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

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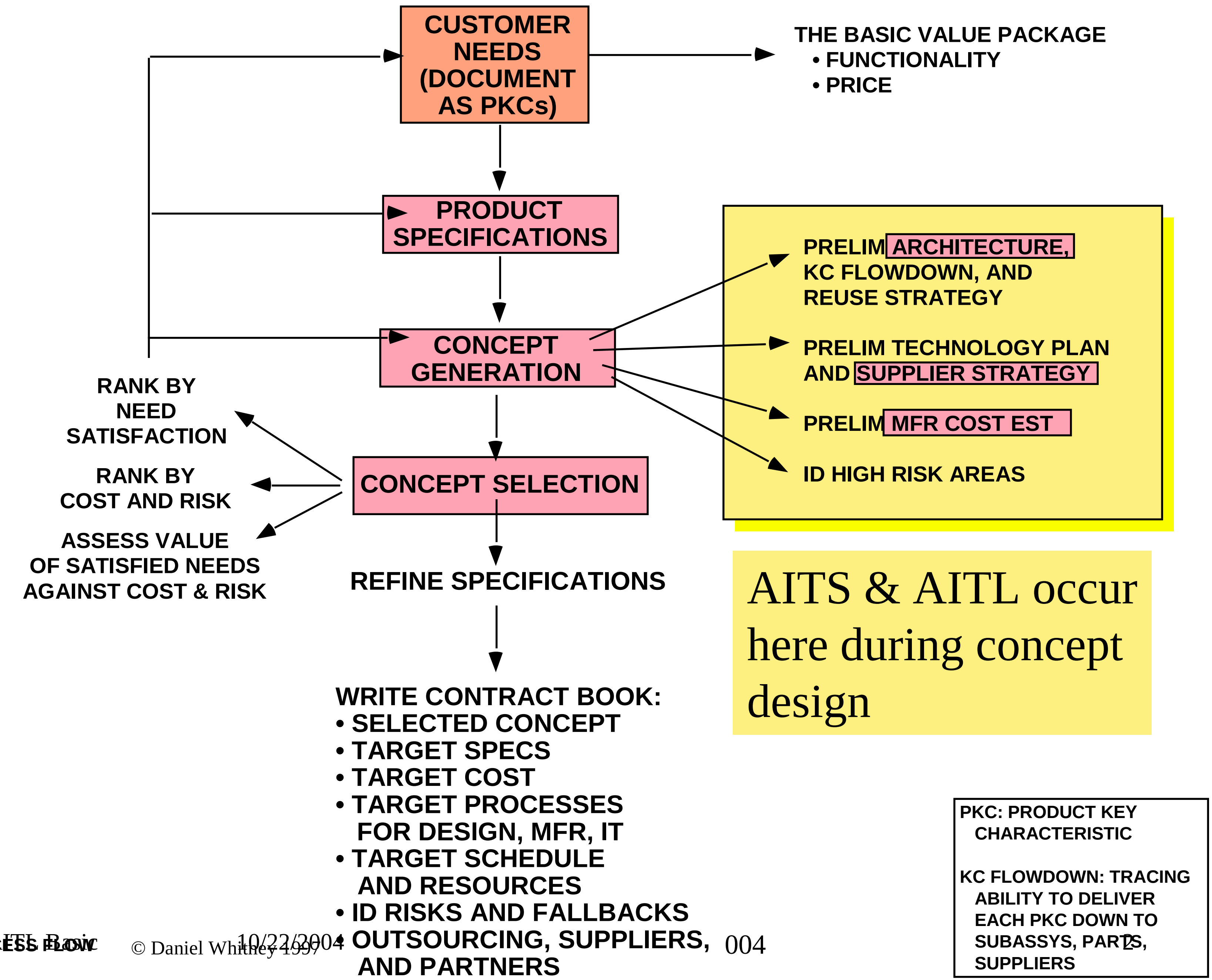
FRONT-END PRODUCT DEVELOPMENT PROCESS



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

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“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?

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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

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Manual Sewing

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Source:
Figure 1-11 in [Whitney 2004] Whitney, D. E. *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development*. New York, NY: Oxford University Press, 2004. ISBN: 0195157826.

Source: "Real Robots Do Need Jigs," Daniel E Whitney, Harvard Business Review, May-June 1986, pp 110-116

Machine Sewing - 1

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Source:
Figure 1-12 in [Whitney 2004] Whitney, D. E. *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development*. New York, NY: Oxford University Press, 2004. ISBN: 0195157826.

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Machine Sewing - 2

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Source:
Figure 1-12 in [Whitney 2004] Whitney, D. E. *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development*. New York, NY: Oxford University Press, 2004. ISBN: 0195157826.

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.

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Comparison of Manual and Machine Sewing Methods

	Manual	Machine
Number of "hands"	Two	One
Number of threads	One	Two
Grasp of needle	Repeated grasp/ungrasp	Never ungrasp
Location of eye	Rear of needle	Tip of needle
Needle movement	Passes through Flips 180°	Point penetrates Never flips
Joining method	One thread passes through repeatedly	Two threads interlock but never pass through

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Four Ways to Print

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Source:
Figure 12-2 in [Whitney 2004] Whitney, D. E. *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development*. New York, NY: Oxford University Press, 2004. ISBN: 0195157826.

Comparing 4 Ways to Print

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

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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

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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

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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!

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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

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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)

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Steps in AITL - 5

- Make final recommendations
  - additional design improvements
  - line design or sequence options
  - remaining risk areas
  - cost estimates

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Structure of System Design Issues

	Global	Local
Product	• Economics and market targets • Volume growth • Model varieties • Design volatility • Quality, reliability, safety • Make or buy decisions • Build to order/stock	• Assembly sequences • Types of operations • Geometric constraints • Part size and weight • Shape, stiffness • Tolerances and clearances • Tests and inspections
Assembly System	• Cost and productivity goals • How it interfaces to the factory • Labor policies • Failure modes and repair policies • Space needs	• System layout • Equipment choice • Task assignment • Part feeding and logistics

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