Design for Manufacturing

DFM with Suppliers

Supplier DFM Objective

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- Leverage supplier domain expertise
- Eliminate design modifications required for schedule, cost and/or producibility
- Align to supplier capabilities and strengths
- Improve quality
- Reduce total cost

Questions??? Ask the expert at mailto::dfss@raytheon.com

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Cost, Quality & Cycle Time

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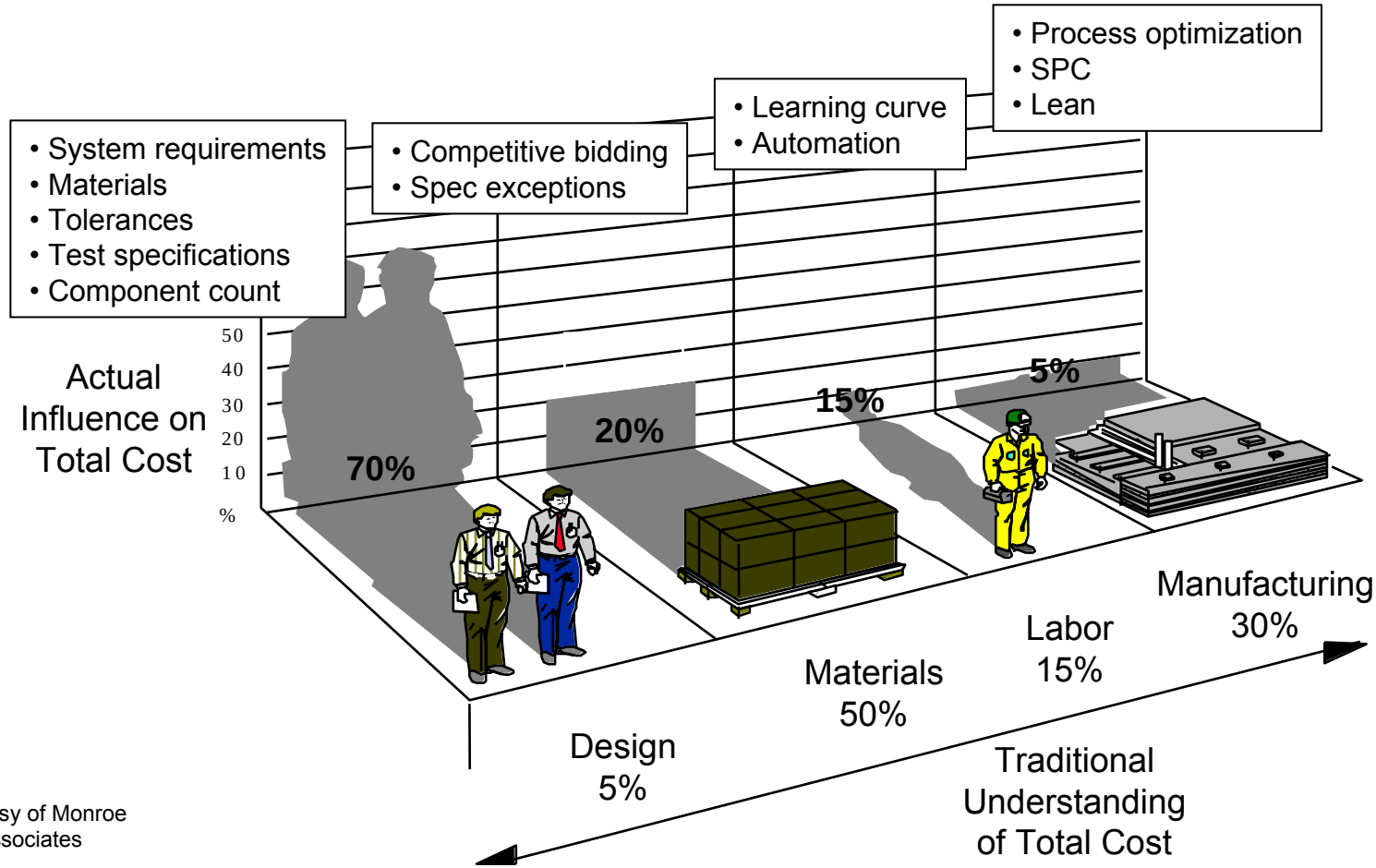

Courtesy of Monroe and Associates

The design phase provides the best opportunity to reduce total cost

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Maximizing Customer Value Through DFM

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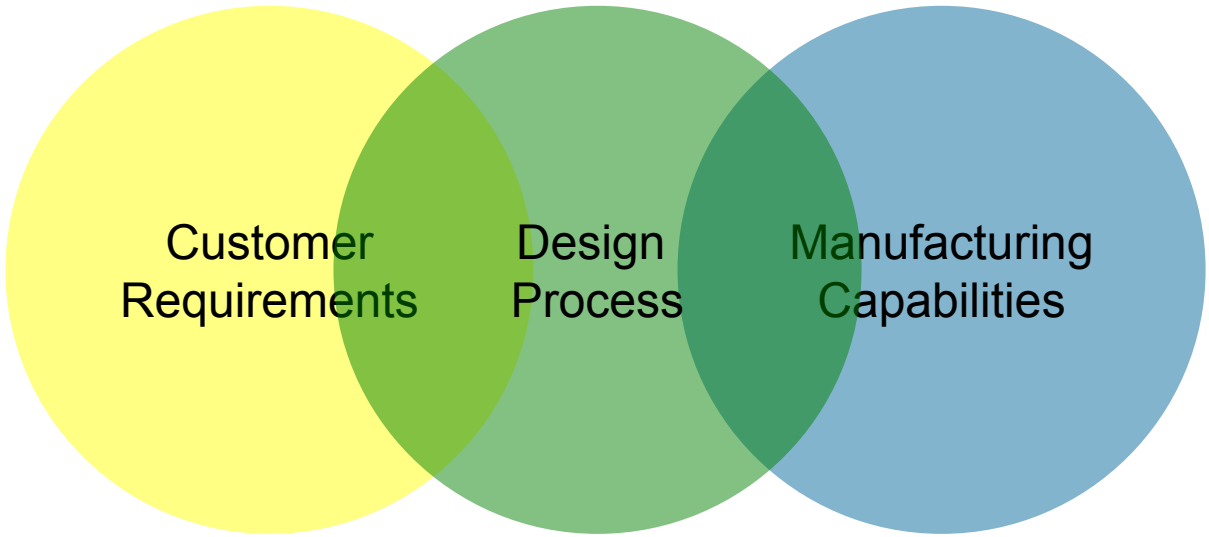
- We have a shared responsibility to provide the best value to our customers
- Optimum design aligns to both the customer requirements and the manufacturing capabilities
- DFM connects the designers responsible achieving customer requirements to the manufacturing and supplier teams responsible for delivering the products



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The Yield Impact from Improving Margin

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Relax requirements and/or improve process

# of parts/steps	Sigma Level Impact on First Pass Yield			
	± 3σ	± 4σ	± 5σ	± 6σ
1	93.3%	99.4%	99.98%	99.999966%
10	50.1%	94.0%	99.77%	99.9966%
30	12.6%	83.0%	99.30%	99.99%
50	---	73.2%	98.84%	99.98%
100	---	53.6%	97.70%	99.97%
150	---	39.4%	96.61%	99.95%
200	---	28.8%	95.45%	99.93%
219	---	25.6%	95.03%	99.92%
250	---	21.1%	94.35%	99.91%
300	---	15.4%	93.26%	99.90%

DFM

DFA

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Some Root Causes for Redesign

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- Insufficient performance margin
  - Design requirements are not matched to existing supplier or manufacturing capabilities
  - Design is too sensitive to manufacturing variation
- Cost is too high
  - Design is difficult to fabricate
  - Design is difficult to assemble
  - Requirements drive utilization of expensive manufacturing processes
  - Poor yield
  - Designers are unfamiliar with commodity cost drivers
- Raw materials are difficult to procure
- Poor communication and/or inadequate review of requirements

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The Help We Need From Our Suppliers

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- Provide a DFM review of incoming designs and clearly communicate your manufacturing capabilities, design cost drivers, concerns, exceptions and any opportunities for cost and risk reduction
  - Designers have the system performance expertise—how variation in the design affects performance
    - Suppliers have no visibility into system performance
  - Suppliers have the fabrication, assembly and test expertise—how much variation their processes create
    - Tolerance defines method! Method impacts cost!
    - Designers have little visibility into supplier process capabilities
- System performance expertise *and* knowledge of supplier process capabilities are both necessary to optimize any design for cost and performance

Suppliers can help designers understand how their requirements drive product cost, schedule and quality risk—and where improvement opportunities exist

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Performance-Cost Trades

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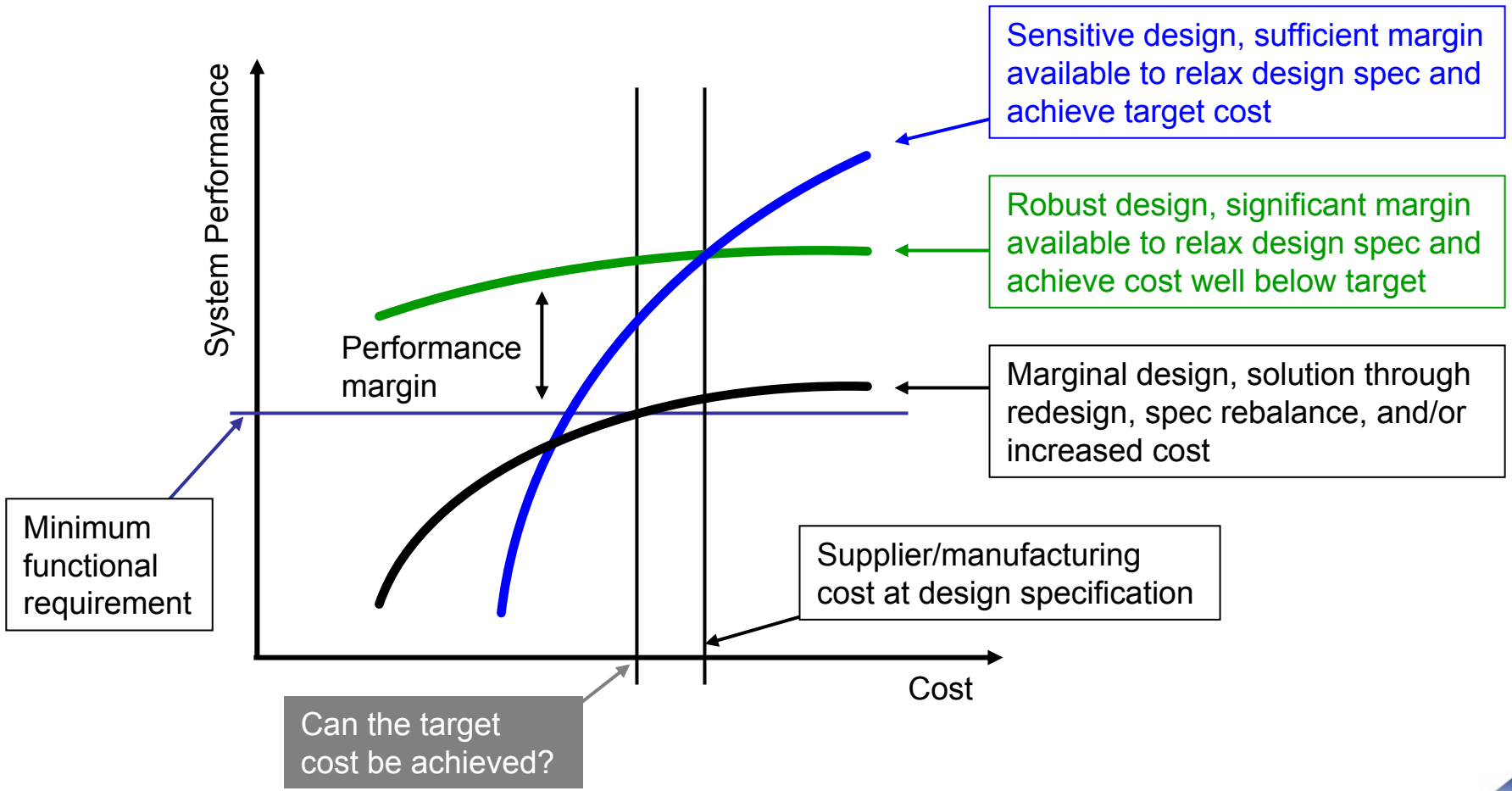
Designers know performance vs. tolerance, suppliers know cost vs. tolerance; neither know performance vs. cost—**communication between the two teams is necessary**



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Performance-Tolerance Trades: Design Expertise

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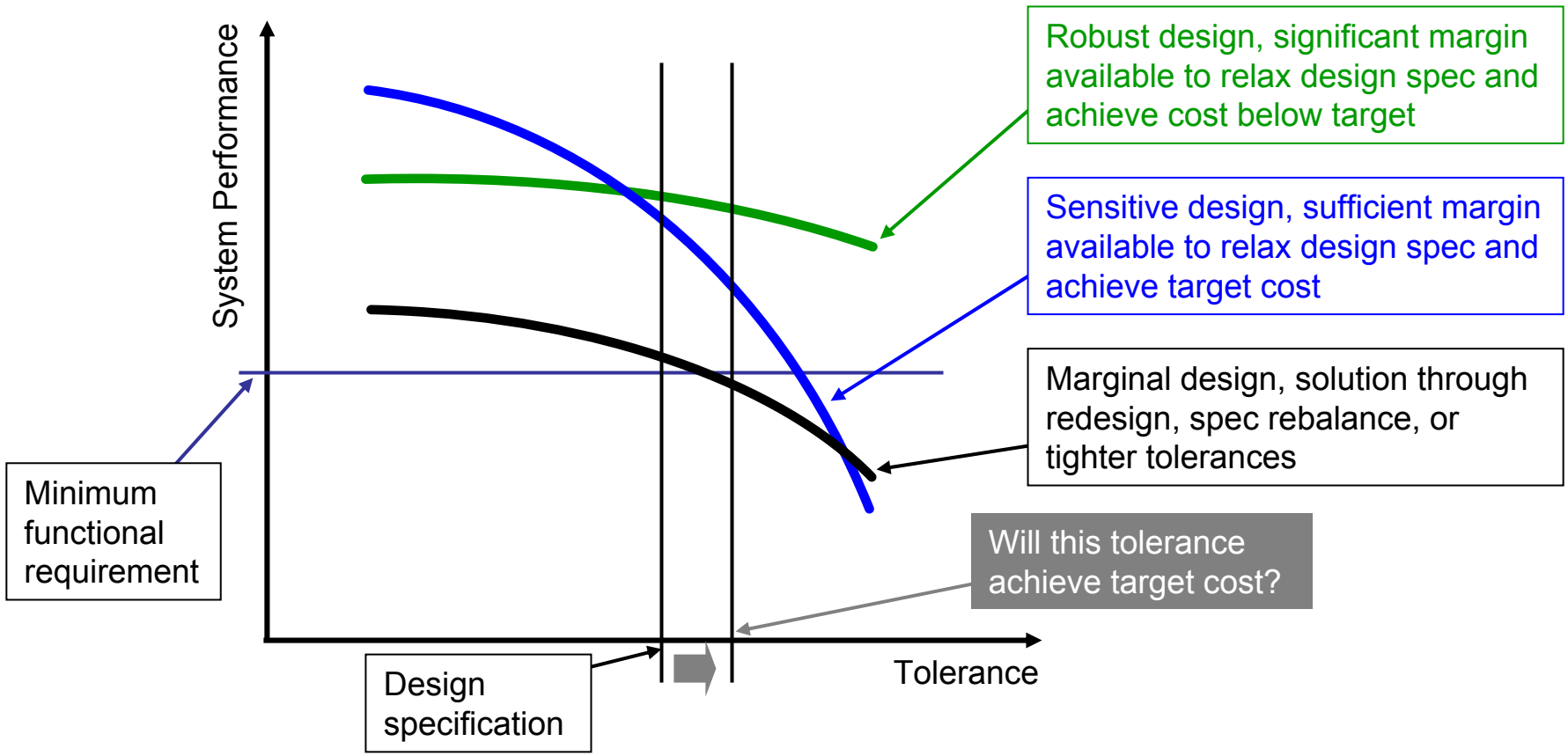
Performance margin defines the design tolerance required; different designs have different characteristics; **only designers will know if the performance-tolerance sensitivity is high**



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Cost-Tolerance Trades: Supplier Expertise

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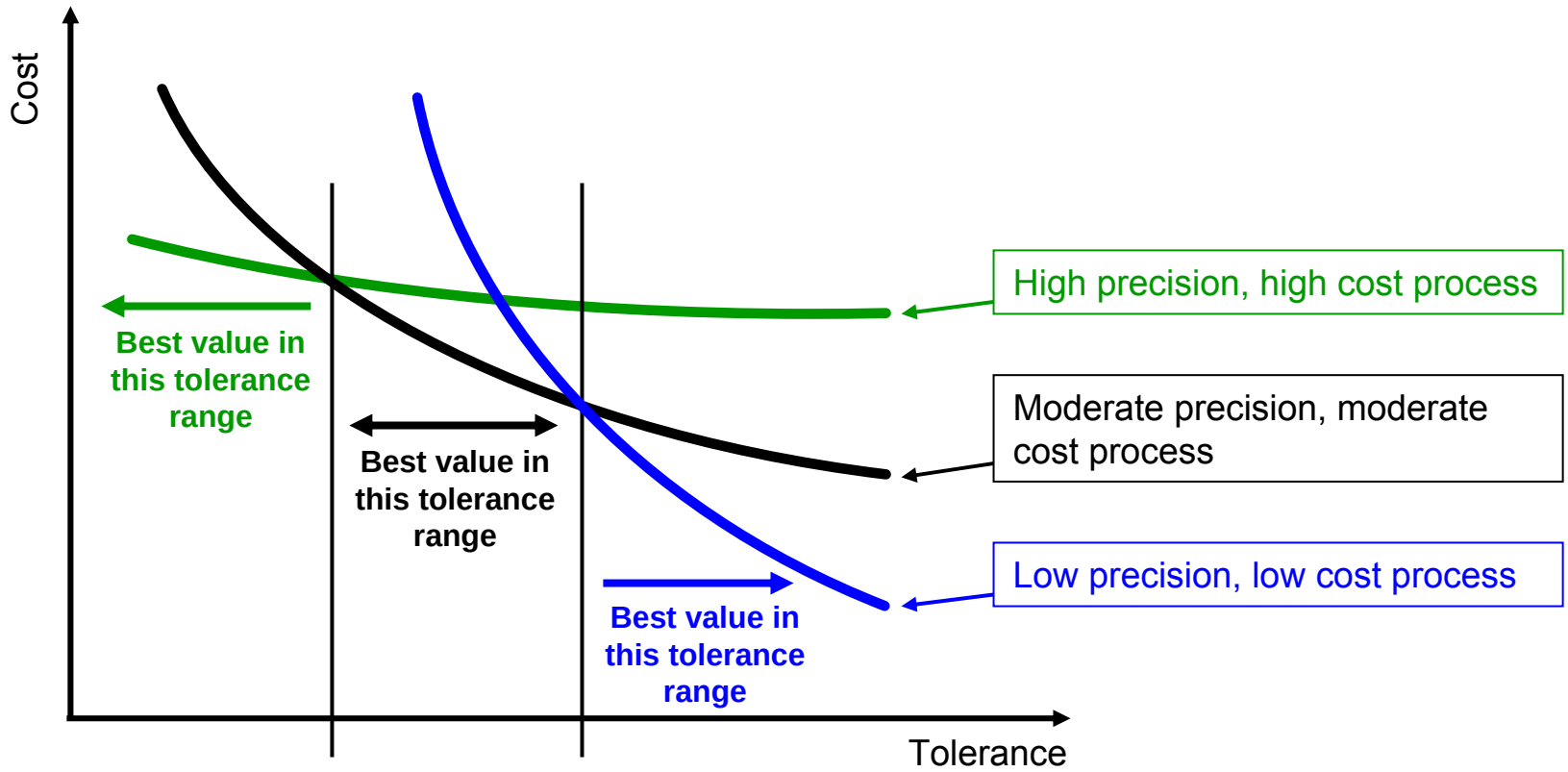
Design tolerance defines the process required; small changes in tolerance may allow alignment to lower cost processes; **only suppliers will know if the cost-tolerance sensitivity is high**



Flexibility in tolerancing can provide opportunities to align to lower cost processes; designers need to understand the cost-tolerance trade space

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DFM Review Content

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- Communicate knowledge of your process capabilities where there is conflict between capability and requirement
- Provide estimates of cost opportunities if requirements are relaxed
  - How will relaxation affect yield and yielded unit cost?
  - How will relaxation affect process selection and process cost/unit?
- Highlight manufacturability concerns and propose alternatives if possible
  - Unique or special processes
  - Difficult to use/procure materials
  - Difficult to measure performance requirements
  - Lack of commonality
- Low volume designs—incorporate supplier concerns and ideas for improving manufacturability
- Moderate to high volume designs—incorporate cost impact estimates of process capabilities, yields, scrap and rework cost relative to specifications

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DFM Example: Low Volume

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Review Objective:
Share knowledge of supplier process capabilities to optimize the design for producibility, cost and performance.
Supplier feedback/input for specific design requirements

Drawing/Spec Number:	HXXXXXX-1
System/Subsystem:	PDU
Component:	Mechanical Enclosure
Supplier Reviewer Name/Position:	Supplier Manufacturing Engineer, Supplier Applications Engineer
Raytheon Design Lead:	Raytheon Design Engineer

	Cost Driver				Supplier Feedback		
Item	Specification Section / Drawing Location	Description	Upper Limit	Lower Limit	Supplier Concern	Supplier Recommendation	Supporting Information/Impact
1	D3, Sheet 2	.0005 edge radius	0.0006	0.0004	Difficult to produce dimension	.001" x 45 deg chamfer	Easy to machine and maintain dimension
2	E2, Sheet 2	.0001 profile	0.0001		Special finishing process and tooling required to hold dimension; NRE req'd	0.00018 profile	Based on similar part HXXXXX-14
3	A4, Sheet 1	Assembled unit			Multiple plates for enclosing each side adds parts and touch labor	Reduce and combine cover plates - use as formed piece	Reduces screws in assembly 30 to 40%; reduces number of panels
4	C5, Sheet 3	Bracket			Mounting bracket to yoke adds parts and touch labor	Integrate brackets into machining of yoke	Reduces part count by 60 brackets and 120 screws, eases assemble less holding of parts
5	D2, Sheet 3	Cable divider			Cable divider to yoke adds parts and touch labor	Integrate cable divider support into yoke	Reduces part count by 36 fewer screws
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DFMA Review Template

Use the template to highlight to designers the cost-drivers caused by spec requirements, assembly requirements, special and/or expensive processes, etc.; propose your ideas on how to reduce cost, touch time, etc

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DFM Example: Med-High Volume

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Review Objective:
Share knowledge of supplier process capabilities to optimize the design for producibility, cost and performance.
Proposed specification changes and / or process and tooling changes to reduce cost

Drawing/Spec Number:	HXXXXXX-1
System/Subsystem:	PDU
Component:	Mechanical Widget
Supplier Reviewer Name/Position:	Supplier Manufacturing Engineer, Supplier Applications Engineer
Raytheon Design Lead:	Raytheon Design Engineer

	Cost Drivers: Specifications and Functional Requirements				Baseline Supplier Capability							Cost Reduction Opportunity: Spec and/or Process/Tooling Changes							
Item	Specification Section / Drawing Location	Description	USL	LSL	Current Process	Expected Average	Expected Std Devn	CpkU	CpkL	Expected Yield	Cost/% Yield Loss	Proposed Process	Proposed USL	Proposed LSL	Predicted Average	Predicted Std Devn	Process Cost Savings / Unit	Predicted Yield	Est Cost Oppty/Unit
1	A-4	Rod length	.18	16	End Mill	17	.2	1.67	1.67	100.0%	$ 0.12	New jig w/saw	18.5	15.5	17	0.45	$ 0.45	99.9%	$ 0.44
2	A-4	Rod diameter	0.35	0.25	Standard lathe	0.35	.1	0.33	0.33	68.3%	$ 0.05	Precision lathe	0.45	0.25	0.35	0.05	$ (0.05)	95.4%	$ 1.31
3	B3	Dimension B	1.20	1.195	End Mill	1.2	.0025	0.67	0.67	95.4%	$ 0.40	CNC	1.205	1.195	1.2	0.0005	$ (0.50)	100.0%	$ 1.32
4	B5	Radius	0.5	0.46	Drill press	0.48	.008	0.83	0.83	98.8%	$ 0.75	New jig	0.5	0.46	0.48	0.005	$ 0.05	100.0%	$ 0.98
5	C4	Dimension F	0.0875	0.0825	End Mill	0.085	.0025	0.33	0.33	68.3%	$ 0.55	CNC	0.0875	0.0825	0.085	0.0005	$ (1.25)	100.0%	$ 16.20
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Use the template to highlight to designers the cost-drivers and yield issues caused by spec requirements, process capabilities, assembly requirements, etc.; propose your ideas on how to reduce cost, touch time and/or improve yield

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Call to Action

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- Provide a DFM review of incoming designs to clearly communicate your manufacturing capabilities, design cost drivers, concerns, exceptions and any opportunities for cost and risk reduction
  - Suppliers have the fabrication, assembly and test expertise—how much variation each of their processes create
  - Designers have the system performance expertise—how variation in the design affects performance
  - Both inputs are required to optimize cost and minimize risk
- Share knowledge of your process capabilities with our designers to optimize any design for producibility, cost and performance

Suppliers must help designers understand how their requirements drive product cost, schedule and quality risk—and where improvement opportunities exist

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References and Resources

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Textbooks:

- Product Design for Manufacture & Assembly: Boothroyd, Dewhurst & Knight
- The Mechanical Design Process: Ullman & Ullman

On the Web:

- www.dfma.com

Questions??? Ask the expert at mailto::dfss@raytheon.com

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