs for Repeatable, On-Field Success

HIGHER LEVEL NEEDS
    Software
    Mechanical design and construction
    Construction fundamentals (batteries, wiring, pneumatics, fasteners, etc.)
    Sponsorship, equipment, and space
    Mentorship and team organization
FUNDAMENTAL NEEDS
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Standardization

Types of FRC Standardization

Part Selection

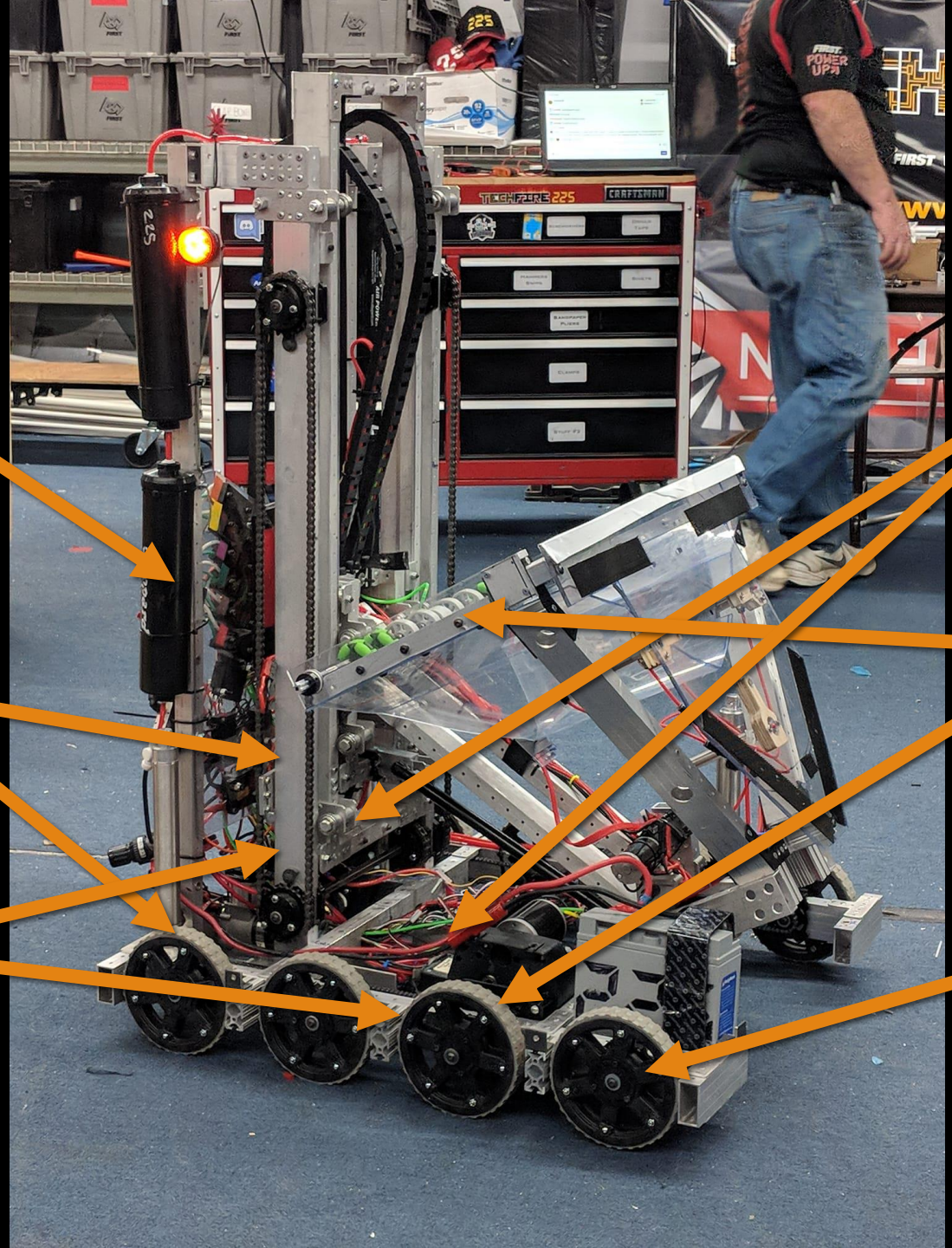
Standard Operating Procedures (SOPs)

Be smart with this – over-standardizing can inhibit your competitive performance

KOP electrical system and wire

COTS Frame and gussets

Pre-stretched, high-strength #25 and #35 chain



COTS Gearboxes

COTS wheels

Consistent drive sprocket size

Aluminum square tube

COTS Sprockets

KOP Pneumatic Tanks

COTS drag chain

COTS wheels

254

LOCKDOWN

Sample 225 Standard Operating Procedure: Making Accurate Chop Saw Cuts

1. Student gets drawing of part to see what measurement should be
2. Student gets material and marks the location to cut the material with a scribe
3. Student has a second student check the mark to make sure it is correct
4. Student gives part to Mentor to make cut on chop saw
5. Mentor makes cut
6. Student checks that the cut is correct

Mark – Check – Cut – Check. *Does not need to be complicated.*

Design for Manufacturing

Always ask the questions…

How long is this going to take to make?

How do we get it done correctly the first time?

Can we get it made faster/easier?

What is the bottleneck in your process right now?

Snip from JVN's Week 4 blog (148 lead engineer):

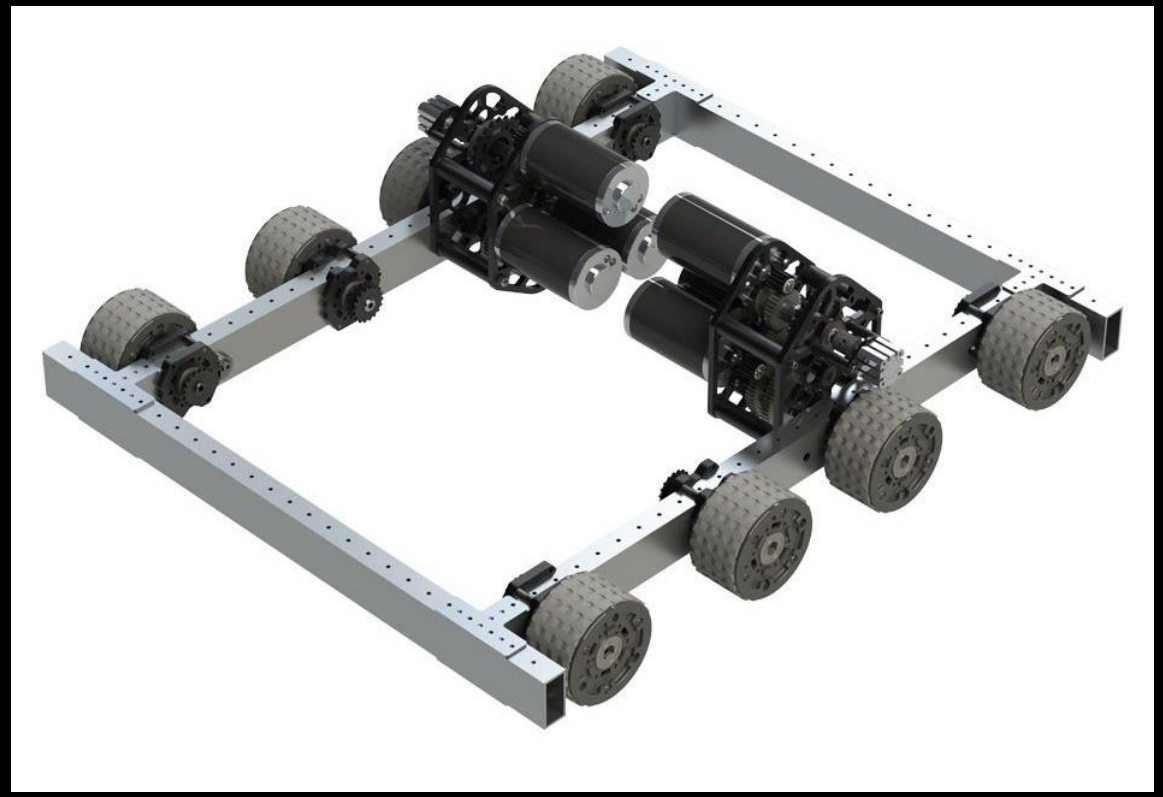
Manufacturing… Delays?

We're bumping into a problem we haven't faced in a long time. Our entire process is built around the fact that we get parts made FAST. Manufacturing so fast the parts are ready before the designers even sleep off their CAD binge. This year, we're continuing the new design methods we experimented with on the 2018 robot and refined in the X019 prototype. Lots of 3D printed parts. Lots of thin sheet-metal structures reinforced in key places with 3D printing.

LOTS of 3D printing… on *EVERY* subsystem. Oops.

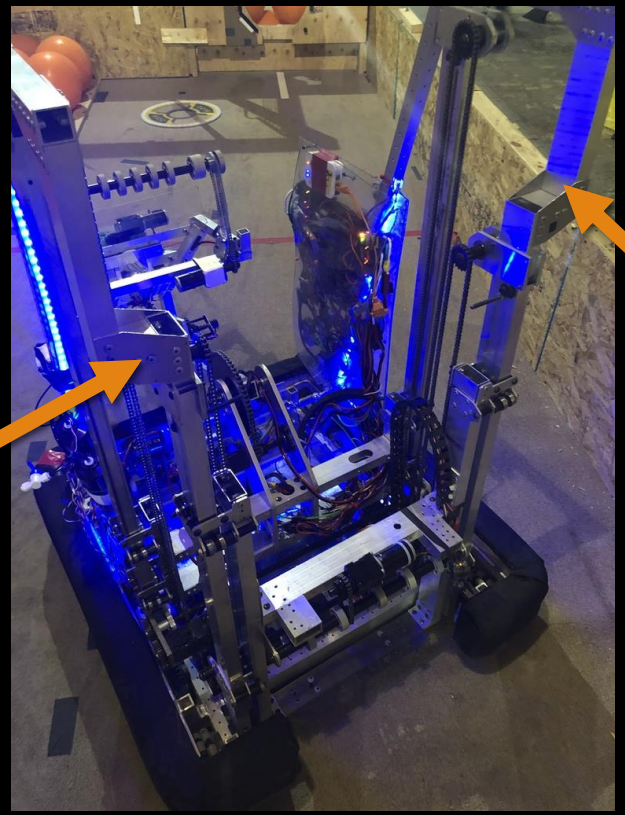
Making Things Faster by Reducing Cuts

- Versaframe system saves time for teams every year
  - Pros
    - You can make the whole thing with a chop saw, rivet gun and step bit or hole saw
    - Super flexible– many configurations
    - Multiple West Coast Drive gearboxes configs
  - Cons
    - Money/COTS costs
    - Some space restrictions
    - Sometimes weight



Part Making If You Have No CNC

1) Print your CAD drawing at 1:1 scale
2) Cut it out with a pair of scissors
3) Tape it with packing tape to your material to cut/drill
4) Make it!



Completed with templating (No CNC, all manual)

Invest in fixturing tools (multiple sizes of clamps) to maintain alignment of parts in your robot

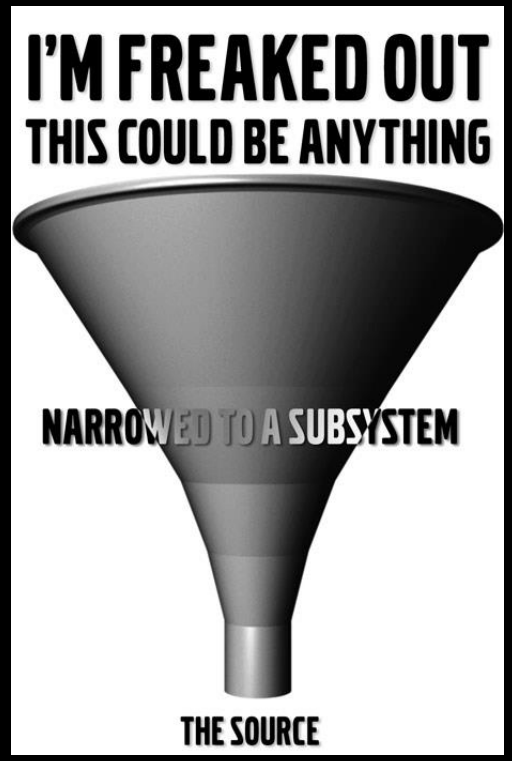
Design of Experiments

Troubleshooting

Something is wrong—how do I fix it?

- Run a test to get more information
  - As you have more information, run further tests to identify the problem
- Determine the problem
- Fix the problem

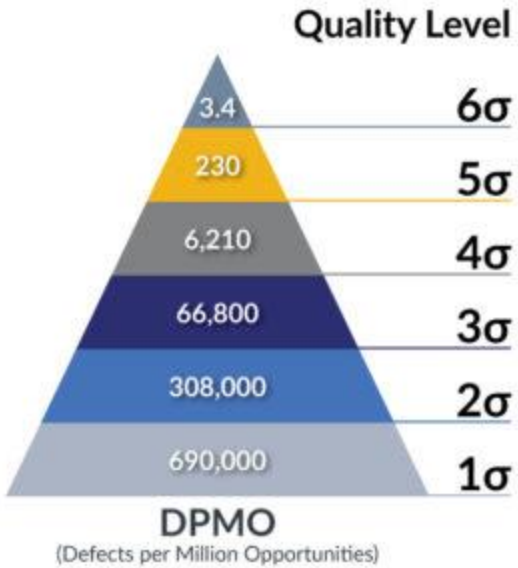
This is a skill—do it more to get good at it.



2AM Ri3D Elevator Debugging Party

Six Sigma


CONTROL
DEFINE
MEASURE
ANALYZE
IMPROVE
Six
Sigma


Quality Level
3.4
6σ
230
5σ
6,210
4σ
66,800
3σ
308,000
2σ
690,000
1σ
DPMO
(Defects per Million Opportunities)

Technique for Process Improvement

Define	Step 0	Select a Project
Measure	Step 1 Step 2	Establish Performance Parameters Validate Measurement System for 'Y'
Analyze	Step 3 Step 4 Step 5	Establish Process Baseline Define Performance Goals Identify Variation Sources
Improve	Step 6 Step 7 Step 8	Explore Potential Causes Establish Variable Relationship Design Operating Limits
Control	Step 9 Step 10 Step 11	Validate Measurement System for 'X' Verify Process Improvement Implement Process Controls

Six Sigma Implementation – 5S Your Parts!

Questions?

BEN MARTIN - BEN@TECHFIRE225.ORG