Application of Value Engineering Studies, Design for Manufacturability Assessments, and Should Cost Analyses during Product Development

2012 International Forum on Design for Manufacture and Assembly

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Topics

- Westinghouse Update (AP1000 and SMR)
- Concurrent Engineering Process
- Value Engineering
- **DFMA**® during New Design
- Should Cost Process
- Lessons Learned
- Conclusions
- Questions

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Westinghouse Electric Company

VISION

Our vision is to be
the customers' choice
in supplying leading-edge
nuclear technology
to satisfy the world's
growing demand
for energy.

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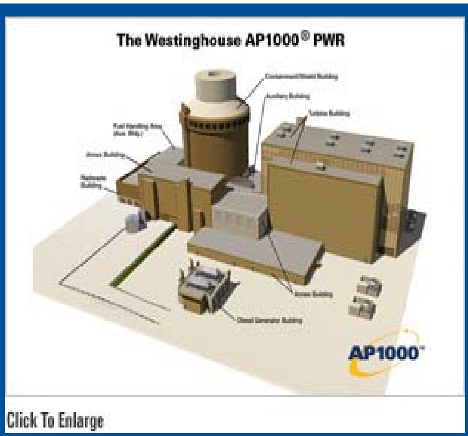
Westinghouse Product Lines

Products and services

- Nuclear Power Plants
- Nuclear Services
- Nuclear Automation
- Nuclear Fuels



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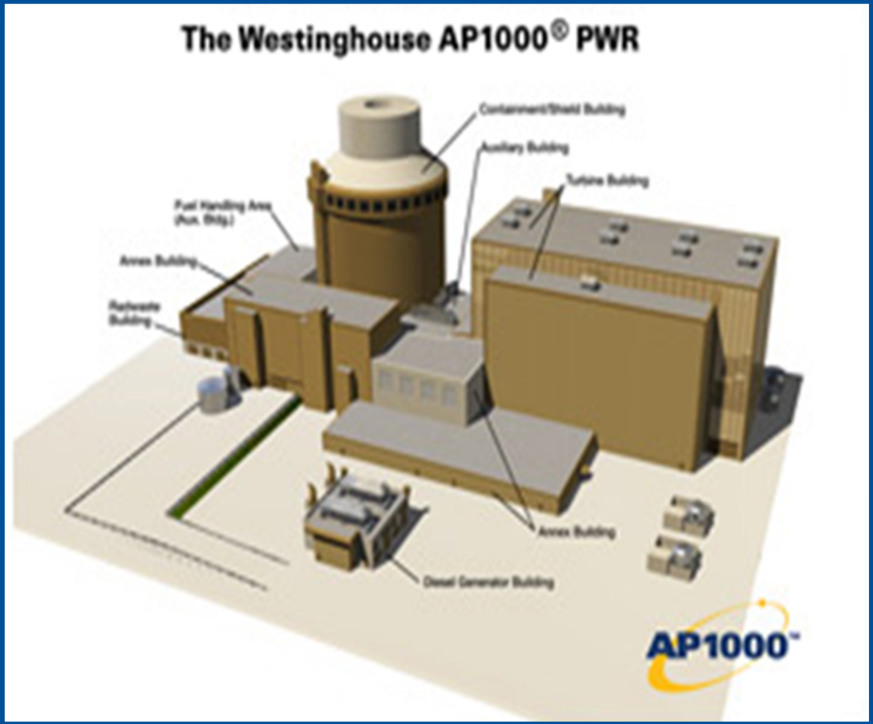
Westinghouse AP1000® Reactor Update

The NRC (Nuclear Regulatory Commission) issued Design Certification for the **AP1000** reactor design.



First and only Design Certification for a Generation III+ reactor issued by the NRC in over 30 years.

Current number of AP1000 reactors under construction is eight, 4 in the U. S. and 4 in China

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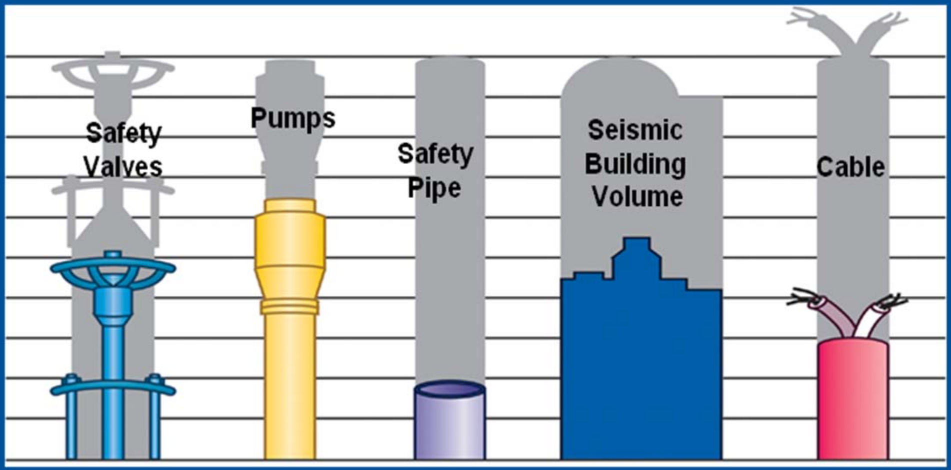
DFMA and the AP1000 Reactor

Part Count Reduction

Standardization

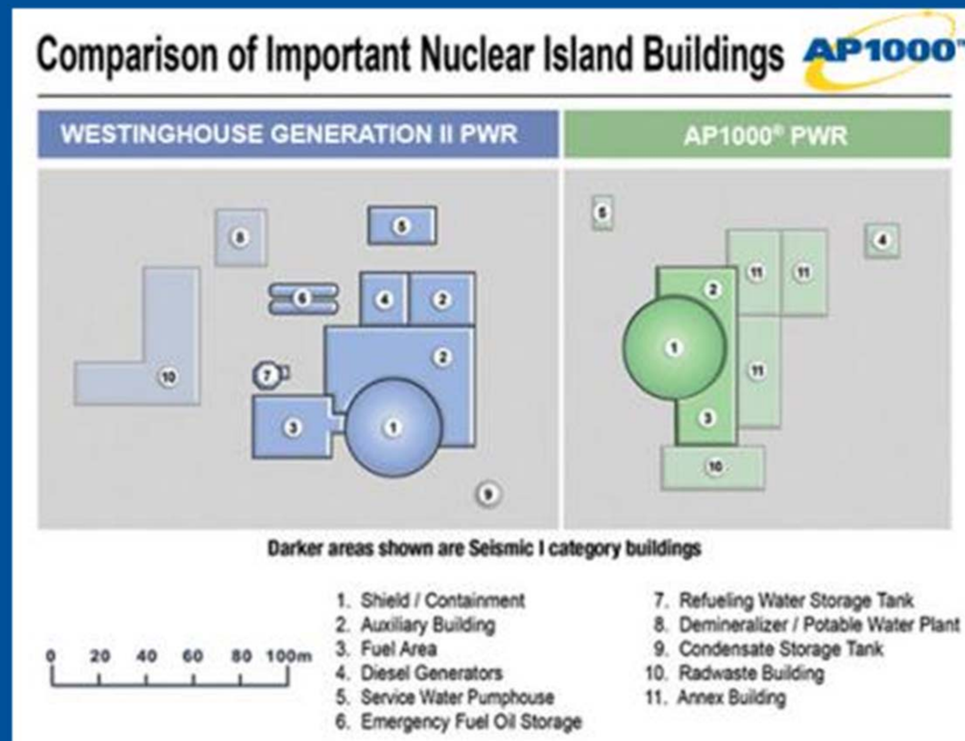


Reduced Number of Components:

	1000 MW Reference	AP1000	Reduction
- Safety Valves	2844	1400	51%
- Pumps	280	184	34%
- Safety Piping	11.0×10^4 feet	1.9×10^4 feet	83%
- Cable	9.1 mil. feet	1.2 mil. feet	87%
- Seismic Building Volume	12.7 mil. ft^3	5.6 mil. ft^3	56%

DFMA and the AP1000 Reactor

Product Envelope Dimensions

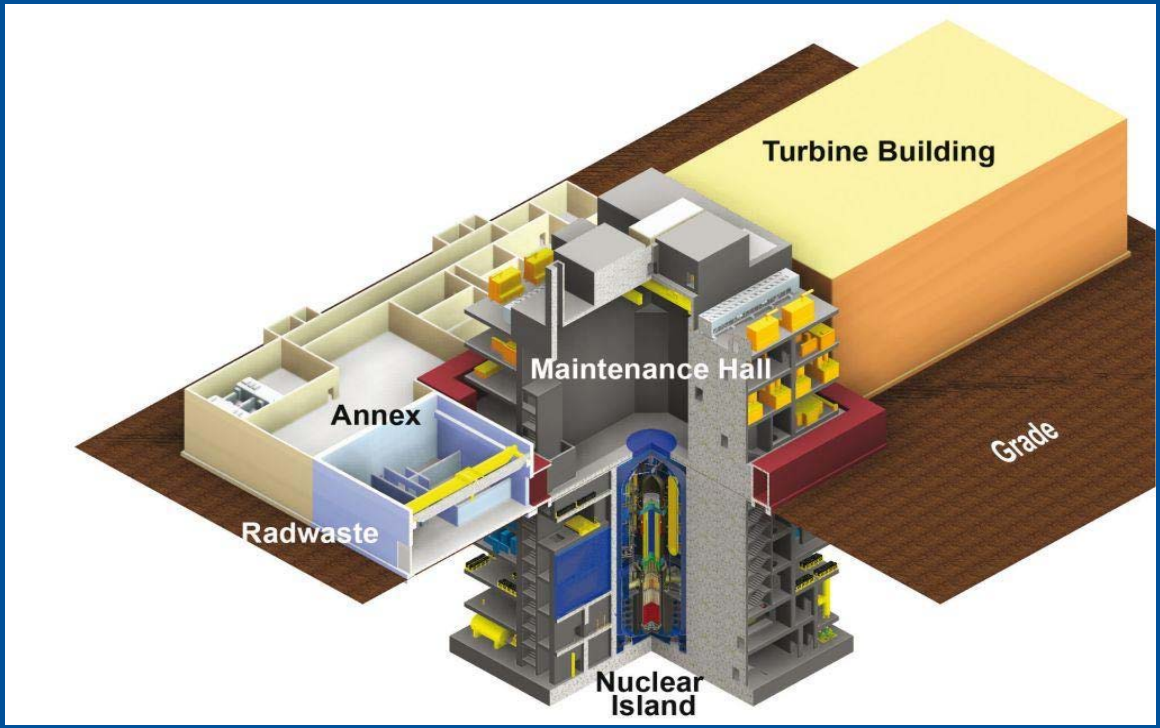


Westinghouse Small Modular Reactor Update

225 Mwe reactor

Approx. ¼ power of **AP1000** reactor

Occupies 1/10 the space of an **AP1000** reactor



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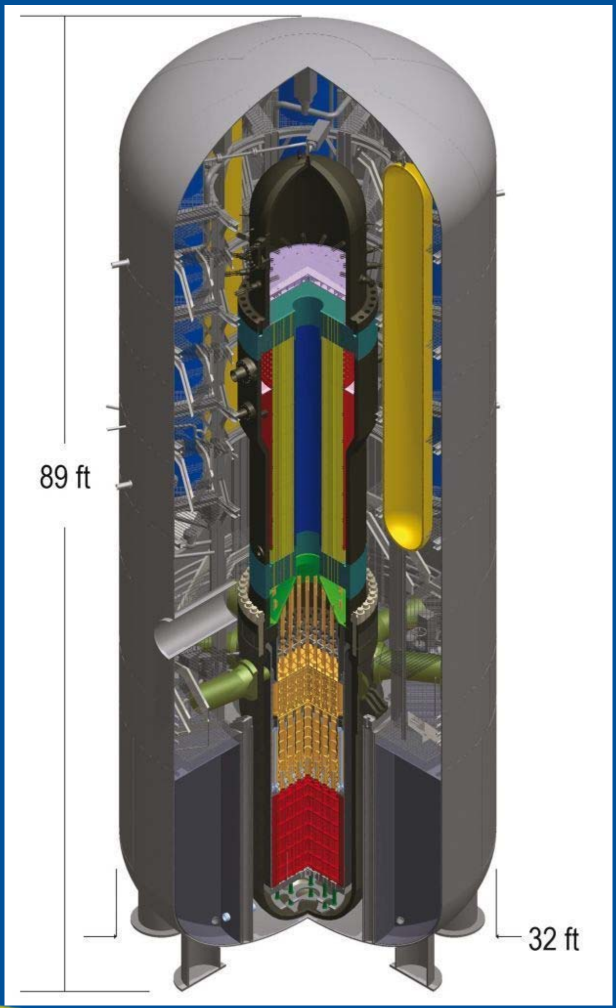
Westinghouse Small Modular Reactor Update

SMR integral reactor, with all the primary components located inside the vessel.

SMR reactor Provided the most recent opportunities for the application of Value Engineering and DFMA



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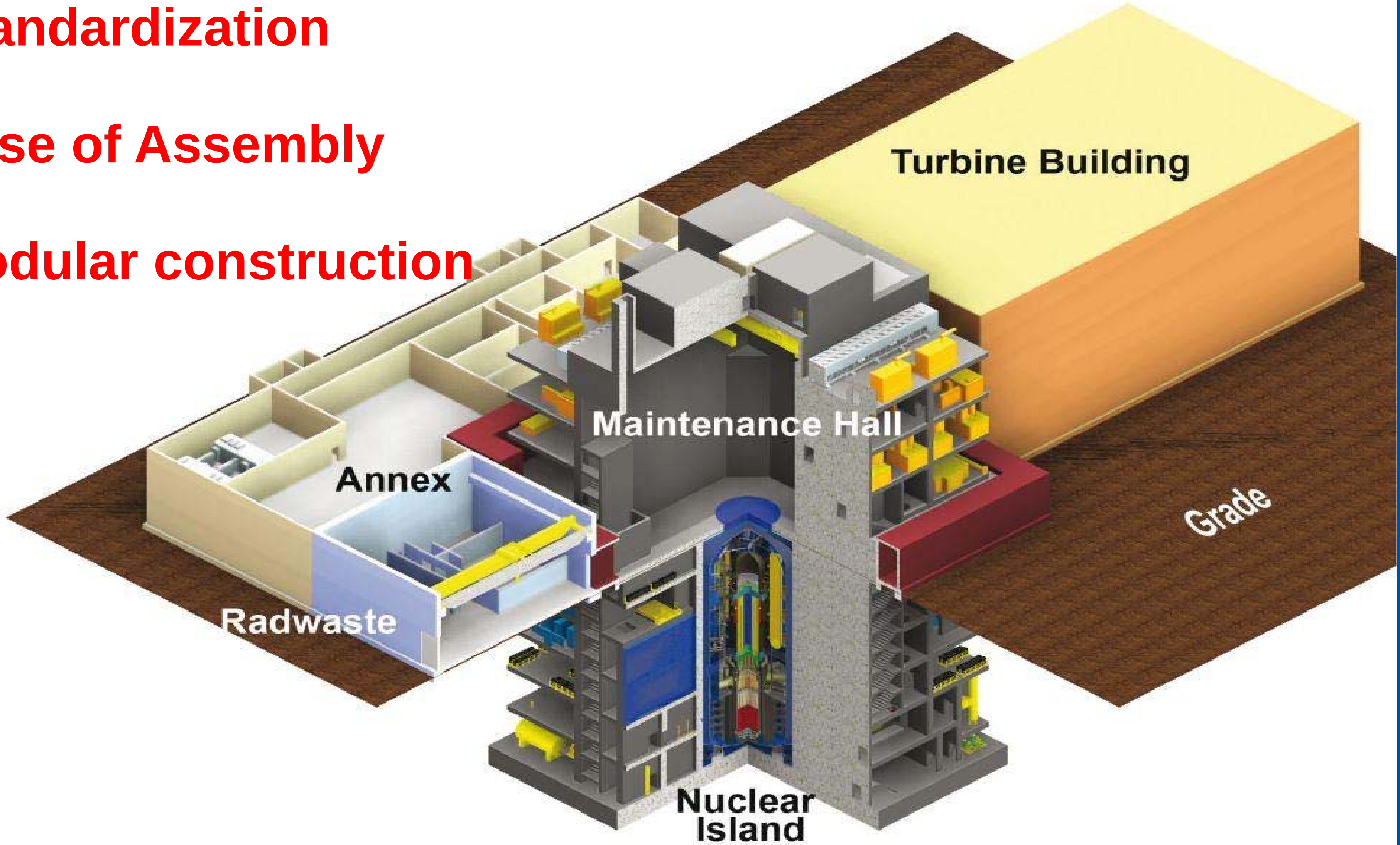
DFMA and the Small Modular Reactor

Standardization

Ease of Assembly

Modular construction



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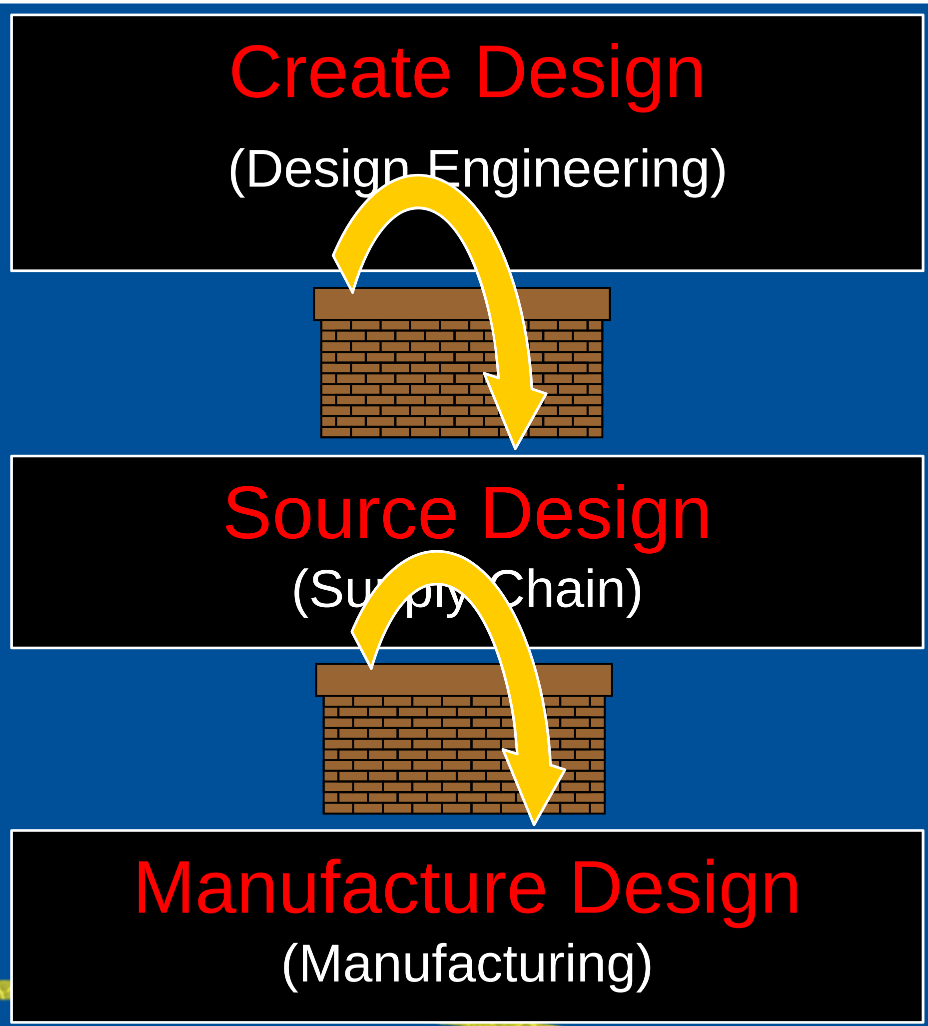
Concurrent Engineering Process

Traditional Design Process



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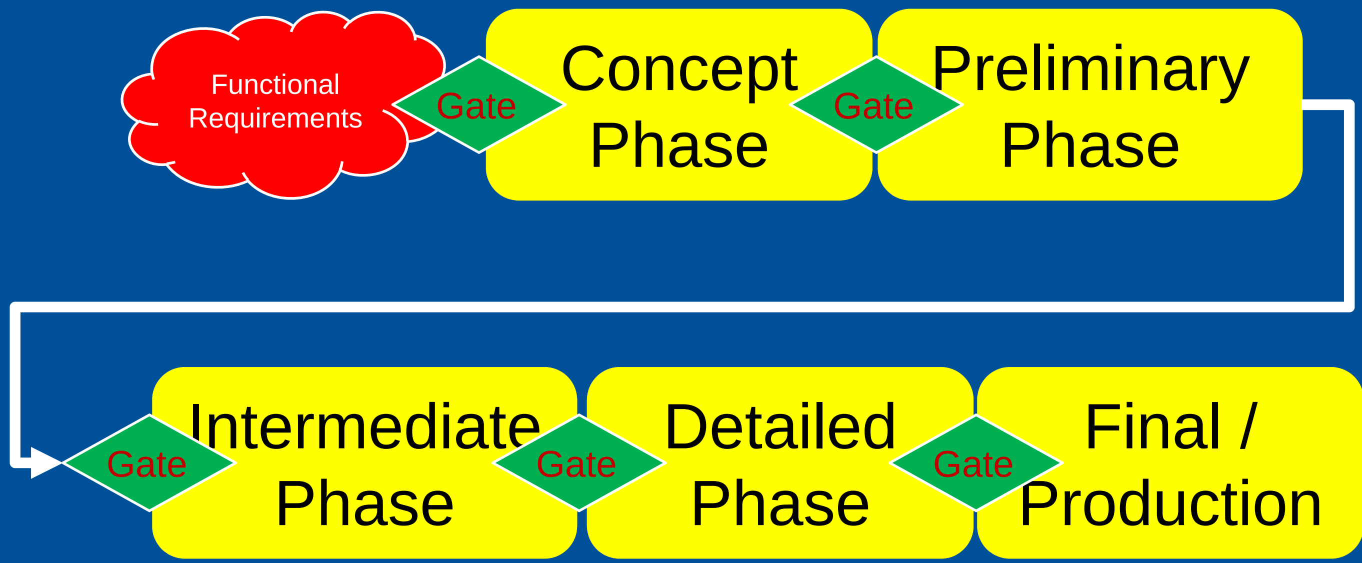
Westinghouse Concurrent Engineering

A gated product , process, and project development procedure involving cross-functional teams during all phases



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Westinghouse Concurrent Engineering

Concept Design Phase
Design Engineering
Product Management
Supply Chain
Manufacturing
Quality

Preliminary Design Phase
Design Engineering
Product Management
Supply Chain
Manufacturing
Quality

Intermediate Design Phase
Design Engineering
Product Management
Supply Chain
Manufacturing
Quality

Detailed Design Phase
Design Engineering
Product Management
Supply Chain
Manufacturing
Quality

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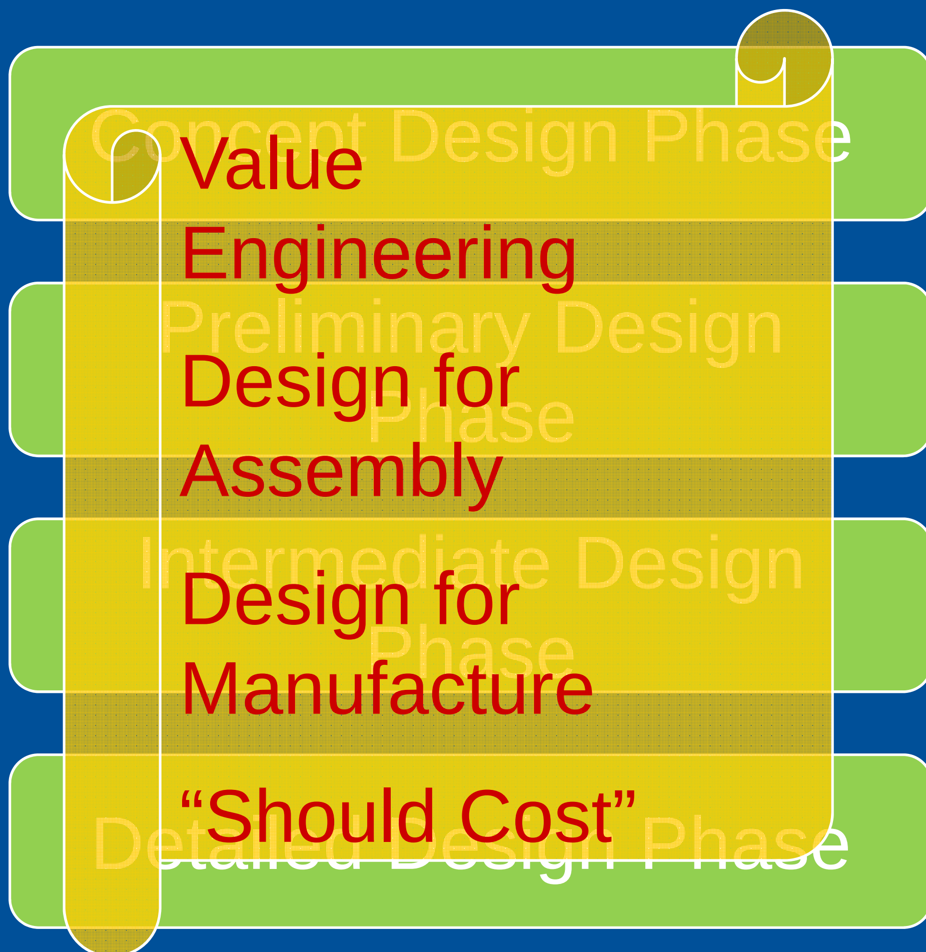
VE, DFMA, and "Should Cost" Integrated



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VE, DFMA, and "Should Cost" Integrated

Concept Design Phase

Value Engineering
Design for Assembly
Design for Manufacture

Early integration

Technical needs met

- Design
- Manufacturing
- Quality

Business needs met

- Cost
- Schedule

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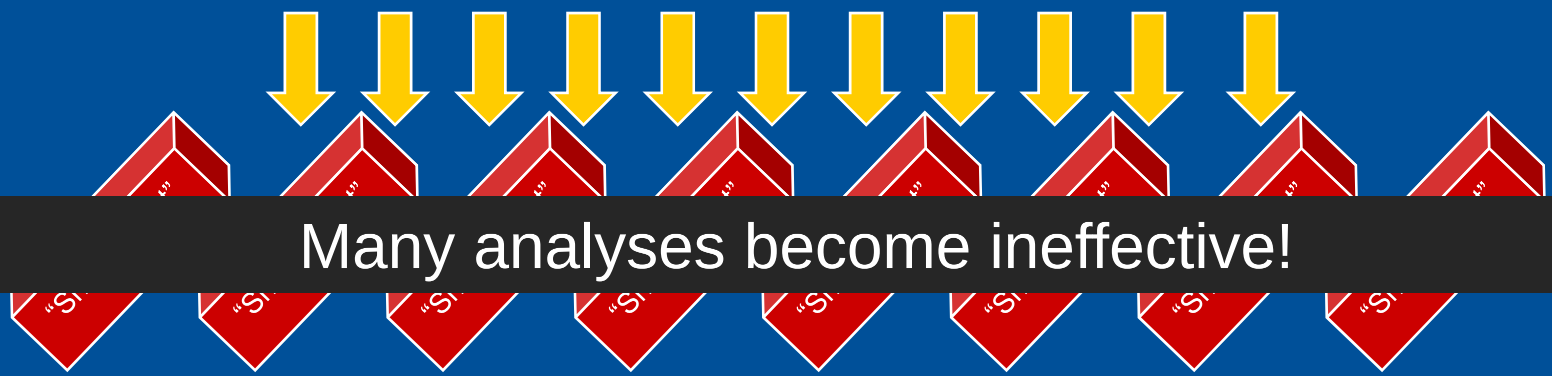
Value Engineering, Design for Manufacturability, and “Should Cost”

Design Process

Value Engineering
Design for Assembly
Design for Manufacture



Many analyses become ineffective!

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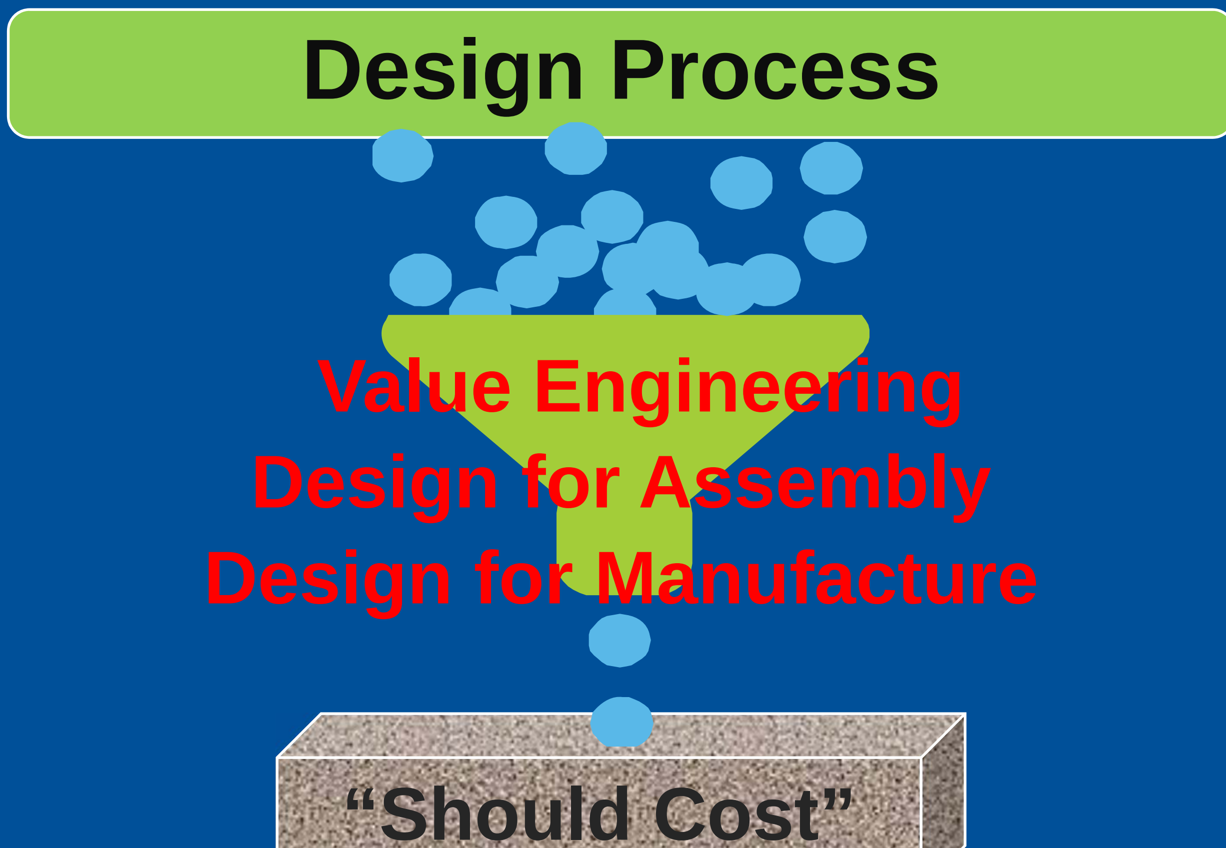
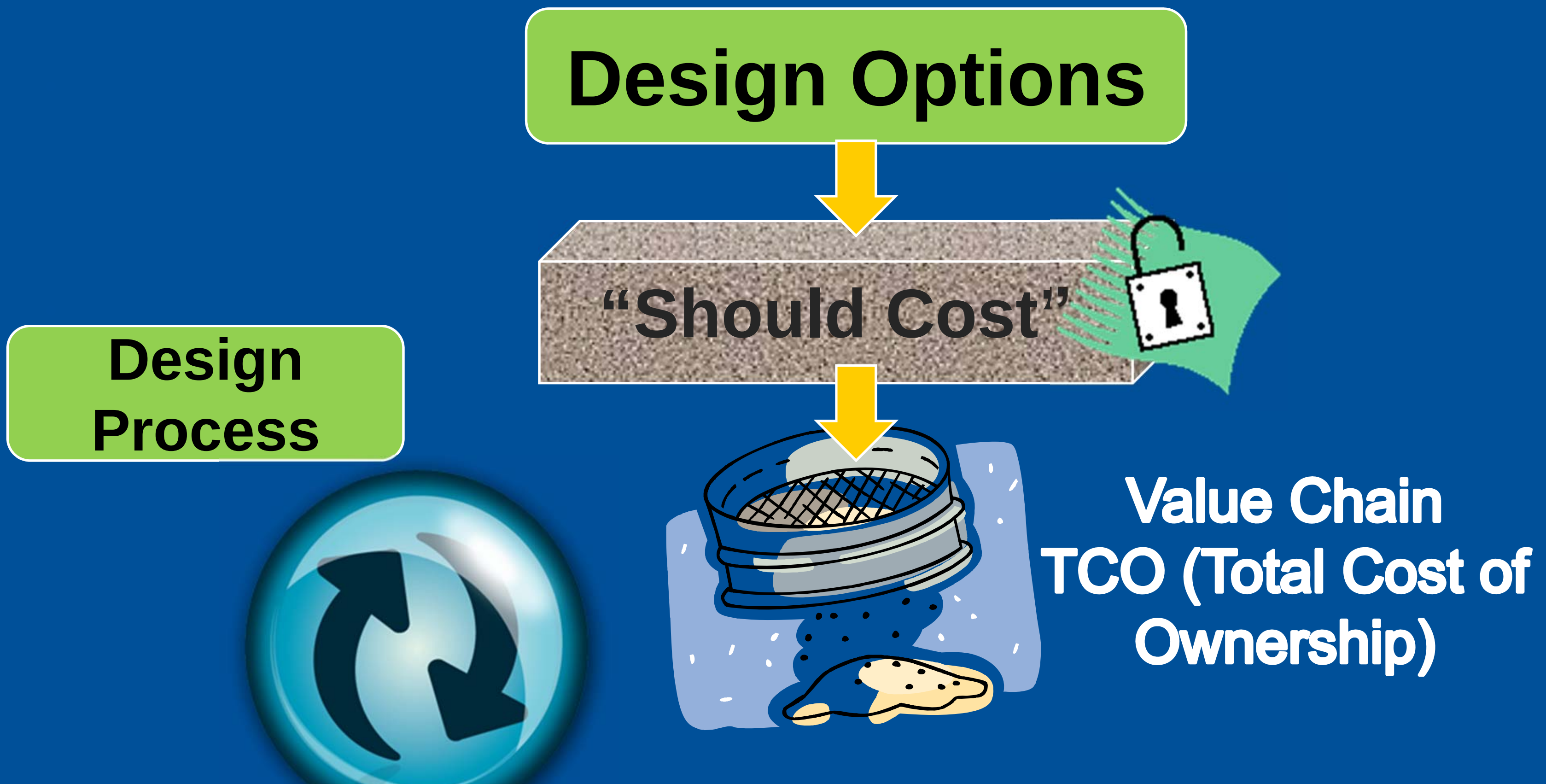
Value Engineering, Design for Manufacturability, and “Should Cost”



Many ineffective analyses become the few effective analyses

The “Should Cost” Process



Design options “sifted” for Value and TCO

Value Engineering

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Value Engineering

Westinghouse VE guideline recommends the use of different methods and/or analyses at each phase of the workshop

The Value Engineer or facilitator can use specific tools to tailor the activity to garner the most benefit from the workshop.

Value Engineering

Westinghouse Value Engineering Workshop Process Recommended Tools

Information Phase:
Quality Function Deployment, Benchmarking
Strengths, Weakness, Opportunities, Threats (SWOT)

Function Analysis Phase:
Function Analysis System Technique (FAST),
Function Matrix, Failure Modes & Effects Analysis

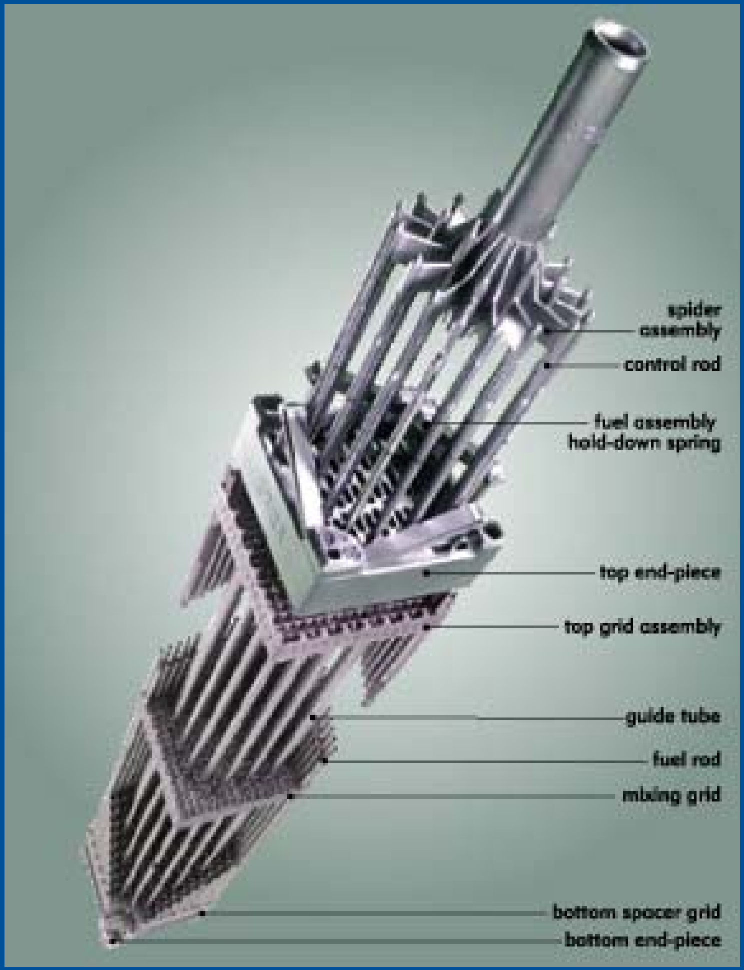
Creative Phase:
Brainstorming, TRIZ

Evaluation Phase:
T-Charts, Pugh Analysis, Kepner-Tregoe

Development Phase:
Design for X-ability, Process Plan Estimates, Cost Comparison Worksheets

Value Engineering Example

The Rod Cluster Control Assembly (RCCA) in the Westinghouse **AP1000** Pressurized Water Reactor provides basic mechanical and operational functions.



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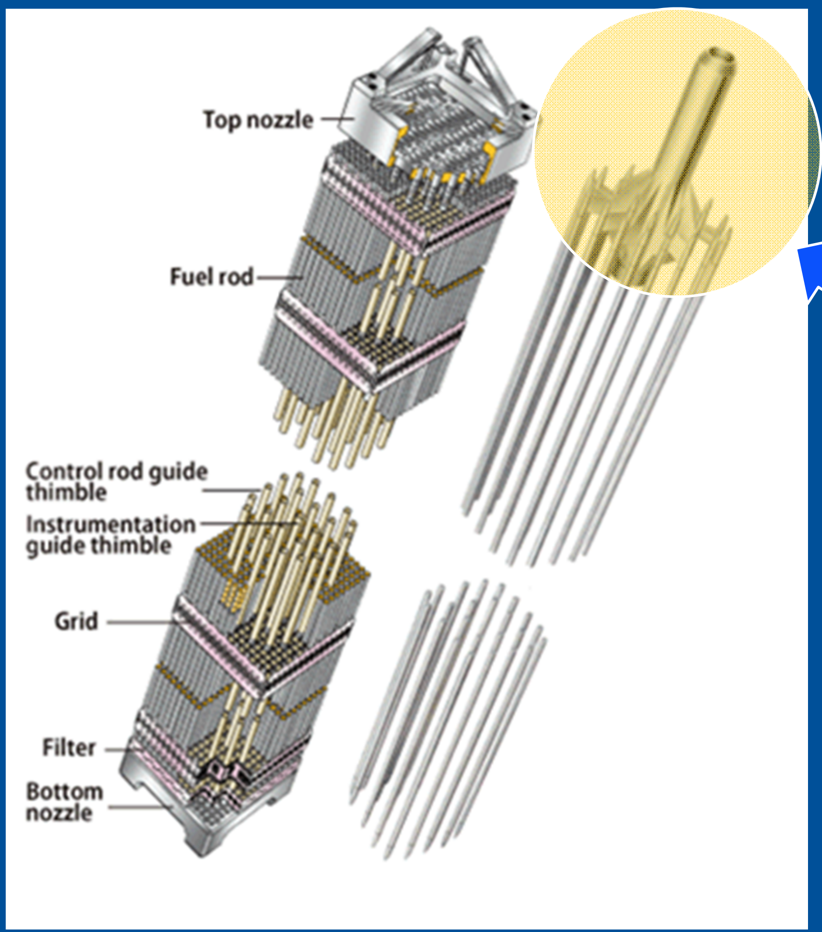
Value Engineering Example

1) Support and position absorber rods
2) Normal shutdown of the core
3) **Rapid shutdown of the core by "tripping" or "scramming"** (VA – Dominion's North Anna Plant)
4) Mate with drive rod couplings for axial positioning
5) Absorb residual kinetic energy of the RCCA after a scram
6) Restrain the absorber rods against ejection

Value Engineering Example



"Spider" Assembly of RCCA

Value Engineering Example

Two Value Engineering Workshops were held with the team consisting of:

- Product Design Engineering
- Supplier Quality Engineering
- Supplier Manufacturing and Value Engineering (SM&VE)
- Supplier

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Value Engineering Example

In the case of the spider, the workshops focused on Design for Assembly, Design for Manufacture, Design for Inspection, and Process Failure Modes and Effects Analysis (PFMEA).

Many value enhancing ideas were generated inside and outside the workshops as the design evolved.

Value Engineering Example

Value Engineering Tools used included

Quality Function Deployment (QFD)

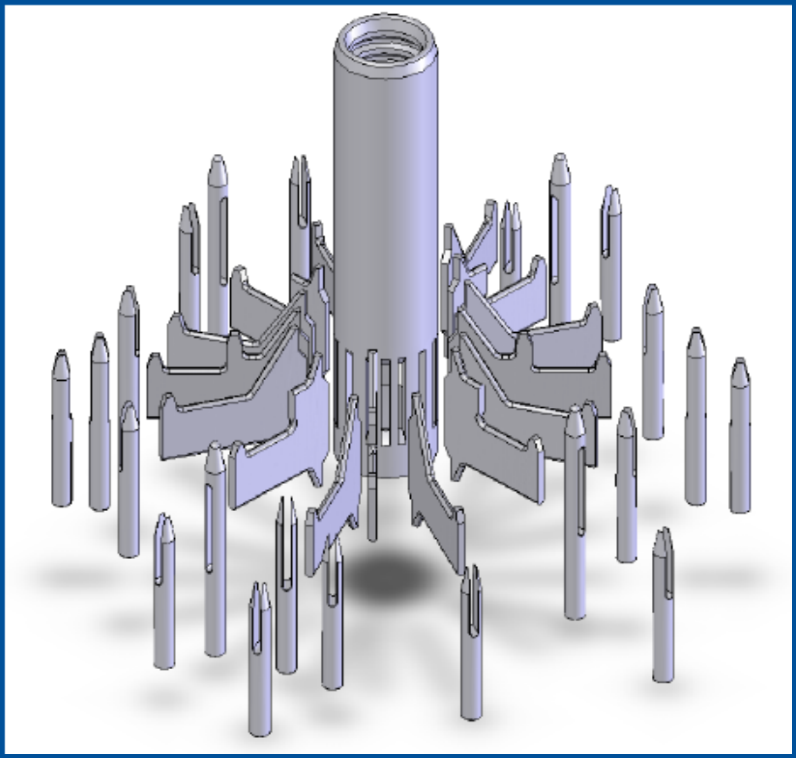
Benchmarking

T-charts

PFMEA

Function Analysis

Value Engineering Example



42 pieces

2 pcs

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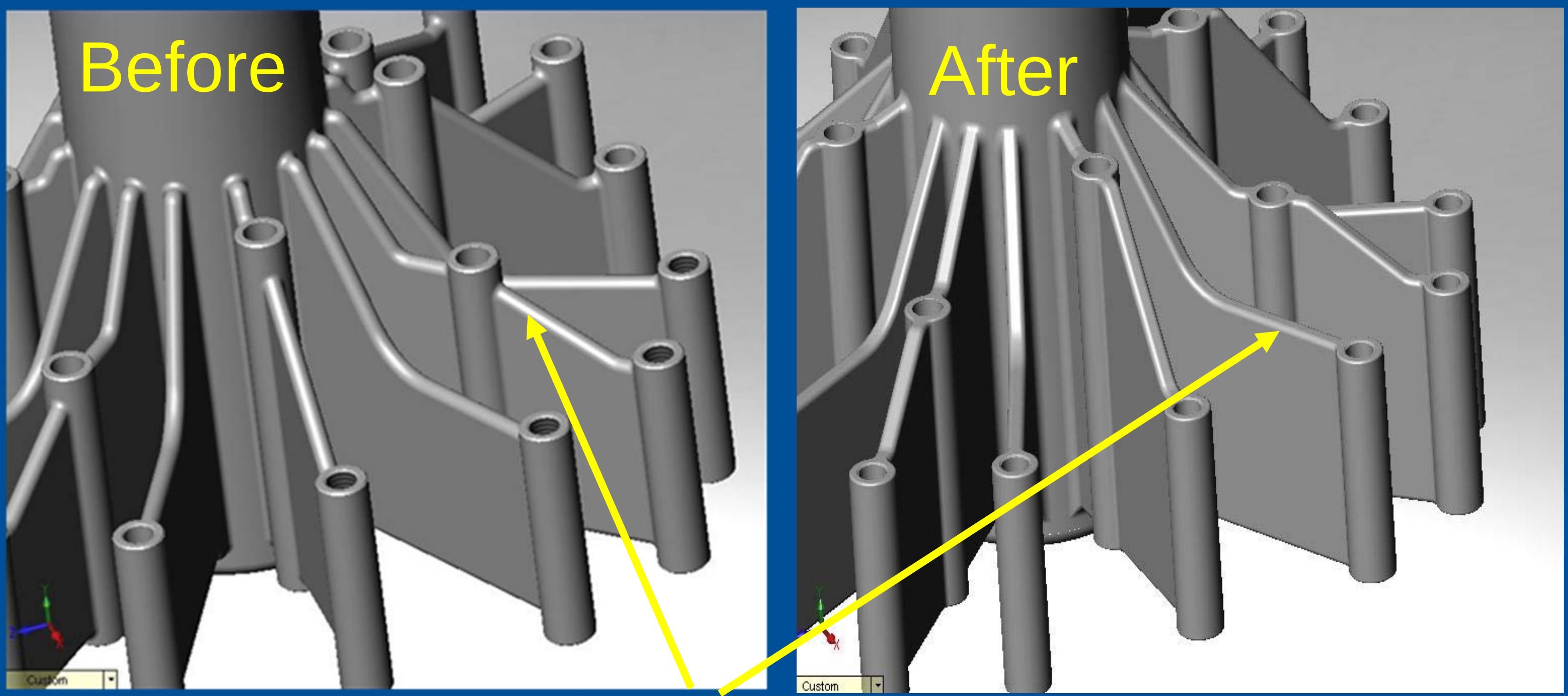
Value Engineering Example



Standardization

- Radii standardized

Changes to the vane, finger, and hub blend geometries that were implemented.

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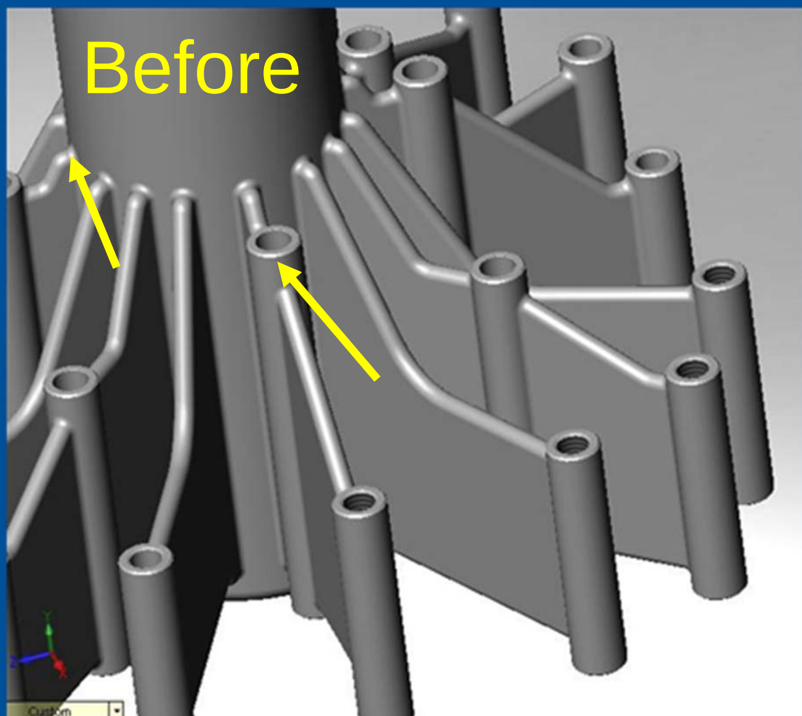
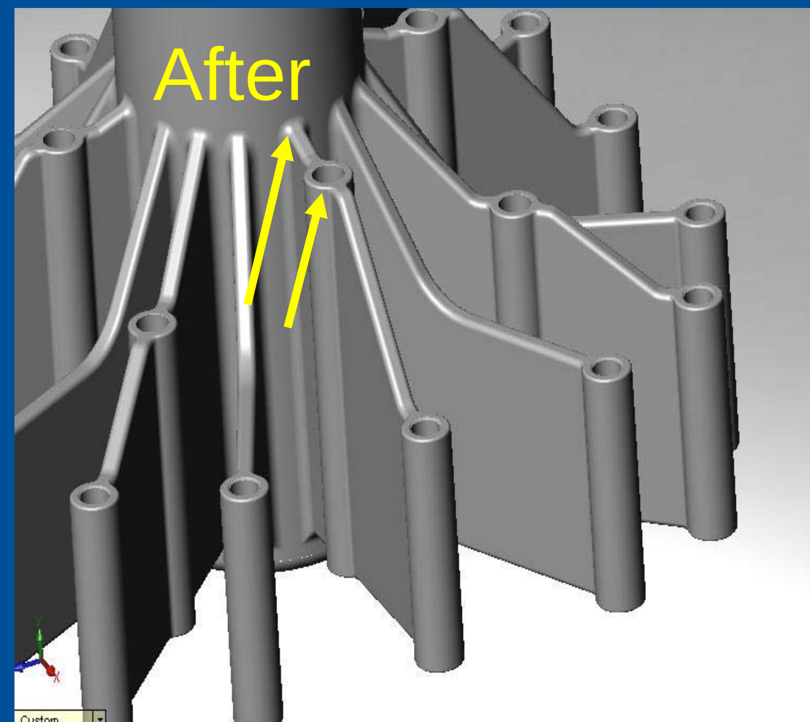
Value Engineering Example





Validation of Manufacturability Rules

- Geometry modified for machining

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Design for Manufacture and Assembly

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DFMA during New Product Design Example

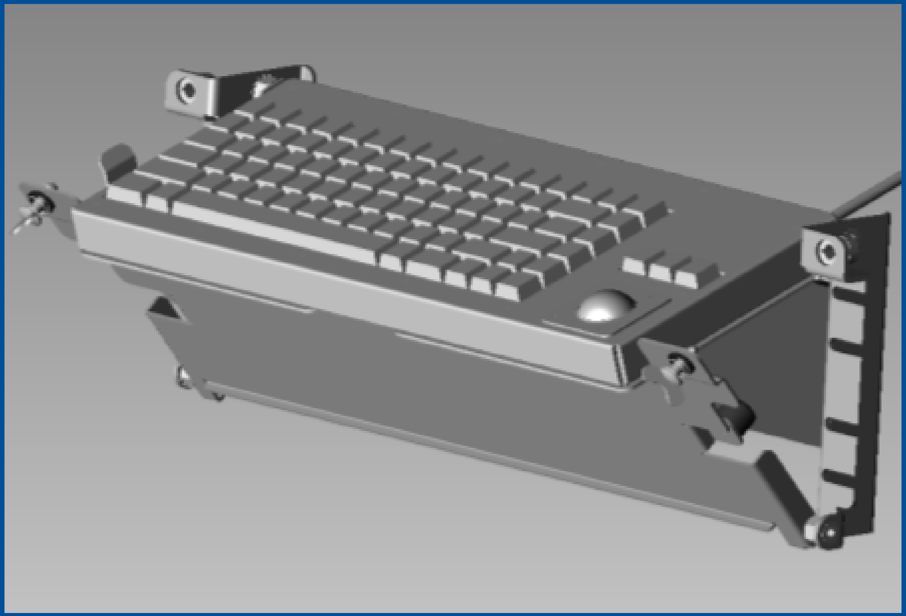
Key DFM / DFA Concepts Utilized

- Part count reduction
- Standardization
  - Tools
  - Features
  - Process
- Ease of Assembly

DFMA during New Product Design Example

Nuclear Automation folding keyboard tray assembly

- Mounts on front of instrumentation and control cabinets
- Easy to access and move safely through the aisles.

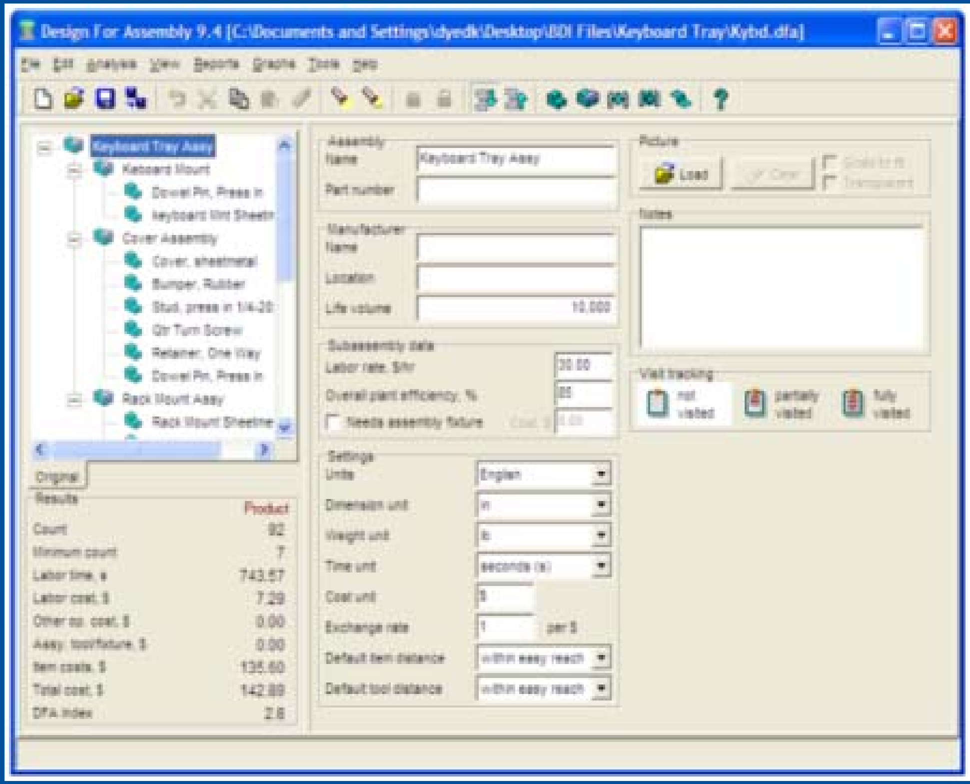


Targeted by SM&VE group as a good candidate for evaluation and improvement due to the number of parts and complexity of the assembly.

DFMA during New Product Design Example

Aggressive construction schedule of **AP1000** reactors

Compressed timeline required quick and accurate recommendations.



Utilizing DFMA software's Design for Assembly module, recommendations were made in less than a day.

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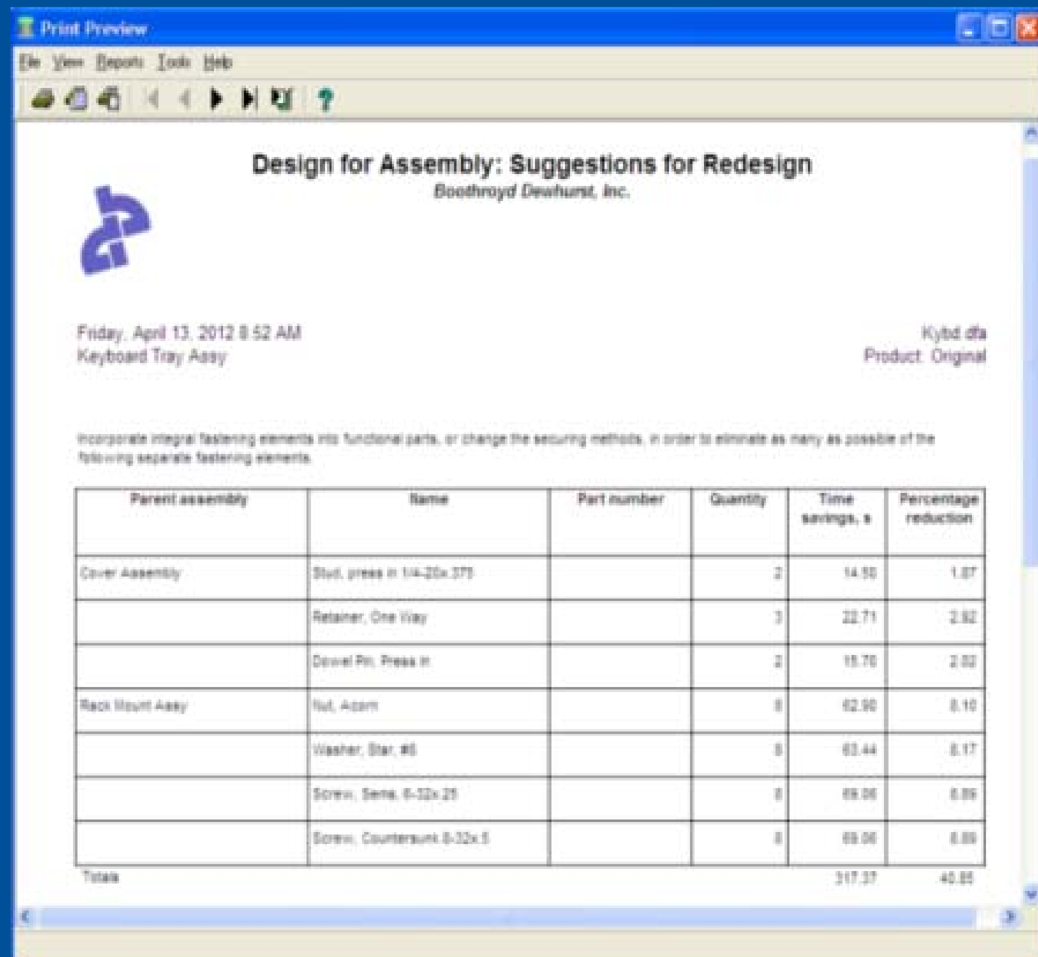
DFMA Reporting Function Utilization

SM&VE Engineers used reporting function in software to generate concepts for product redesign.

Part combination and elimination strategies used.

- Fasteners
- Sheet Metal
- Redundancy



Design for Assembly: Suggestions for Redesign

Boothroyd Dewhurst, Inc.

Friday, April 13, 2012 8:52 AM
Keyboard Tray Assy

Kybd dfa
Product: Original

Incorporate integral fastening elements into functional parts, or change the securing methods, in order to eliminate as many as possible of the following separate fastening elements.

Parent assembly	Name	Part number	Quantity	Time savings, s	Percentage reduction
Cover Assembly	Stud, press in 1/4-20x.375		2	14.50	1.87
	Retainer, One Way		3	22.71	2.92
	Dowel Pin, Press in		2	15.70	2.02
Rack Mount Assy	Nut, Acorn		8	62.90	8.10
	Washer, Star, #6		8	63.44	8.17
	Screw, Sems, 6-32x.25		8	69.06	8.89
	Screw, Countersunk 8-32x.5		8	69.06	8.89
Totals				317.37	40.85

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DFMA during New Product Design Example

- The improved design reduced part count and assembly complexity dramatically.

- A total of 56 fasteners and 10 other parts were eliminated for a total of 66 parts removed.

Initial Part Count	**92**
Part Count after DFA analysis	**26**
% reduction	**72%**

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"Should Cost" Analysis

DFMA Software and "Should Cost" Analysis

Requests

- Made by Westinghouse Sourcing and Program Management
- During project development
- Often occur when supplier quotes are higher than expected

Buyers

- Find leverage for negotiations through cost estimates and often obtain lower quotes than original

Project Team

- Able to make informed comparisons between options providing better long term design alternatives

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DFMA Software and "Should Cost" Analysis

Supplier Manufacturing Engineer Roles

- Ensure a mutual understanding of expectations by receiving and reviewing with the requestor:
  - all design information (e.g. materials, tolerances)
  - quantities
  - time frame

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DFMA Software and "Should Cost" Analysis

Supplier Manufacturing Engineer Roles (con't)

- Determines which components will be estimated using a bottoms up method:
  - Involves estimating labor rates and times for a series of manufacturing steps to create the part
  - For some parts, (e.g., standard hardware and off-the-shelf items) involves simply plugging in purchasing information
  - Emphasizes parts that drive the cost (not a commercially available low-priced bolt)

DFMA Software and "Should Cost" Analysis

- A nozzle dam is a part used to plug a steam generator during an outage.
- The assembly uses several off-the-shelf parts, including fasteners and electronics.
- The bulk of the cost comes from the large machined components shown.

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DFMA software and "Should Cost" Analysis

Nozzle Dam Bill of Materials

1722-001						
Drawing Number	Qty	Unit Cost Estimate	Package of	Subtotals		Assembly Minutes
1722-002	1	$ 10.00		$ 10.00	Estimate	1
1708-001	1	$ 150.00		$ 150.00	Similar parts McMaster	1
R1-04 / MP04-04	3	$ 50.00		$ 150.00	Similar parts McMaster	3
B-QC4-S-4PFK1	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PMK2	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PMK8	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PMK5	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PFK3	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PMK1	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PFK2	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PFK8	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PFK5	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-QC4-S-4PMK3	1	$ 12.00		$ 12.00	Similar parts McMaster	1
B-4CP4-1	2	$ 10.00		$ 20.00	Similar parts Grainger	2
92385A012	1	$ 23.52		$ 23.52	McMaster Carr	1
97840A49	12	$ 11.66		$ 139.92	McMaster Carr	12
97840A45	2	$ 2.19	2	$ 2.19	McMaster Carr	2
97481A266	1	$ 5.41	100	$ 5.41	McMaster Carr	1
7483K35	AR	$ 4.78	50	$ 4.78	McMaster Carr	AR
			Material	$ 625.82	Assembly	$ 55.00
			Total	$ 680.82		

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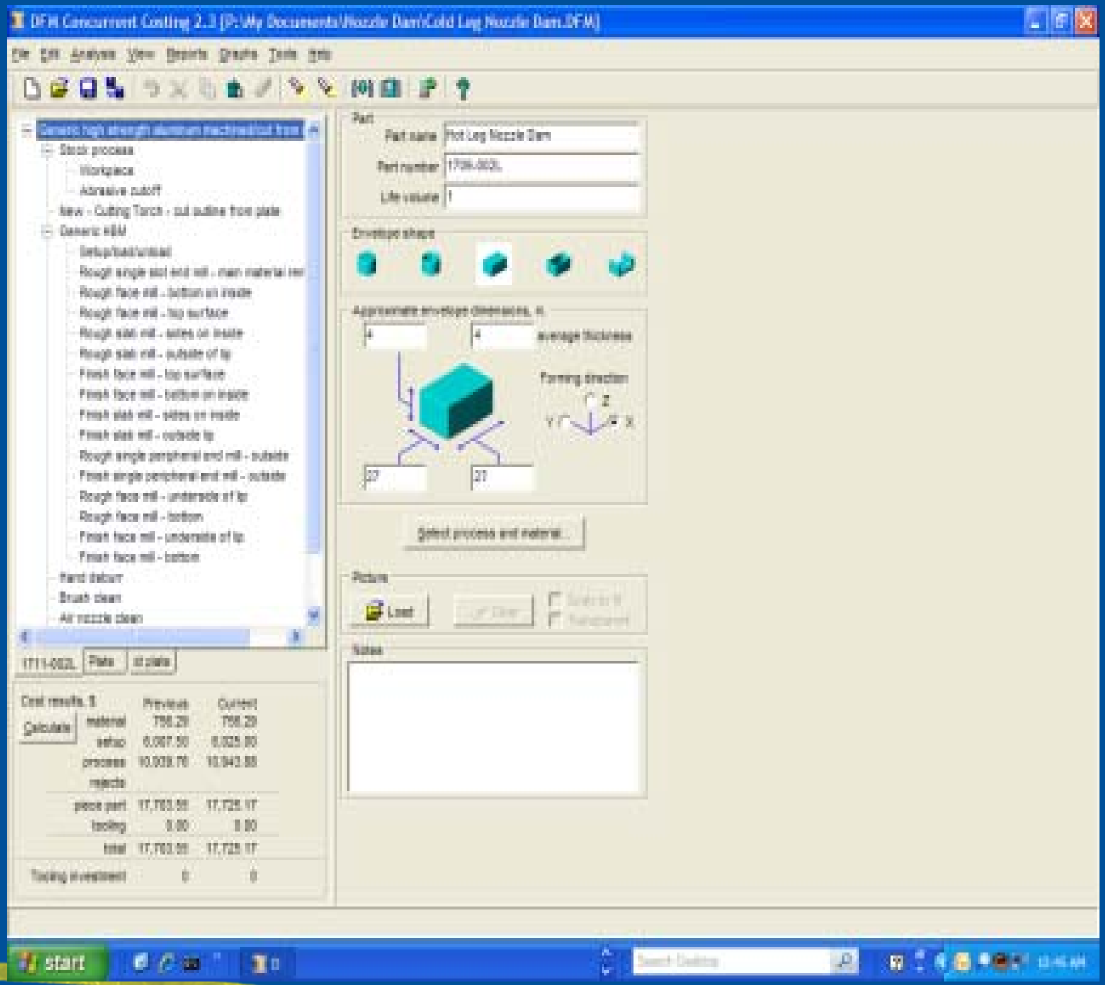
DFMA Software and “Should Cost” Analysis

DFM Module used to estimate large or complex component costs

Each process step is accounted for and analyzed for its value added



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DFMA Software and "Should Cost" Analysis

The Should Cost Worksheet:

- Represents cost only
- Does not include mark-ups for profit or overhead

Total Nozzle Dam				
Drawing Number	Description	Qty	Unit Cost Estimate	Subtotals
1709-001	Nozzle Dam - Hot Leg	1	$ 40,480.75	$ 40,480.75
1711-001	Nozzle Dam - Cold Leg	2	$ 36,163.20	$ 72,326.39
1722-001	Hose Bundle	3	$ 680.82	$ 2,042.46
1710-001	Support Console	1	$ 7,277.97	$ 7,277.97
1738-001	Console Air Supply Regulator	1	$ 234.74	$ 234.74
			Total	**$ 122,362.31**

- Does not include Design Engineering, Supplier Manufacturing Engineering, or Supplier Quality hours

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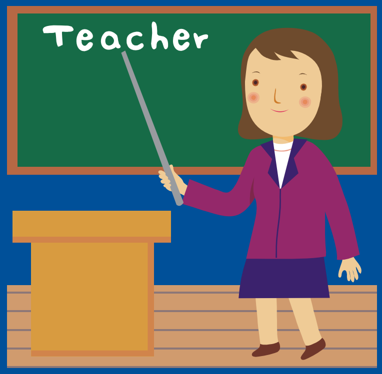
DFMA Software and "Should Cost" Analysis

These early analyses permit the project team to focus their attention and efforts on features that drive costs and provide required functionality effectively.

Lessons Learned

Early cross functional team involvement avoids costly redesigns late in the process when:



- Costs to change are higher
- Design potentially unmanufacturable
- Long term costs are determined

Value Engineering, DfA, and DfM disciplines are instrumental in the Westinghouse "Should Cost" process.

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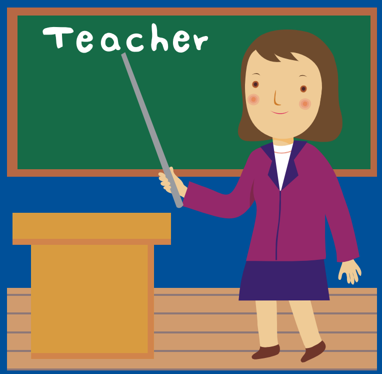
Lessons Learned (cont'd)

- Should cost" process is a powerful method for teams to make informed decisions early in the design phase in order to affect the Total Cost of Ownership (TCO).



- Always take into consideration supplier's feedback

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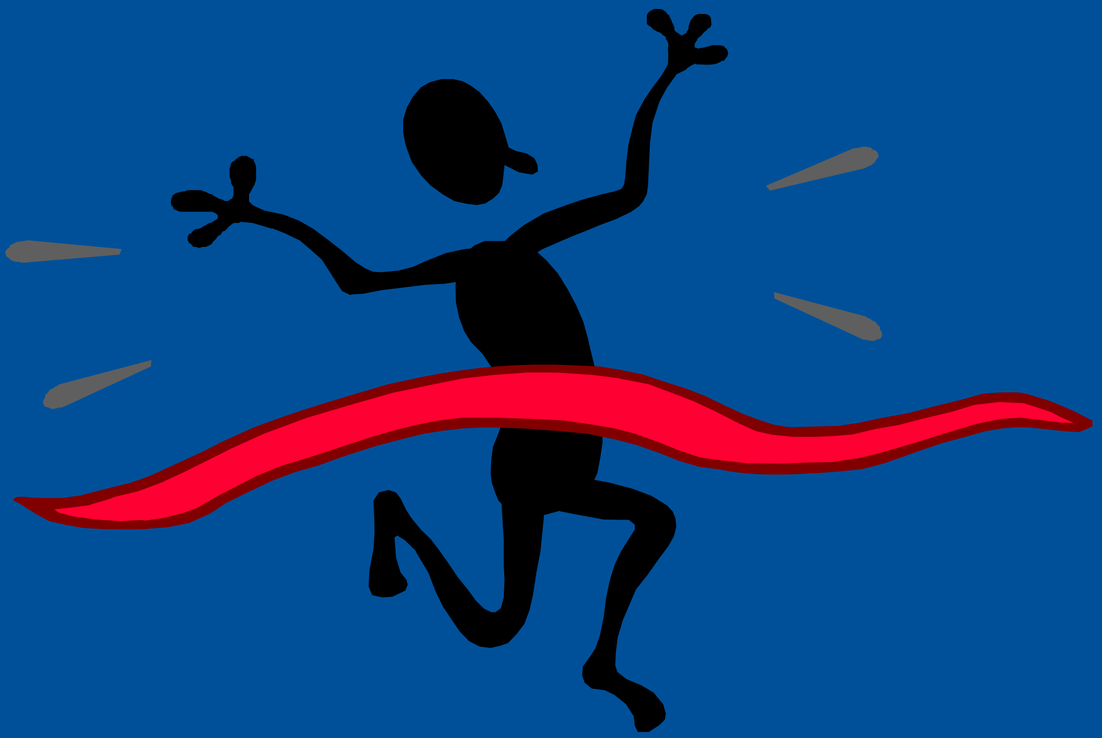
Conclusions



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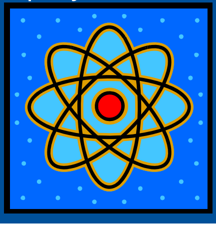
Conclusions



- The concurrent engineering process involves more functional groups earlier and focuses efforts on design options that fulfill business and technical requirements better than traditional engineering processes.

- The DFMA software has multiple uses within the concurrent engineering process (most notably during Design for Manufacturability and “Should Cost” analyses).

- “Should Cost” assessments are improved dramatically when Value Engineering, DfA, and DfM principles are applied throughout the product development cycle.

Conclusions (cont.)

- Previous "Should Cost" analyses were insufficient due to the number being looked at.
- Designs and costs are optimized for both value and function when Value Engineering studies and Design for Manufacture and Assembly analyses are used in the process.
- BDI **DFMA** software can be utilized to drive redesigns of both product and process, and ultimately drive negotiations with potential suppliers.
- Suppliers can benefit from the output due to more manufacturable designs and a production process that is better aligned with the final product characteristics.

Conclusions (cont.)

Unexpected Benefit:

Supply Chain Management personnel spend less time quoting and analyzing designs that are either not manufacturable or are too expensive.

Questions?

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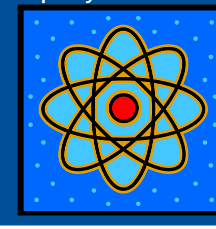
Statements



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