- **TO DO:**
  - Goals for Sprint 3
  - Sprint 3 Calendars
  - BOM and Target Costing
  - Cost Analysis must be turned in before you leave
  - Consolidate customer feedback and iterate as needed
  - Begin building if materials are available

- **LOOKING AHEAD:**
  - Week 9 BEEST due – 10/26 @ 11:59pm (LAST ONE!)

  - Three weeks of build time and product testing planning

Documentation from this Sprint goes in "6. Construction of a Testable Prototype"

WEEK 10 DAY 1

Welcome to Sprint 3

WEEKS 1-3

Project Pitch

WEEK 4-6

SPRINT 1 REVIEW

WEEKS 7&8

SPRINT 2 REVIEW

WEEKS 10-13

SPRINT 3 REVIEW

WEEK 15-16

IDENTIFICATION & JUSTIFICATION OF THE OPPORTUNITY

- Accessibility Simulation & Design Theme
- Ethnography & Site Observation Activity
- Opportunity Proposals
- Team formation, mission statements, team logo & team charters
- Identify primary Subject Matter Expert (SME)
- Background/Rationale Research

- **PROJECT PITCH PREP**
- **BINDER CHECKS**
- **PART 1 of IPP**

SPRINT 1

- Outcome-driven Innovation & customer needs statements
- Compile “Must do, might do, must NOT do” requirements
- Patent Searches, Market Research
- Concept Generation activities
- Concept Screening & Selection, Decision matrices
- Prototyping in Design
- Mock-up (small scale, Level 1) prototypes of top 2 concepts to gather customer feedback

- **SPRINT REVIEW PREP**
- **BINDER CHECKS**

SPRINT 2

- Final concept selection based on feedback
- Iterate Design Requirements based on feedback
- Quantify at least one design requirement into a target specification related to customer productivity
- Revise design and build next level prototype (full scale)
- Create bill of materials with cost, place material orders
- Gather customer feedback including price

- **SPRINT REVIEW PREP**
- **BINDER CHECKS**
- **PART 2 of IPP**

SPRINT 3

- Iterate Design Requirements based on feedback
- Revise and/or add additional quantifiable target specifications
- Revise bill of materials with cost
- Final product architecture drawing (with component info)
- BOM & Target Costing
- Build Final Prototype
- Robust Design & Product Testing
- Test final prototype and gather customer feedback

- **SPRINT REVIEW PREP**
- **BINDER CHECKS**
- **PART 3 of IPP**

FINAL SPRINT

- Final product refinements based on feedback and test data
- Deliver the working prototype to the customer

- **FINAL BINDER CHECKS**
- **FINAL INDIVIDUAL PROJECT PAPER (IPP)**
- **FINAL PROTOTYPE**
- **FINAL EXPO POSTER**
- **FINAL EXPO VIDEO**

Photo Documentation of the Design Process

PROJECT TIMELINE

EGE 2123 Entrepreneurial Engineering Design Studio

GOALS FOR SPRINT 3 WEEKS 10-14

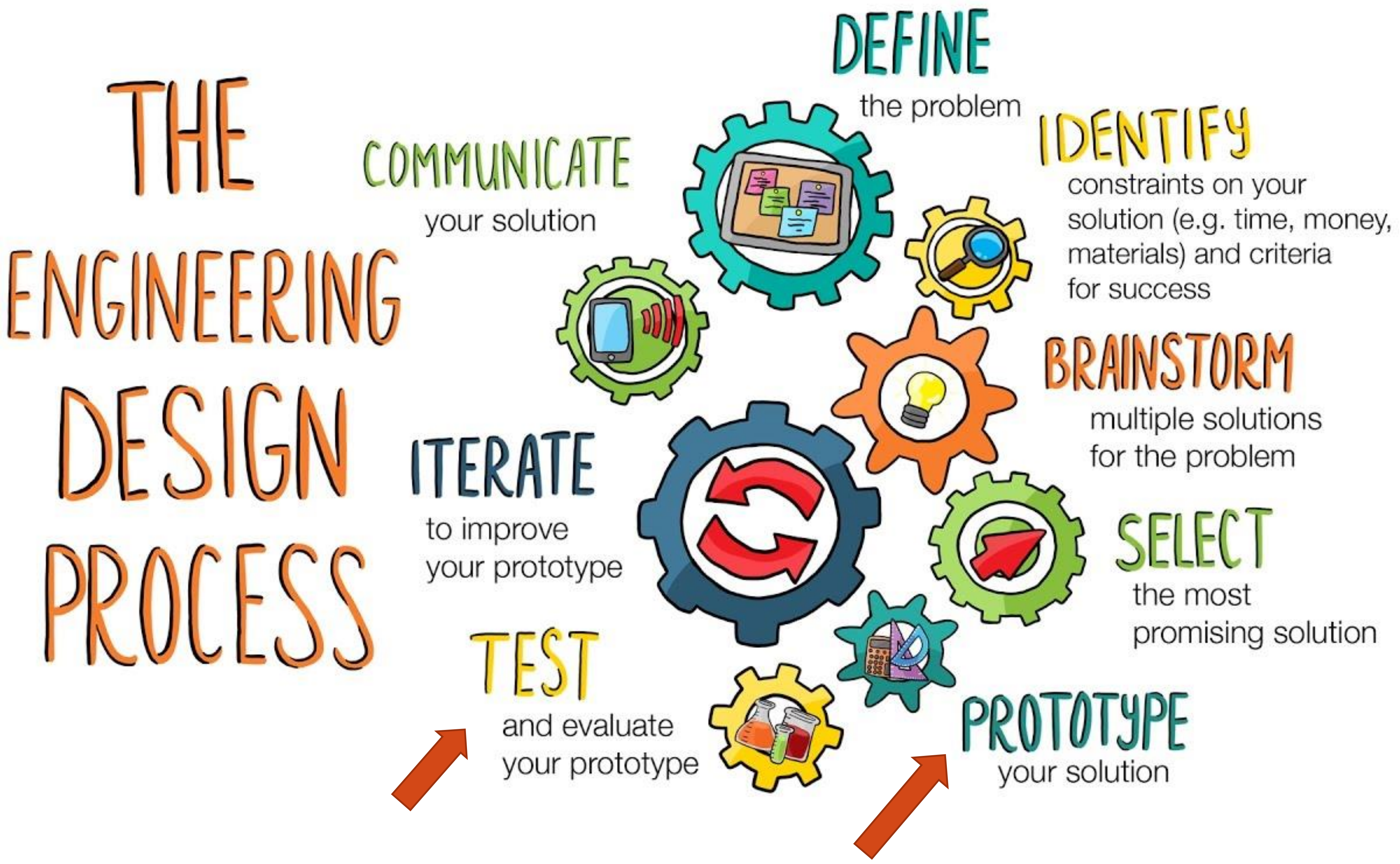
By the end of Sprint 3, your team will:

- **Iterate as needed based on customer feedback**
- **Perform BOM & Target Cost Analysis**
- **Build a final, working prototype**
- **Create and execute a product test plan**

SPRINT 3

- Iterate Design Requirements based on feedback
- Revise and/or add additional quantifiable target specifications
- Revise bill of materials with cost
- Final product architecture drawing (with component info)
- BOM & Target Costing
- Build Final Prototype
- Robust Design & Product Testing
- Test final prototype and gather customer feedback

- **SPRINT REVIEW PREP**
- **BINDER CHECKS**
- **PART 3 of IPP**


THE ENGINEERING DESIGN PROCESS
DEFINE
the problem
IDENTIFY
constraints on your solution (e.g. time, money, materials) and criteria for success
BRAINSTORM
multiple solutions for the problem
SELECT
the most promising solution
PROTOTYPE
your solution
TEST
and evaluate your prototype
ITERATE
to improve your prototype
COMMUNICATE
your solution

YOU ARE HERE

LET'S TALK ABOUT $$$

- Engineers must be able to estimate the cost of projects and the monetary value of projects to customers
- An invention must be something customers are willing to pay for such that the company makes a profit.
- PROFIT = REVENUE – COST
- How do we know what the product costs us?
- How do we set the price for our product?

ESTIMATING YOUR COST WITH BOM

- Start with a bill of materials and estimates of assembly and overhead costs

- This is #1 on your Product

Development Economics document.

- Is there another way to estimate cost?

TARGET COSTING

- **<u>Traditional approach</u>**

  design → calculate cost → set price

- **<u>Target Costing</u> - the customer sets the price**
  - **What do you want?**
  - **What are you willing to pay?**

- **Use what customers are willing to pay and desired margin to determine what your product <u>can cost you</u>**

- **This is #2 on your Product Development Economics document**

TARGET COSTING

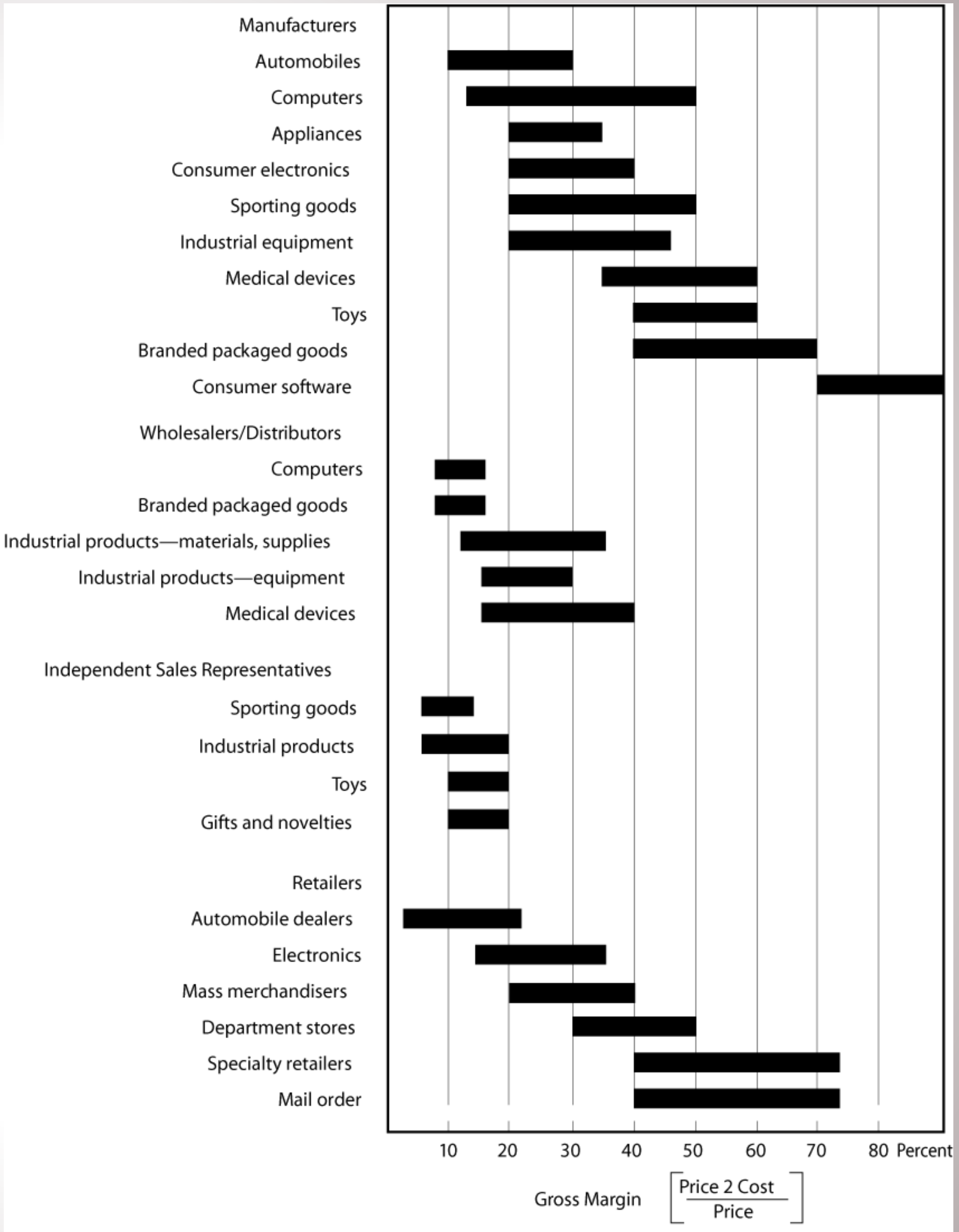
The reverse of the "cost-plus" approach to pricing

$$C = P \prod_{i=1}^{n} (1 - M_i)$$

From *Product Design and Development*
by Karl Ulrich and Steven Eppinger
(McGraw-Hill/Irwin)

C = your target cost to produce the product
P = price paid by the end user
n = number of stages in the distribution channel
M= desired gross margin

What is a reasonable margin for my product?



From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

PROFIT = REVENUE - COST

THREE FACTORS MAKE THE EQUATION COMPLICATED:

- **Time – when costs or revenues are delayed or accelerated (borrowing, inventory, bulk purchasing, investments)**
- **Evaluations – when costs and revenues come from many different sources, how do you treat them? (direct costs, indirect costs, fixed cost, variable cost, etc.)**
- **Market Influences – supply and demand hard to predict sometimes**

PROFIT = REVENUE - COST

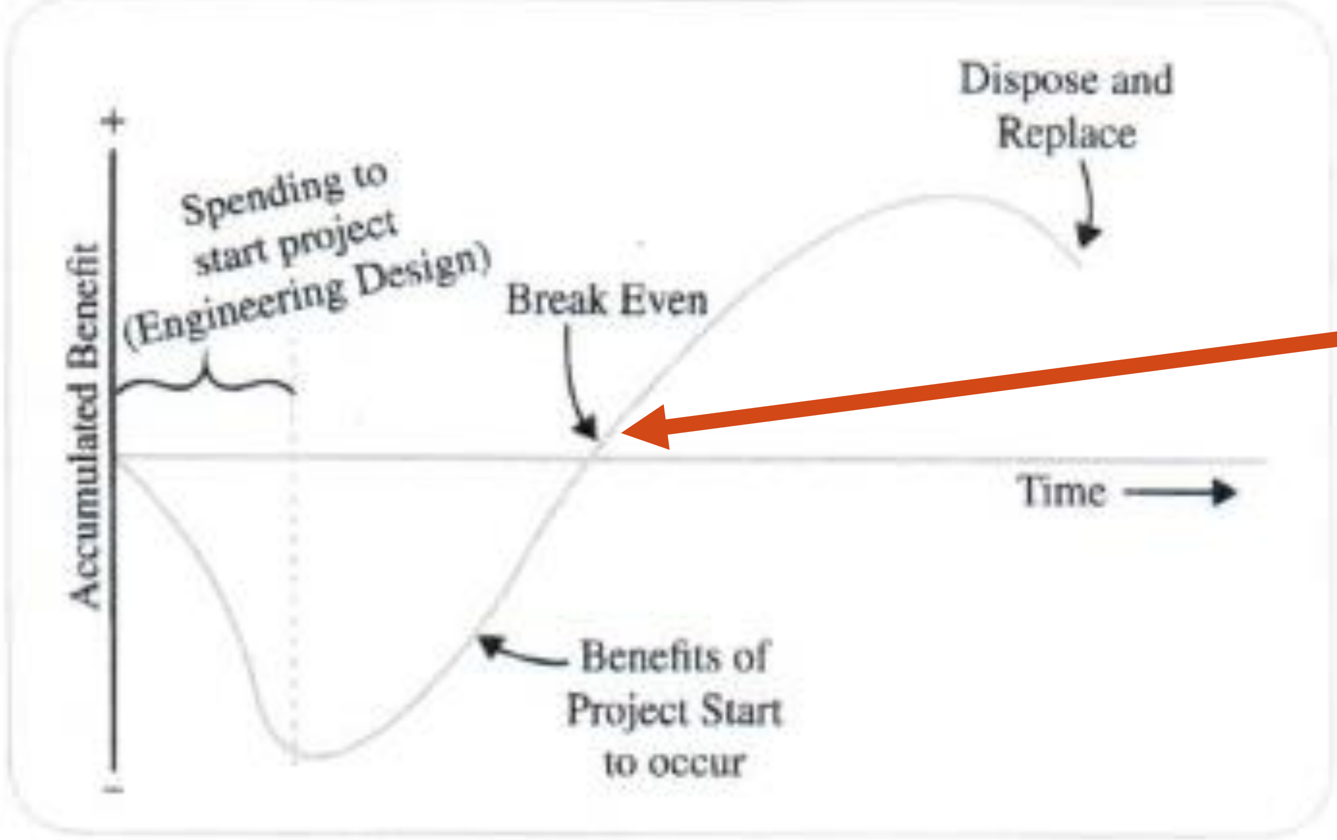
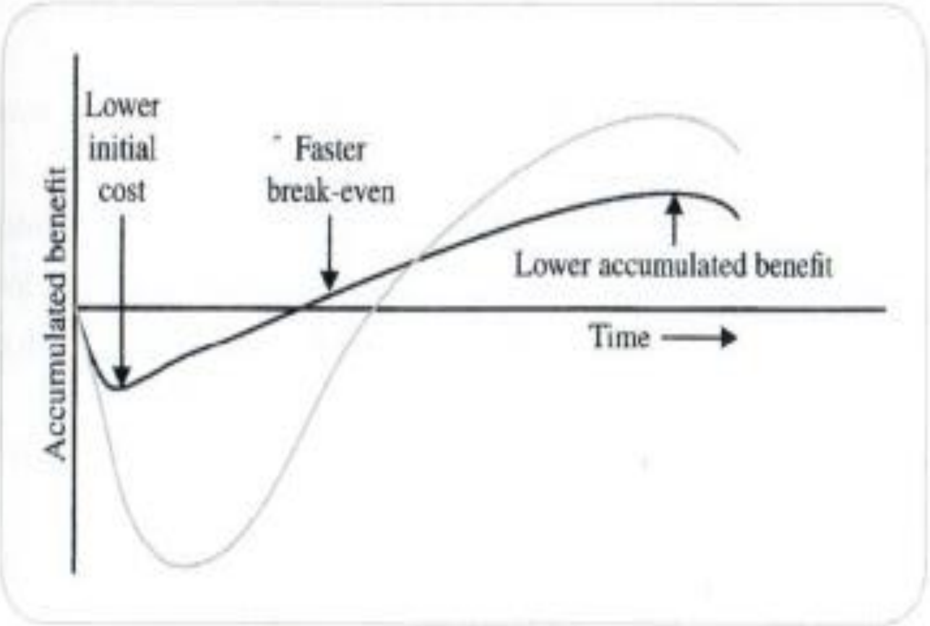


FIGURE 3 The accumulated benefit curve.

What does the equation look like at this point?

From *Designing Engineers: An Introductory Text* by McCahan et al.

USEFUL FOR MAKING PROJECT DECISIONS…



URE 3 Comparison of two possible projects with different accumulated profit es.

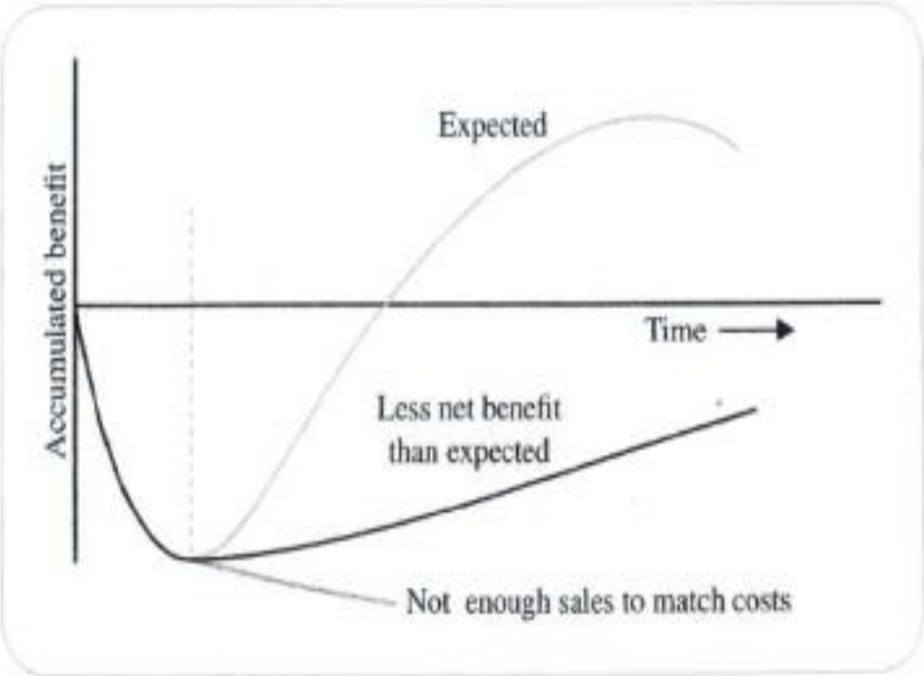


FIGURE 4 Accumulated benefit curves for three different scenarios.

From *Designing Engineers: An Introductory Text* by McCahan et al.

PROFIT = REVENUE - COST

TYPES OF COST

- Fixed Costs – costs that occur regardless of whether you sell anything or not.
  - Initial or Capital Costs
  - Rent, utilities, insurance, maintenance

- Variable Costs – recurring costs that occur because you are making and selling product.

  Directly proportional to the number of units sold
  - Material costs
  - Labor

- TOTAL COST = FIXED COST + VARIABLE COST (# sold)

BREAK EVEN ANALYSIS

- **What does "breaking even" mean?**
  - **Costs = Revenue**
  - **Once Revenue > Cost, you become profitable ☺**

- **Helps you estimate when you will become profitable**

Costs = Revenue

Fixed Costs + Variable Cost * (# units sold) = (Price) * (# units sold)

BREAK EVEN in # UNITS = Fixed Costs / (Price – Variable Cost)

WEEK 10 DAY 2

- **TO DO:**
  - Build Time (take pictures)

- **LOOKING AHEAD:**
  - Week 9 BEEST due – 10/26 @ 11:59pm (LAST ONE!)
  - Build time through 11/13 (M/W) OR 11/14 (T/Th)
  - Week 11 – all build time
  - Robust Design and Product Testing covered during week 12 but teams can still be building

Documentation from this Sprint goes in “6. Construction of a Testable Prototype”

WEEK 11 DAY 1

- **TO DO:**
  - **Build Time (take pictures)**

- **LOOKING AHEAD:**
  - **Build time through 11/13 (M/W) OR 11/14 (T/Th)**
  - **Week 11 – all build time**
  - **Robust Design and Product Testing covered during week 12 but teams can still be building**

Documentation from this work goes in "6. Construction of a Testable Prototype"

WEEK 11 DAY 2

- **TO DO:**
  - EML Direct Assessment Survey (10 points!)
  - Build Time (take pictures)

- **LOOKING AHEAD:**
  - EML Surveys due 11/5 by 11:59 pm
    https://goo.gl/forms/AgjVT7L6FjEkeUOq2
  - Build time through 11/13 (M/W) OR 11/14 (T/Th)
  - Week 11 – all build time
  - Robust Design and Product Testing covered during week 12 but teams can still be building

Documentation from this work goes in “6. Construction of a Testable Prototype”

WEEK 12 DAY 1

- **<u>TO DO:</u>**
  - **Build Time (take pictures)**

- **<u>LOOKING AHEAD:</u>**
  - **Build time through 11/13 (M/W) OR 11/14 (T/Th)**
  - **Robust Design and Product Testing covered during week 12 but teams can still be building**

Documentation from this work goes in "6. Construction of a Testable Prototype"

- **TO DO:**
  - Robust Design & Product Testing
  - Build Time (take pictures)

- **LOOKING AHEAD:**
  - Final Test Plan – by end of next class
  - Build time through 11/13 (M/W) OR 11/14 (T/Th)

Documentation from this test plan work goes in "7. Prototype Testing and Analysis"

WEEK 12
DAY 2

TIME TO TEST YOUR DESIGN

<u>GOAL</u>: Design a test plan to measure the success of your device.

HOW DO WE DECIDE IF OUR DESIGN IS SUCCESSFUL??

TARGET SPECIFICATIONS

So our Design Validation Plan (DVP) starts with our Target Specifications…

Design Requirement	Metric	Accepted Value(s)	Actual Value	Pass/Fail

Is this enough? Can we be sure that our design will work as *we* intend it to?

THE GOAL OF ROBUST DESIGN METHODOLOGY

<u>GOAL</u>: Design a product that operates within the performance (target) specifications **under the effects of noise.**

ROBUST DESIGN METHODOLOGY

A robust product is one that performs as intended, even _under nonideal conditions_.

Robust design entails identifying:

- ✓ Interfaces

  How do the major elements of your design interact with each other? With the external world?

- ✓ Noises

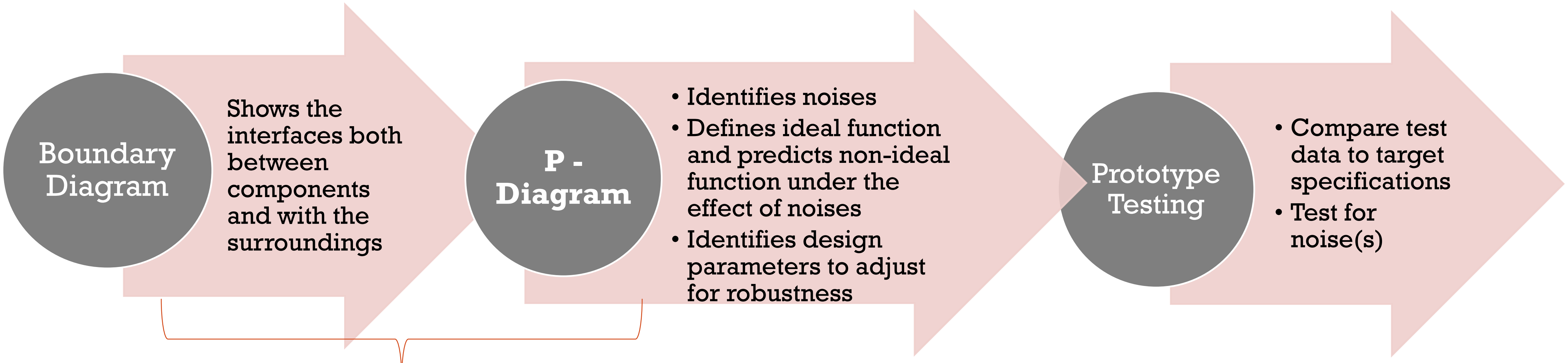
  Uncontrollable factors such as environmental changes, wear over time, variations in operating conditions, operator misuse, manufacturing variabilities, etc.

- ✓ Control factors

  Input parameters, things you can vary in your design that affect performance

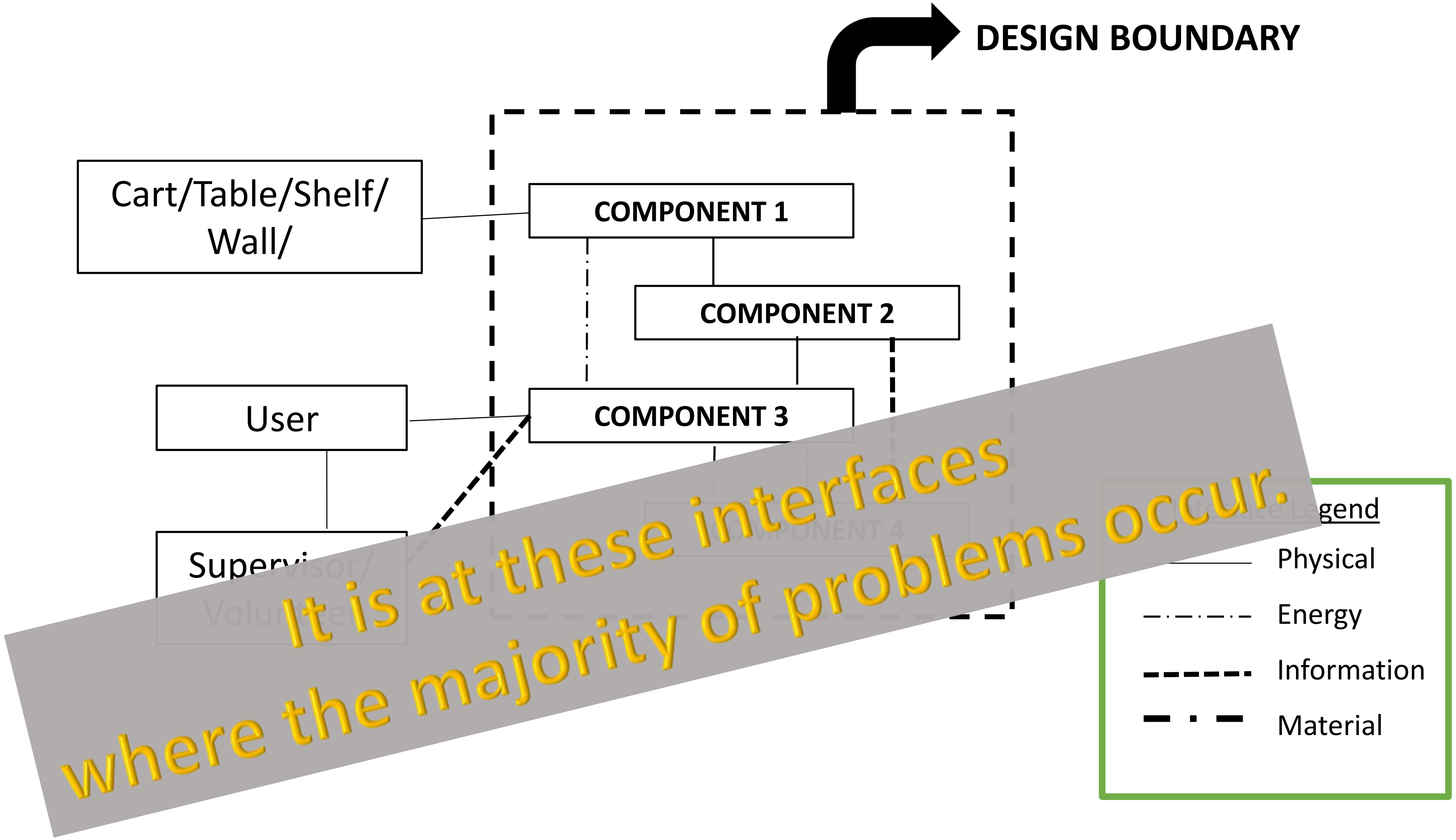
Tools used in robust design practices include boundary diagrams, interface matrix, p-diagrams, DFMEA (design failure mode effects analysis), DVP (design verification plan).

DESIGN VALIDATION PLAN FOR ROBUST DESIGN



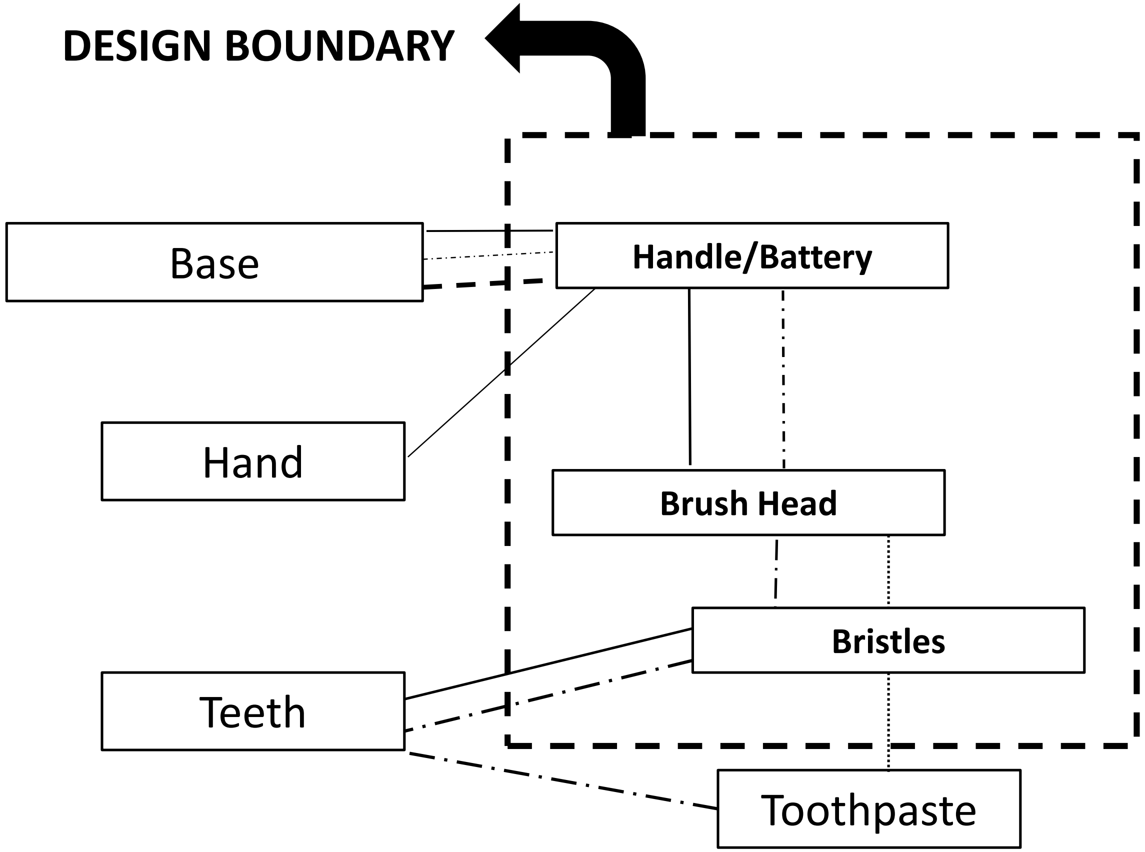
These 2 basic tools allow design engineers to think through the functionality of their design.

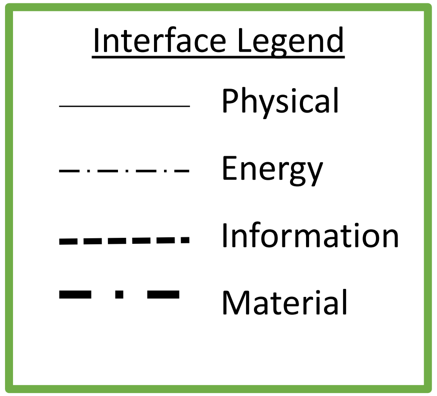
BOUNDARY DIAGRAM



- *Inside the dashed boundary,* you want to include a box for each component included in your product architecture drawing.
- Represent the interactions between those components (both physical and elsewise) by using different styled lines. You will need to include a legend with your boundary diagram.
- *Outside the dashed boundary,* you will show how your product interacts with its surroundings (physical connections and others*) as well as all category of users of your product. Each user as well as the surrounding(s) should have its own box and corresponding lines showing these interactions.

BOUNDARY DIAGRAM EXAMPLE





- *Inside the dashed boundary,* you want to include a box for each component included in your product architecture drawing.
- Represent the interactions between those components (both physical and elsewise) by using different styled lines. You will need to include a <u>legend</u> with your boundary diagram.
- *Outside the dashed boundary,* you will show how your product interacts with its surroundings (physical connections and others*) as well as all category of users of your product. Each user as well as the surrounding(s) should have its own box and corresponding lines showing these interactions.

Now it's your turn.

Create a boundary diagram for your design.

Boundary Diagram

Shows the interfaces both between components and with the surroundings

P - Diagram

- Identifies noises
- Defines ideal function and predicts non-ideal function under the effect of noises
- Identifies design parameters to adjust for robustness

Step 1 - IDENTIFY NOISES

- A ***noise*** is any uncontrollable or unpredictable variable that adversely affects the intended function of your design.
- Common noises fall under the following categories:
  - Environmental variables
  - Change of user, operator mis-use
  - Wear over time

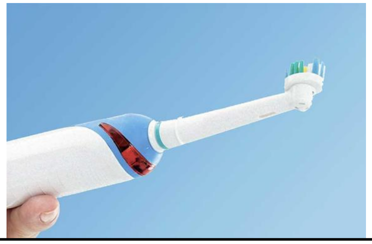
Step 2 -

HOW WOULD THESE NOISES ALTER THE FUNCTION OF YOUR DESIGN?

- Ideal Function
- Non-ideal function
  - No Function (most severe)
  - Intermittent Function
  - Partial Function
  - Unintended Function

Step 3 – Look for parameters of your design that you could change to decrease the effect of these noises on its intended function

P-DIAGRAM EXAMPLE



NOISES:

- **Handle improperly placed on base**
- **Brush head not secured on handle**
- **Toothpaste falls off bristles**
- **User presses too hard on teeth**
- **Bristles worn down on brush head**

NON-IDEAL FUNCTION:

- **Battery doesn't charge; weak brush motion for intermittent or partial function**
- **No rotation of bristles; only partial function**
- **Food particles removed but stains remain (partial function)**
- **Enamel and gums damaged (unintended function)**

- NOISES: Try to think about any uncontrollable factors that could affect the performance of your design. Some noises to consider:
  - Environmental changes
  - Wear over time
  - Customer Usage/Change of customer
- IDEAL FUNCTION would occur when your design meets all of your target specifications and, in turn, meets your customer needs.
- NON-IDEAL FUNCTION: How would your product perform if it were not meeting your specifications? How would it perform subject to Noises?

IDEAL FUNCTION:
User places pea-sized amount of toothpaste on bristles and places brush head in mouth against teeth surfaces and brush head rotates while bristles remove food particles and stains from teeth.

Now create a p-Diagram for your design

Final Question: Is there any aspect of your design that you could change that would *lessen the effect of noises* on your design's performance? Brush head design parameters, base docking parameters, removable brush head, etc.

Back to your Design Validation Plan…

Design Requirement	Metric	Accepted Value(s)	Actual Value	Pass/Fail

GOAL: Design a product that operates within the performance (target) specifications **under the effects of noise.**

- Include all of your Target Specifications
- Take a look at the noises you've identified and the consequential non-ideal functions.
- Come to a consensus as a team on the most likely/most severe noise of those that you've identified
- Include this noise(s) in your test plan.

Turn in your completed DVP to your instructors before you leave.

WEEK 13
DAY 1

- **TO DO:**
  - Requirements for Sprint 3 Review
  - Build Time (take pictures)
  - Finalize test plan with instructors

- **LOOKING AHEAD:**
  - Binder Check #4 – next class
  - In Class consulting – next class
  - Sprint 3 Review - 11/20 (M/W) OR 11/28 (T/Th)
  - Part 3 of IPP – 11/26 by 11:59 pm

Documentation from this test plan work goes in "7. Prototype Testing and Analysis"

WEEK 13
DAY 1

- **TO DO:**
  - **Requirements for Sprint 3 Review**
  - **Build Time (take pictures)**
  - **Finalize test plan with instructors**

- **LOOKING AHEAD:**
  - **Binder Check #4 – next class**
  - **In Class consulting – next class**
  - **Sprint 3 Review - 11/20 (M/W) OR 11/28 (T/Th)**
  - **Part 3 of IPP – 11/26 by 11:59 pm**

Documentation from this test plan work goes in “7. Prototype Testing and Analysis”

- **TO DO:**
  - Binder Checks
  - Prep for Sprint 3 Review
  - In class consulting with final prototypes, cost analysis, & test plan

- **LOOKING AHEAD:**
  - Binder Check #4 – next class
  - In Class consulting – next class
  - Sprint 3 Review - 11/20 (M/W) OR 11/28 (T/Th)
  - Part 3 of IPP – 11/26 by 11:59 pm

Documentation from this test plan work goes in "7. Prototype Testing and Analysis"

WEEK 13 DAY 2

WEEK 14, DAY 1
OR
WEEK 15, DAY 1

- SPRINT 3 REVIEWS & Product Testing