Functional Analysis and Physical Decomposition

ME/EE 386
Functional Analysis

• An organized method of presenting a product’s operations is needed
  – Documentation
  – Personnel transitions
  – Future Modifications

• Functional Analysis (or decomposition) is one means of accomplishing these objectives
Functional Analysis

• A function is
  – A physical behavior or action
  – Indicates
    • What the item must do
    • How the item must do it
      – Relate to other items/components/subsystems
  – Note: There are many documented methods of doing functional analysis, but we will just do one, simple approach.
Functional Analysis

- Top-down approach:
  1. Define generally how the product is operated
  2. Refine the activities necessary to accomplish the operations
     1. Segregate operations into separate blocks, with simple titles
     2. Arrows between blocks indicate flow of action, activity or energy
  3. Repeat refinement for each block
     1. Document hierarchically at lower levels
     2. Eventually, the subsystem/component functions are identified in these operations
  4. Add the secondary operations as necessary and repeat
Example:
A simple traveler’s shaver

- How do you operate the shaver?

- How is the operation accomplished through the shaver?
Refine the Shaver’s primary function (Shave hairy skin) by defining its operation
0. Shave Hairy Skin

1.0 Grasp Shaver

2.0 Remove Cover

3.0 Push Slide Button to ON

4.0 Cut hair

5.0 Push Slide Button to OFF

6.0 Replace Cover

7.0 Store Shaver
2.0 Remove Cover

2.1 Push Cover

OR

2.2 Push CW

2.3 Push CCW

2.4 ‘Click’ to 180° position

Function identified: Cover (assy) rotates bidirectionally

Needs further refinement to identify function of components
3.0
Push Slide Button ON

3.1 Close Power Contact

3.2 Current flows in circuit

3.3 Motor Turns

3.4 Blades Move
4.0 Push screen across skin

4.1 Locate uncut hair

4.2 Connect screen to skin

4.3 Hair pushes through screen

4.4 Blades cut hair

4.5 Move screen to next skin location

4.6 Finish
5.0
Push Slide Button OFF

5.1 Open Power Contact

5.2 No current in circuit

5.3 Motor Stops

5.4 Blades Stop
6.0 Replace Cover

6.1 Push Cover

OR

6.2 Push CW

6.3 Push CCW

6.4 ‘Click’ to 180° position
Example

• Note:
  – The levels were *not* refined as low as possible

• Assumed:
  – Batteries assumed in the shaver
  – Batteries assumed to be sufficiently charged
  – No maintenance functions
Add battery replacement (a maintenance operation)

1.0 Grasp Shaver
2.0 Remove Cover
3.0 Push Slide Button to ON
4.0 Cut hair
5.0 Push Slide Button to OFF
6.0 Replace Cover
7.0 Store Shaver
8.0 Motor Starts
9.0 Replace Batteries

G

Add battery replacement (a maintenance operation)
Adding battery replacement

• A “No-Go” situation ($\bar{G}$) would predicate a need for the maintenance function of battery replacement.
• What additions or changes are needed now in the lower operational/functional definitions?
9.0 Replace Batteries

5.0 Push Slide Button to OFF

6.0 Replace Cover

9.1 Open Battery Compartment Door

9.2 Remove Old Batteries

9.3 Insert New Batteries

9.4 Close Battery Compartment Door
Complexity

• Note that we reference other-level operations or functions inside the lower-level operation of “Replace Batteries”
  – Note that the referenced operation or function must be very isolated from adjacent definitions
    • Implies a separate subsystem, assembly or block
  – If this reference is not sensible, then it may imply a lack of refinement at higher levels
    • Rearrange the higher-level functional layout
Functional Analysis and Physical Decomposition

- The functional analysis allows for identifying the operations, then subsystems and functions, for a product/system design concept.

- *Physical Decomposition* is a method by which an existing product/system can be dissected to establish subsystems and components.
Functional Analysis and Physical Decomposition

• Together, these methods can be used to
  – check that all product operations are understood
  – check that all component/subsystem functions are understood
  – better understand the hierarchy behind the physical product/system architecture

• Physical decomposition excellent means to understand design for assembly (DFA) approaches as well
Physical Decomposition

1. Decompose the product into subassemblies/components
   – Note: Function understanding is valuable
2. Understand the couplings
   – Interactions or connections between subsystems/components
   – How couplings accomplish larger functions
3. Establish product architecture
   • Levels of assembly
   • Circuitry and software included
4. Refine until all subsystems or components are sufficiently defined for functionality within product
Shaver

Back Assy 1.0
Screen Assy 2.0
Battery Cover 3.0
Front Assy 4.0
Screw 5.0 (2)
Gasket 6.0
Front Assy 4.0

- Front Shell 4.1
- Button Slide 4.2
- Recip. Assy 4.3
- Motor Assy 4.4
- Lock Assy 4.5 (2)
Motor Assy 4.4

Motor 4.4.1

Wires 4.4.2 (3)

Battery Contact (2)
Functional Analysis and Physical Decomposition

• Cleaning up the work:
  – Establish common terms for subsystems/components in each analysis
  – Which functions are associated with which physical subsystems/components?

• Important check:
  – Which subsystems/components in the PD are not referenced in the FA?
  – Which functions and/or operations in the FA are not traced to any items in the PD?
  – Which functions/operations and/or subsystems/components are not referenced at all?