Assembly in the Large: Basic Issues

• Goals of this class
  – put assembly in the large in the context of product development
  – relate it to customer expectations
  – start to think about architecture
FRONT-END PRODUCT DEVELOPMENT PROCESS

1. CUSTOMER NEEDS (DOCUMENT AS PKCs)
   - THE BASIC VALUE PACKAGE
     - FUNCTIONALITY
     - PRICE

2. PRODUCT SPECIFICATIONS
   - PRELIM ARCHITECTURE, KC FLOWDOWN, AND REUSE STRATEGY
   - PRELIM TECHNOLOGY PLAN AND SUPPLIER STRATEGY
   - PRELIM MFR COST EST
   - ID HIGH RISK AREAS

3. CONCEPT GENERATION
   - RANK BY NEED SATISFACTION
   - RANK BY COST AND RISK
   - ASSESS VALUE OF SATISFIED NEEDS AGAINST COST & RISK

4. CONCEPT SELECTION
   - REFINE SPECIFICATIONS
   - WRITE CONTRACT BOOK:
     - SELECTED CONCEPT
     - TARGET SPECS
     - TARGET COST
     - TARGET PROCESSES FOR DESIGN, MFR, IT
     - TARGET SCHEDULE AND RESOURCES
     - ID RISKS AND FALLBACKS OUTSOURCING, SUPPLIERS, AND PARTNERS

AITS & AITL occur here during concept design
A Little History

- Is my product ready for robot assembly?
- Well, is your product ready for assembly at all?
- What are the requirements for assembly?
- Can we explain them to a machine?
- Do we understand the product well enough that our suggestions
  - make sense
  - do not compromise performance
- We may have to reverse engineer it to find out
“Product Character”

• Which of the following products is most like a fire extinguisher?
  – (a) sewing machine
  – (b) hand grenade
  – (c) lawn sprinkler

• What are the issues that go into answering this question?
Two Kinds of Copiers

• Industrial strength and capacity
  – Costs a lot
  – Is finnicky: design is not robust
  – Customer can afford full time service person

• Home or small business
  – Must be low cost
  – Must work
  – Can’t afford service person on site

• The manufacturer did OK with the first but failed with the second
Manual Sewing

Image removed for copyright reasons.
Source:

Machine Sewing - 1

Image removed for copyright reasons.
Source:
The needle pokes through the cloth and leaves a loop.
The bobbin is shown passing through the loop.
In fact, a hook catches the loop and slips it under the bobbin.
When this step is finished, an arm above pulls the loop tight.
<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of &quot;hands&quot;</td>
<td>Two</td>
<td>One</td>
</tr>
<tr>
<td>Number of threads</td>
<td>One</td>
<td>Two</td>
</tr>
<tr>
<td>Grasp of needle</td>
<td>Repeated grasp/ungrasp</td>
<td>Never ungrasp</td>
</tr>
<tr>
<td>Location of eye</td>
<td>Rear of needle</td>
<td>Tip of needle</td>
</tr>
<tr>
<td>Needle movement</td>
<td>Passes through Flips 180°</td>
<td>Point penetrates Never flips</td>
</tr>
<tr>
<td>Joining method</td>
<td>One thread passes through repeatedly</td>
<td>Two threads interlock but never pass through</td>
</tr>
</tbody>
</table>

Images removed for copyright reasons.

Source:
## Comparing 4 Ways to Print

<table>
<thead>
<tr>
<th></th>
<th>Typewriter</th>
<th>Ballhead</th>
<th>Dot Matrix</th>
<th>Inkjet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic actuation method and power source</strong></td>
<td>Manual, complex linkages</td>
<td>Manual input, solenoid actuation, simple linkages</td>
<td>Electro-magnet for each dot maker</td>
<td>Piezo-electric for each color of ink</td>
</tr>
<tr>
<td><strong># DOF</strong></td>
<td>Carriage: 2</td>
<td>Platen: 1</td>
<td>Platen: 1</td>
<td>Platen: 1</td>
</tr>
<tr>
<td></td>
<td>Ribbon: 2</td>
<td>Ribbon: 2</td>
<td>Ribbon: 2</td>
<td>No ribbon</td>
</tr>
<tr>
<td></td>
<td>Keys: 1 each<em>50+ keys</em>many links/key</td>
<td>Keys: 1 each*50+ keys electrically actuated</td>
<td>No keys</td>
<td>No keys</td>
</tr>
<tr>
<td></td>
<td>Key carrier: 1</td>
<td>Ball carrier: 3</td>
<td>Dot carrier: 1</td>
<td>Jet carrier: 1</td>
</tr>
<tr>
<td><strong># of parts</strong></td>
<td>Many hundreds</td>
<td>Hundreds</td>
<td>25-50</td>
<td>10-20</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td>Heavy metal</td>
<td>Heavy metal</td>
<td>Metal and plastic</td>
<td>Almost all plastic</td>
</tr>
<tr>
<td><strong>Shapes printed</strong></td>
<td>Fixed character shapes</td>
<td>Fixed character shapes but different balls have different fonts</td>
<td>Unlimited shapes but low resolution</td>
<td>Unlimited shapes and high resolution</td>
</tr>
<tr>
<td><strong>Colors</strong></td>
<td>Two</td>
<td>Two</td>
<td>Two</td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Media</strong></td>
<td>Paper, two or three sheets</td>
<td>Paper, several sheets</td>
<td>Paper, many sheets</td>
<td>Any, but one sheet</td>
</tr>
</tbody>
</table>
Takeaways

• There are many ways to implement a function
• They differ in technology choice, materials, degrees of freedom, allocation of dof, number of parts
• Different implementations have different capabilities for function, customization, upgrade
• They also have different assembly requirements
• Sometimes assembly requirements can drive redesign – IBM ProPrinter example
Steps in AITL - 1

• Understand the business context
  – product character, type of market, customer expectations
  – sales volume anticipated
  – model variety anticipated
  – plans for new versions
  – delayed commitment
  – supplier logistics and make vs buy
  – cost limits
  – labor costs and any regulations
  – cost calculation and ROI methods
  – ROI targets
Steps in AITL - 2

• Understand the factory context
  – labor conditions, training, shift policies
  – space and facility constraints

• Understand the as-is assembly (AITL)
  – study the existing manual process, if any
    • inspecting fiber
  – ignore the existing manual process and focus on
    • technical and economic requirements
  – may give rise to a new level of “DFA” especially if automatic assembly is under consideration
    • sewing, Sony VCR line, RAM with fuses
  – do not ever imply that performance might have to be compromised!
Steps in AITL - 3

- Identify system requirements
  - alternate assembly sequences
  - tentative cycle time
  - production flow and floor layout
  - parts presentation
  - feasible methods and equipment
  - required sensing and communication
  - required displays and controls
  - fixtures and parts carriers
Steps in AITL - 4

- Design a concept assembly system
  - system architecture
  - equipment selection and task assignment
  - cost and economic performance
  - simulation
    - average flow and production rate
    - model changeovers and maintenance (scheduled downtime)
    - failures, repair time (unscheduled downtime)
    - queues, blockage, starvation (unscheduled downtime)
Steps in AITL - 5

• Make final recommendations
  – additional design improvements
  – line design or sequence options
  – remaining risk areas
  – cost estimates
## Structure of System Design Issues

<table>
<thead>
<tr>
<th>Product</th>
<th>Global</th>
<th>Local</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Economics and market targets</td>
<td>• Assembly sequences</td>
</tr>
<tr>
<td></td>
<td>• Volume growth</td>
<td>• Types of operations</td>
</tr>
<tr>
<td></td>
<td>• Model varieties</td>
<td>• Geometric constraints</td>
</tr>
<tr>
<td></td>
<td>• Design volatility</td>
<td>• Part size and weight</td>
</tr>
<tr>
<td></td>
<td>• Quality, reliability, safety</td>
<td>• Shape, stiffness</td>
</tr>
<tr>
<td></td>
<td>• Make or buy decisions</td>
<td>• Tolerances and clearances</td>
</tr>
<tr>
<td></td>
<td>• Build to order/stock</td>
<td>• Tests and inspections</td>
</tr>
</tbody>
</table>

| Assembly System       | Cost and productivity goals                                           | System layout                                                        |
|                       | • How it interfaces to the factory                                     | • Equipment choice                                                   |
|                       | • Labor policies                                                      | • Task assignment                                                    |
|                       | • Failure modes and repair policies                                    | • Part feeding and logistics                                          |
|                       | • Space needs                                                         |                                                                       |