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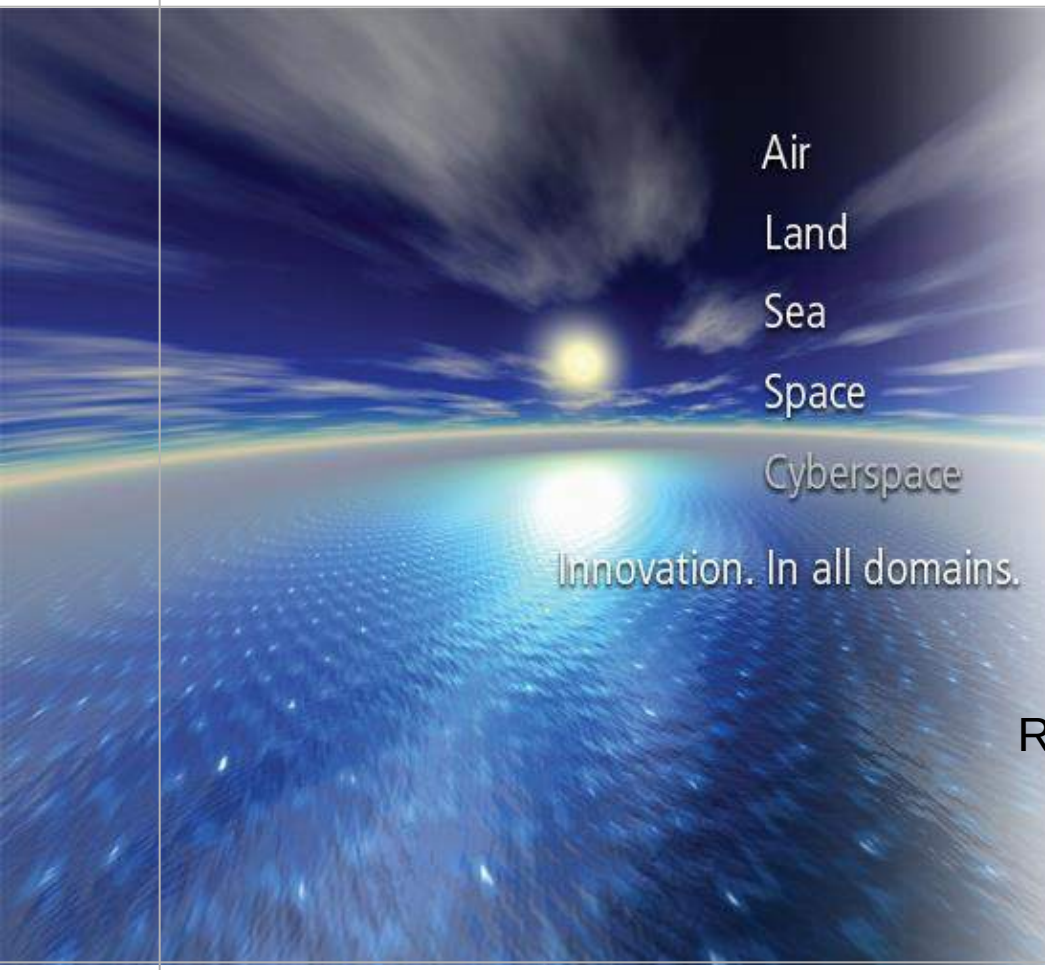
Customer Success Is Our Mission



Building a Complex Hardware Cost Model for Antennas

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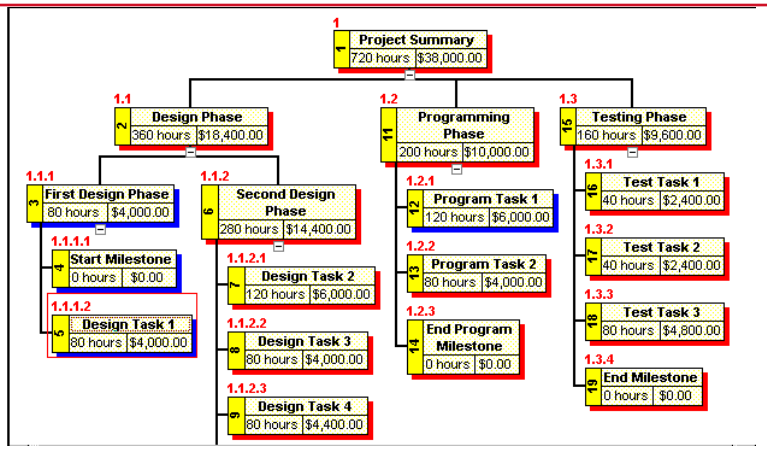
Raytheon Space and Airborne Systems
4/13/2014

To drive standardization, integration, implementation, and optimization of SAS processes, measures, and resources to achieve proven Mission Assurance.

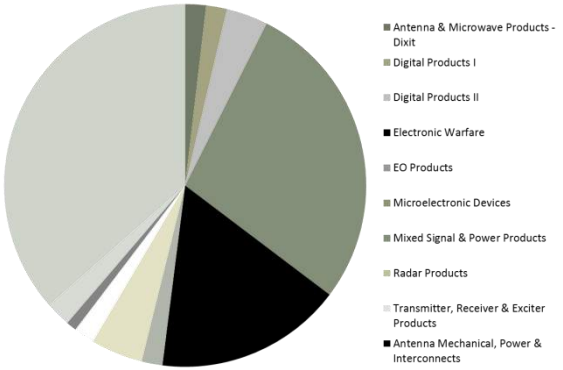
Introduction: An Erector Set Analogy

Challenges of Product Level Cost Model Development

A. Government DOD Contractor Challenge (Cost)
   1. Customer expects WBS
   2. Engineering works to PBS
   3. Must untangle cost relationship between WBS and PBS



B. Internal Organizational Challenge (Cost)
   1. Matrix organizations make collecting product level costs problematic
   2. Matrix organizations in flux are even more problematic
   3. Must unmix organizational data from product data



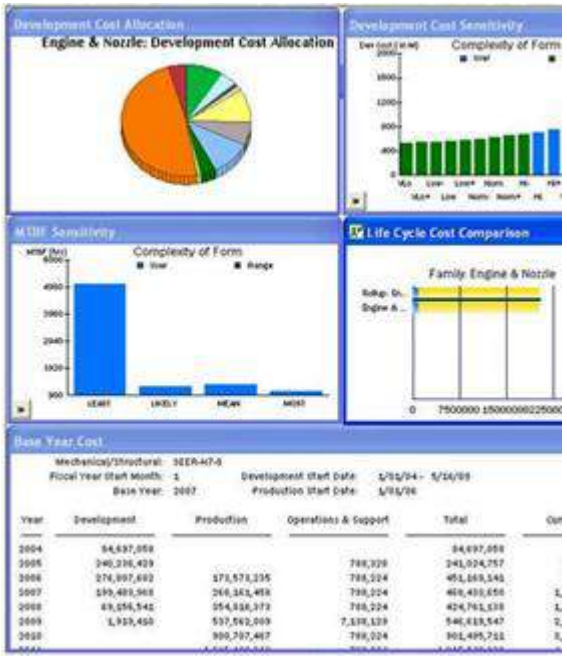
C. Must Get Agreement on Cost Drivers (Size)
   1. Costs are causal
   2. Key size and scaling factors are causing factors

Challenge of Bidding Work With Commercial Cost Models

A. Strengths of Commercial Cost Models
   1. Great at getting the bid in the ballpark
   2. Great for tops down, reduced cost, bidding
   3. Great for organizing bid into PBS
   4. Great for remembering the hidden costs that are often forgotten

B. Weaknesses of Commercial Cost Models
   1. Strong matrix organizations argue over allotment
   2. Tend to not have a good grasp on todays technology (maybe a few years old technology)
   3. No flags for items with wide variance in costs tasks such as a performance threshold for ASIC
   4. Jobs are performed bottoms up

C. Observations of Commercial Cost Models
   1. Great for ROMs!
   2. Should be calibrated for actual bids
   3. Possible disconnect between bid and performance



Connecting Tops Down With Bottoms Up

A. Cost Model Connecting Gate 3 (ROM) to Gate 4 (actual bid)

1. Gate 3 ROM is organizational independent
2. Gate 4 is organizational and execution dependent
3. Cost Model must bridge this gap
4. Cost Model must also provide flags for high cost variance items that can drive architectural and performance trade offs
5. Cost and size must be based on historical actuals

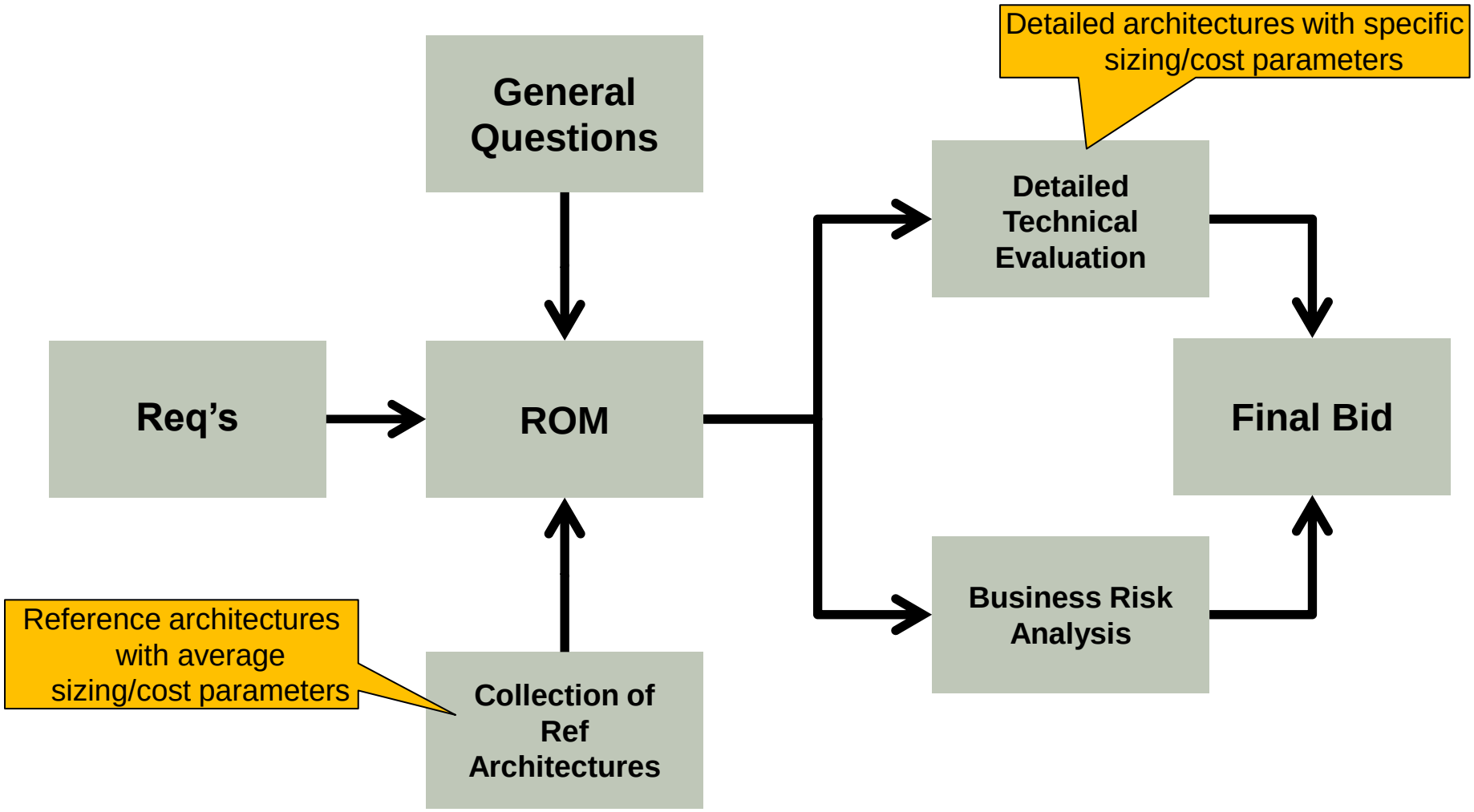
B. Cost Model Connecting Gate 4 (actual bid) to Gate 5 (plan after win)

1. Must be detailed enough to provide cost details for execution plan
2. Must be flexible enough to account for organizational changes

C. Cost Connecting Gate 5 (plan after win) to Execution

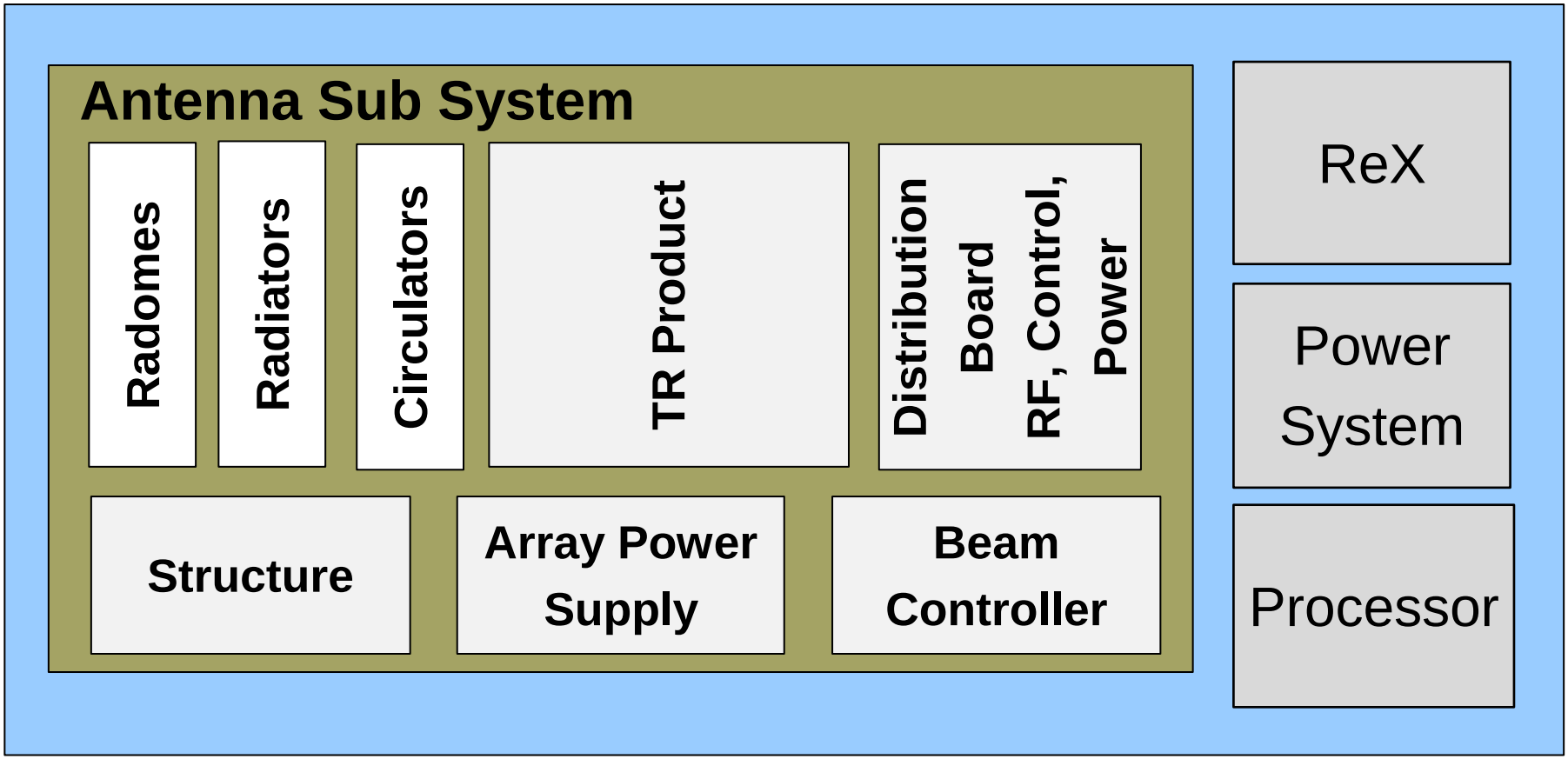
1. Must apply to EACs also!
2. Must have standardized cost and size collection forms
3. Must be able to rapidly evolve with technology

Synergistic "Bottoms Up" Cost Estimation Approach



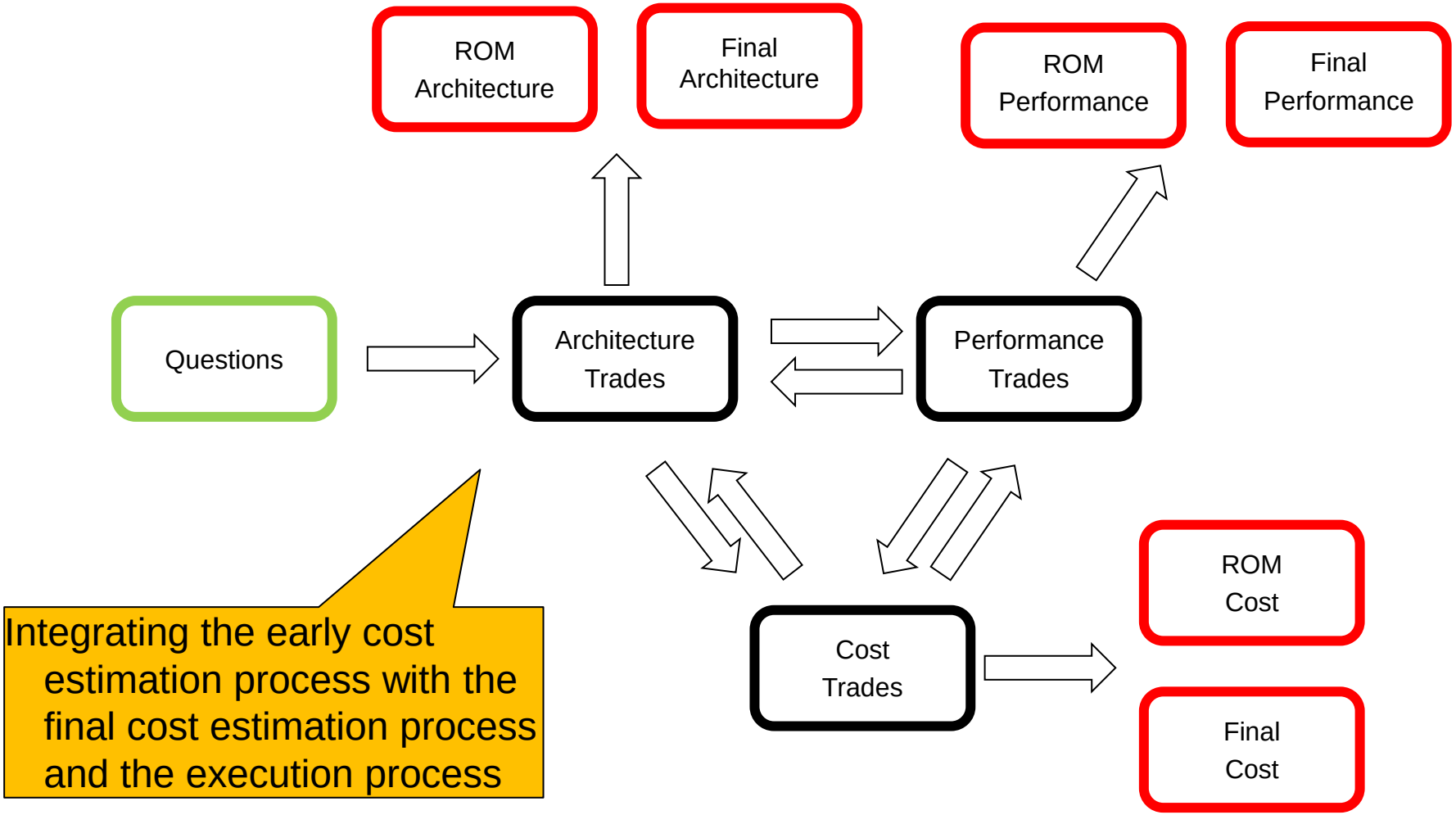
Beginning With a Standard Reference Architecture

Radar Functional Block Diagram – Generic and applicable to any Program



Consistent Product Structure

Overall Antenna Cost Estimation Process



Getting to a ROM Architecture

Questions

	A	B	C	D
1				
2		**Requirements**		
3				
4	Bandwidth & Frequency			
5		What is the tunable bandwidth		1
6		What is the instantaneous bandwidth		2
7		Feed/distribution to the back end		3
8	erp			
9		elemental power		4
10		What is the number of elements		5
11	swap			
12		input power (input to PCU)		6
13		cooling		7
14		weight		8
15		volume (depth)		9
16				
17				
18	Electrical Performance			
19		What is the NF of the Receiver		10
20		system nf		11
21				
22	Architecture			
		Aperture		12
		rcs (cross section)		13
		stearable apertures		14
	BSC			
		architecture		15

Simple set of high level questions answered using rough requirements

ROM
Cost

Architectural Trade-offs

ROM Architecture

ROM Performance

Questions

Architecture Trades

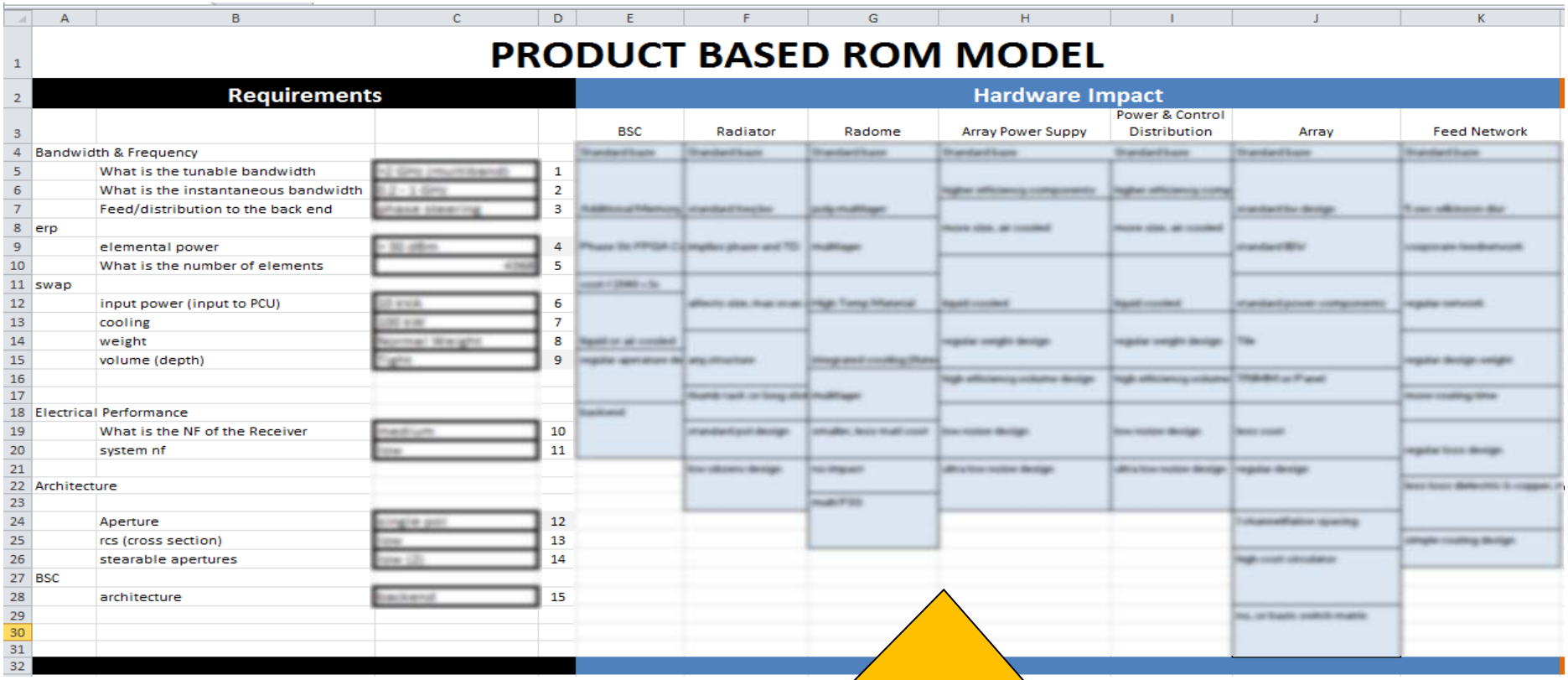
Performance Trades

Cost Trades

ROM Cost

Answers to questions drive choice of architecture of antenna (panel, tile, etc.) which drives cost

Flexible Reference Architecture Key to Result



	A	B	C	D	E	F	G	H	I	J	K
1	PRODUCT BASED ROM MODEL										
2	Requirements				Hardware Impact						
3					BSC	Radiator	Radome	Array Power Suppy	Power & Control Distribution	Array	Feed Network
4	Bandwidth & Frequency										
5		What is the tunable bandwidth		1							
6		What is the instantaneous bandwidth		2							
7		Feed/distribution to the back end		3							
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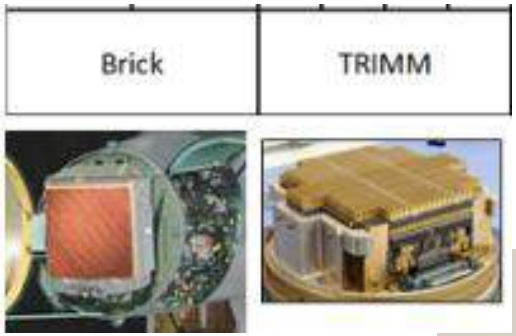
26		stearable apertures		14							
27	BSC										
28		architecture		15							
29											
30											
31											
32											

Specific antenna architecture with specific sub products related to that architecture with average cost driving parameters

Still Top Down Cost Estimation



ROM Architecture

ROM Performance

Questions

Architecture Trades

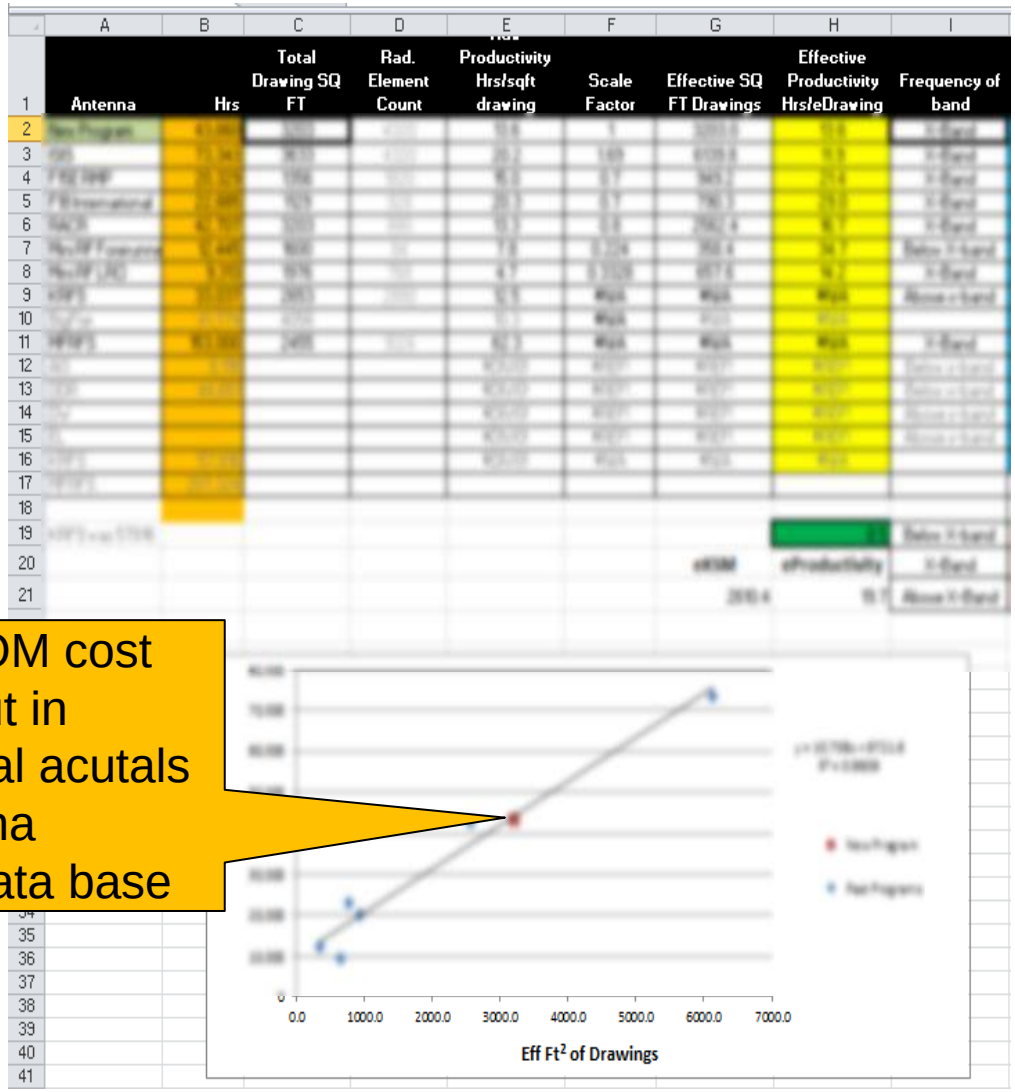
Performance Trades

Cost Trades

ROM Cost

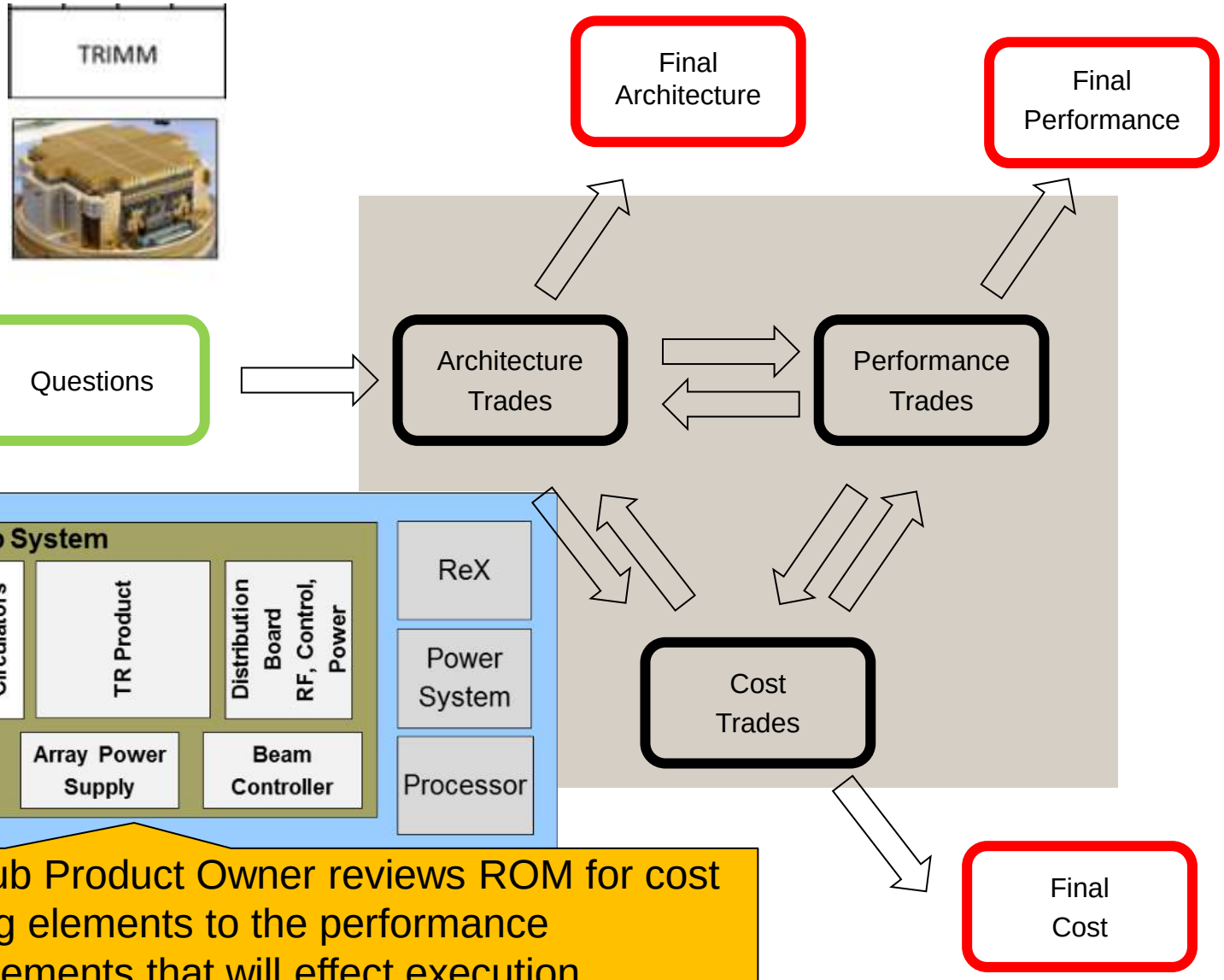
High level cost trades based on answers to questions and customer needs

Result of the ROM Bidding Process



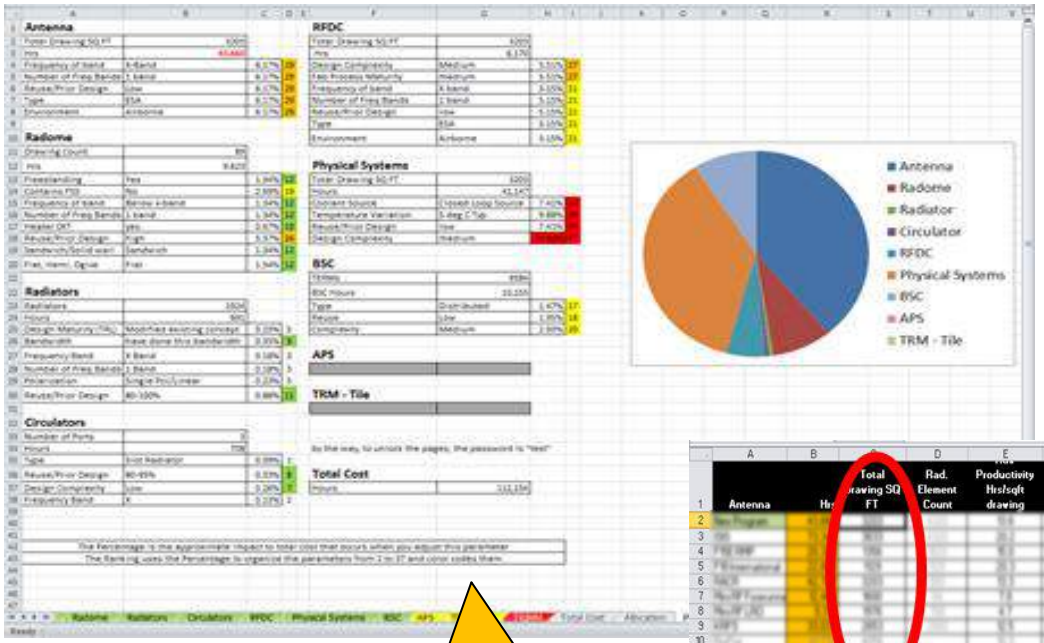
Effort results in a ROM cost estimate that is put in context of historical acutals of previous antenna programs in the data base

Moving to the Final Cost Estimate

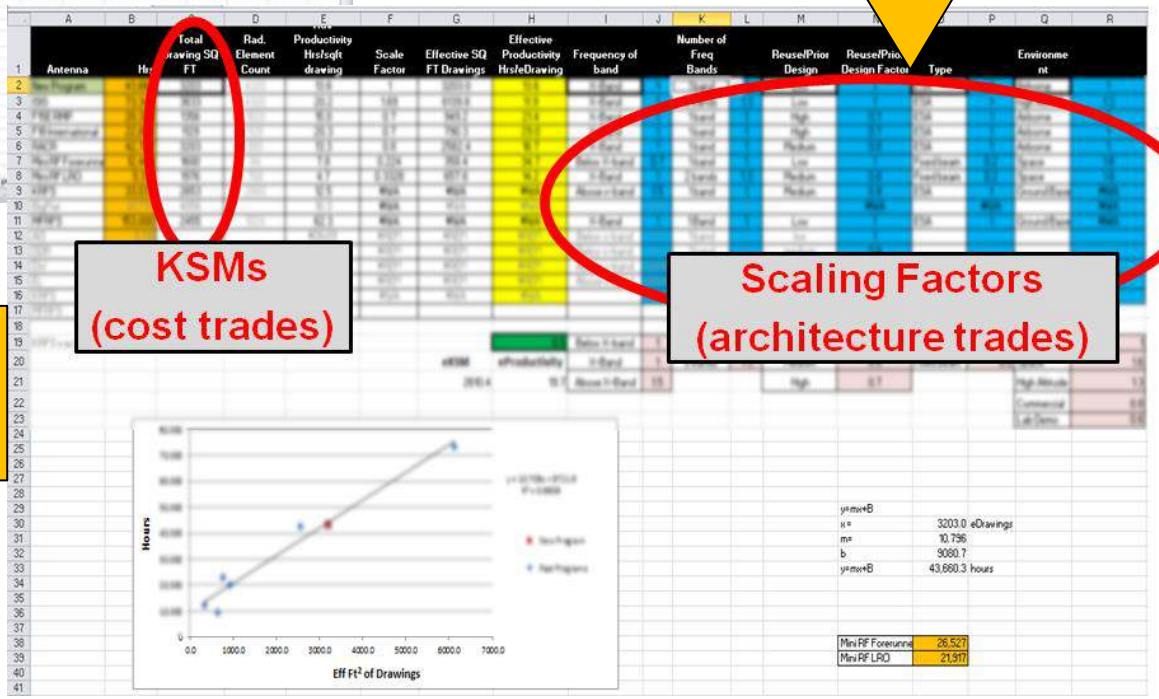


Each Sub Product Owner reviews ROM for cost driving elements to the performance requirements that will effect execution

Expert Review of the ROM Cost Estimate



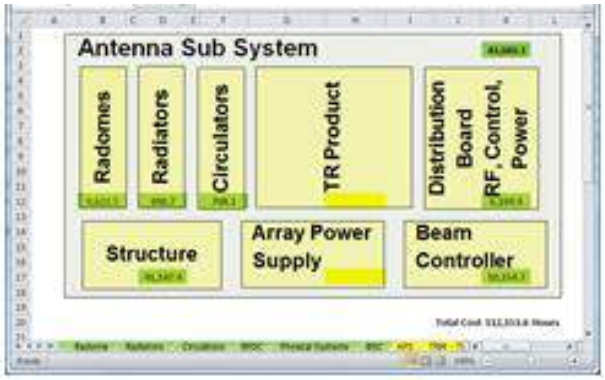
Pre-populated size factors of each subproduct from the ROM is now reviewed in detail for applicability to the final bid



Cost Model maintains running bid total of updated subproduct cost information

Final Basis Of Estimate is Based on Historical Actuals

Final Cost Totals



Final Cost Subproduct Allocations

Final Architecture With Sizing Parameters

Review Tops Down, Bottoms Up Approach

15 Questions: High level, Product Requirements

Hardware Impact

Start

Antenna Sub System

Radomes | Radiators | Circulators | TR Product | Distribution Board RF, Control, Power | Structure | Array Power Supply | Beam Controller

PRODUCT BASED ROM MODEL

Requirements | Hardware Impact

			BSC	Radiator	Radome	Array Power Suppy	Power & Control Distribution	Array	Feed Network
6	What is the instantaneous bandwidth	0.2 – 1GHz	2						
7	Feed/distribution to the back e	phase steering	3						
10	What is the number of element	> 30 dBm / 4368	4 / 5						
12	input power (input to PCU)	10 kVA	6						
13	cooling	100 kW	7						
14	weight	Normal Weight	8						
15	volume (depth)	Tight	9						
18	Performance								
19	What is the NF of the Receiver	medium							
20	system nf	low							
34	Labor Hours	279,546		40,076	13,795	34,487	32,727	22,968	94,213	5,750
35	Labor Dollars	$46,125		$6,613	$2,276	$5,690	$5,400	$3,790	$15,546	$949
36	ODC/Material Dollars	$263								
37	Total Dollars	$61,470								
38	Man Months	1,732								
42	Labor Hours			11,726		27,245	25,691	17,315		
43	Labor Dollars			$1,935		$4,495	$4,239	$2,956		
44	ODC/Material Dollars									
45	Total Dollars									

Rapid Cost Determination

Total Cost. Based on Actuals

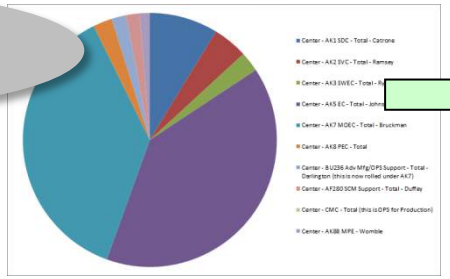
Level 3 Cost. Based on Actuals

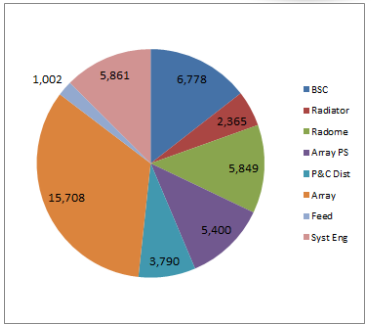
Priced To Win?

Design To Cost sensitivity calculations

Top Down Cost Reviewed by Sup Product Owner

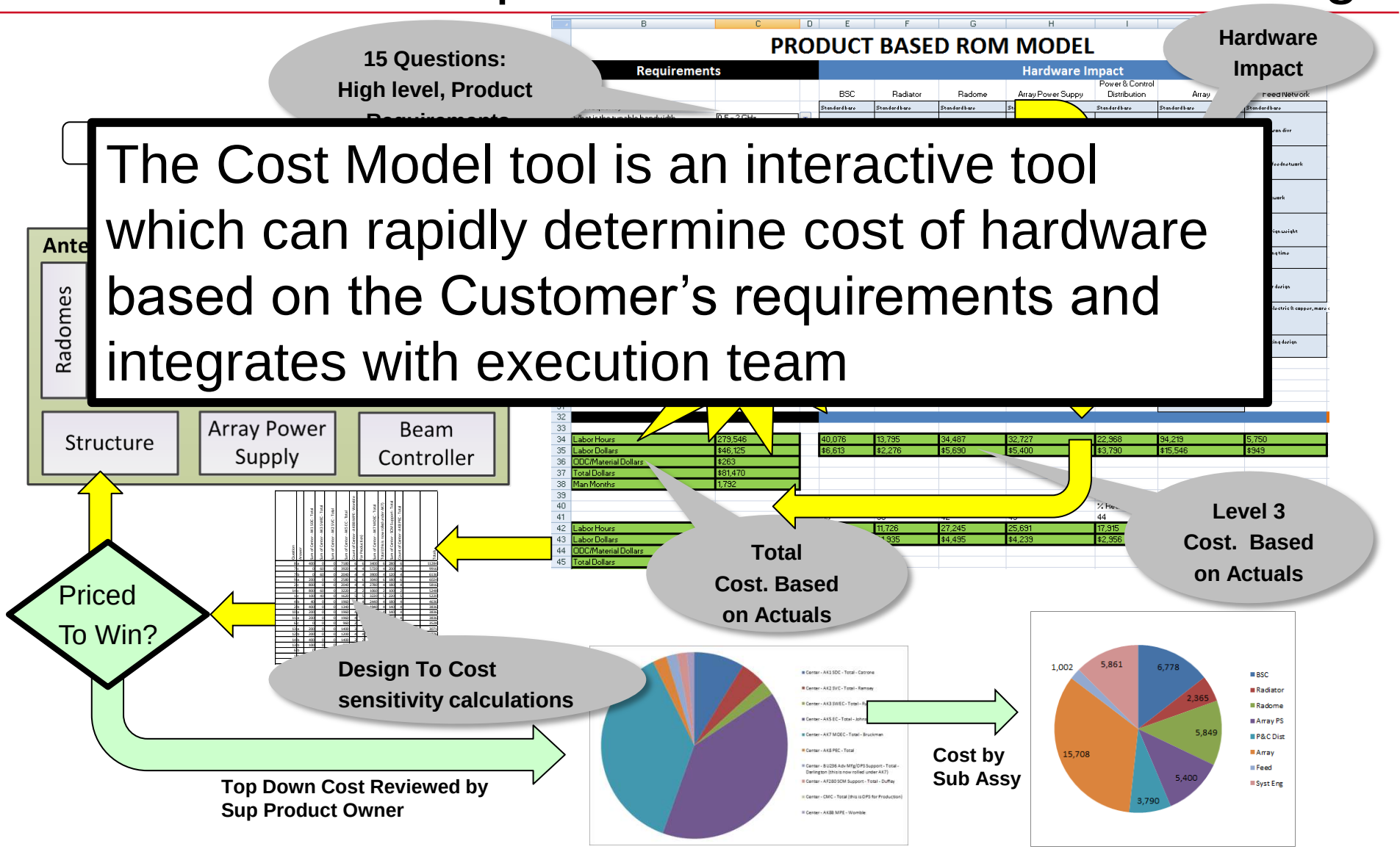
Cost by Sub Assy



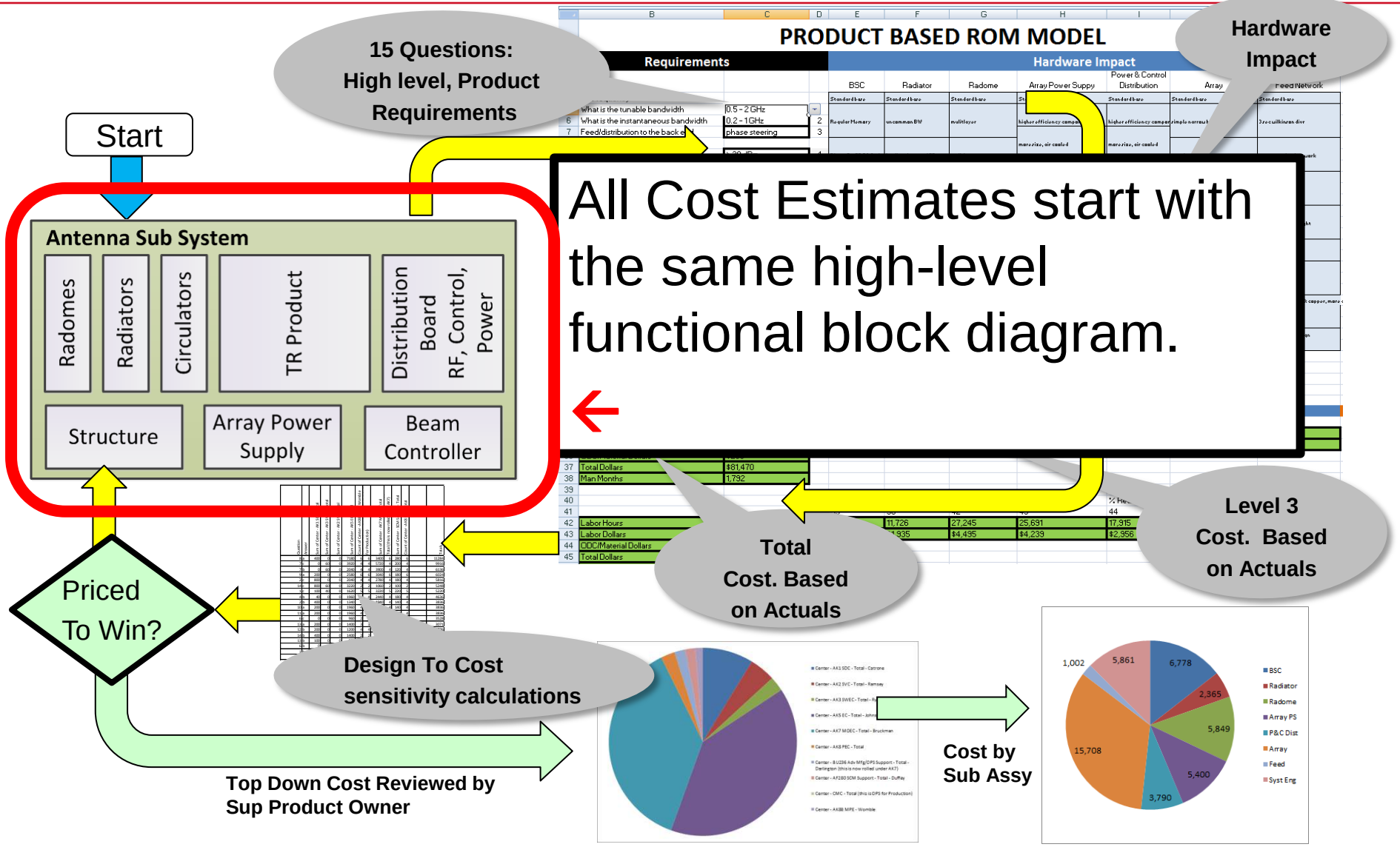


Cost Models – Tops Down, Model Based bidding

The Cost Model tool is an interactive tool which can rapidly determine cost of hardware based on the Customer's requirements and integrates with execution team

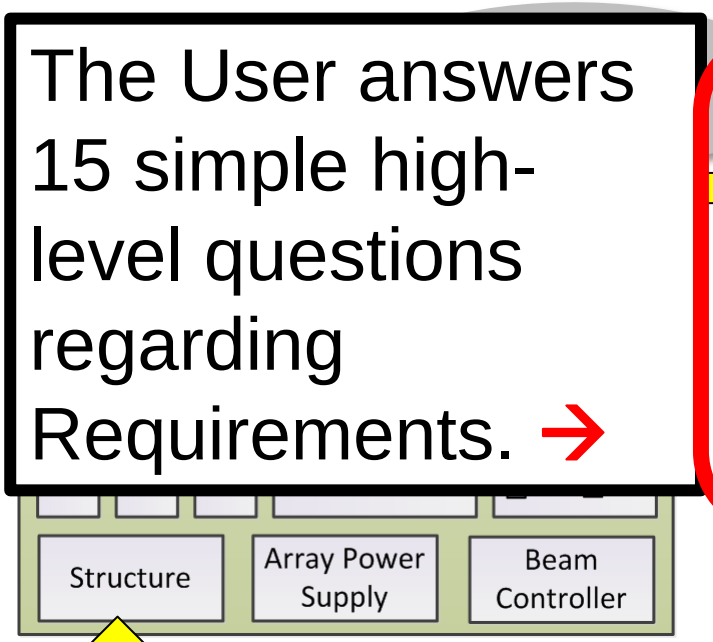


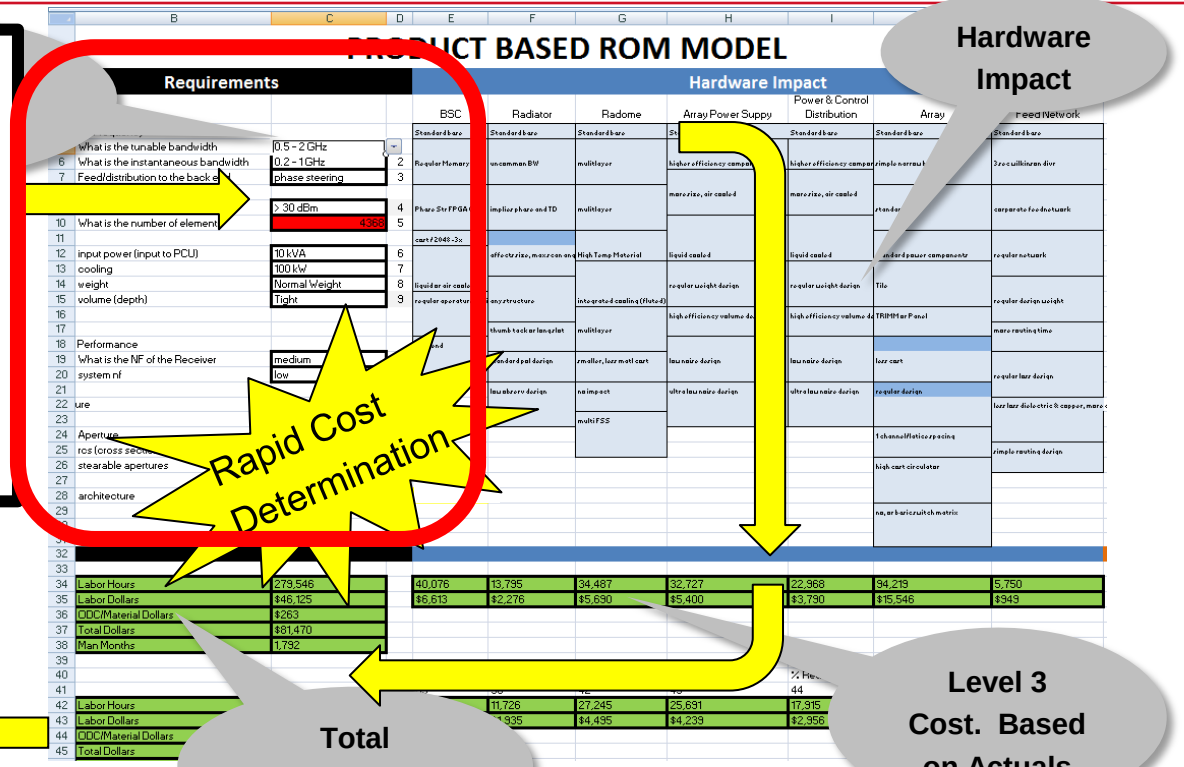
Cost Models – Tops Down, Model Based bidding

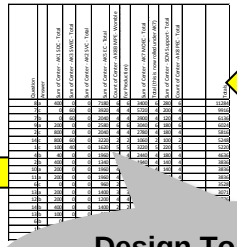


Cost Models – Tops Down, Model Based bidding

The User answers 15 simple high-level questions regarding Requirements. →



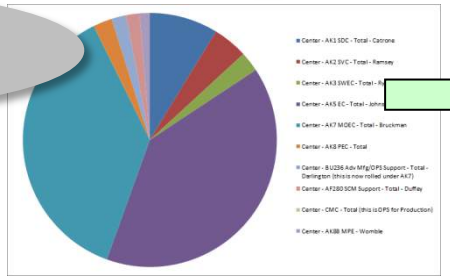




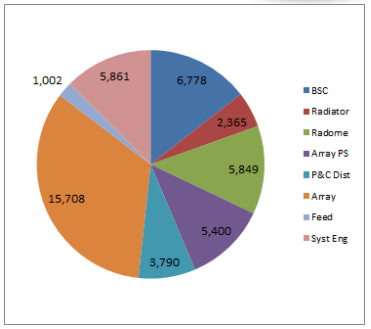
Priced To Win?

Design To Cost sensitivity calculations

Top Down Cost Reviewed by Sup Product Owner

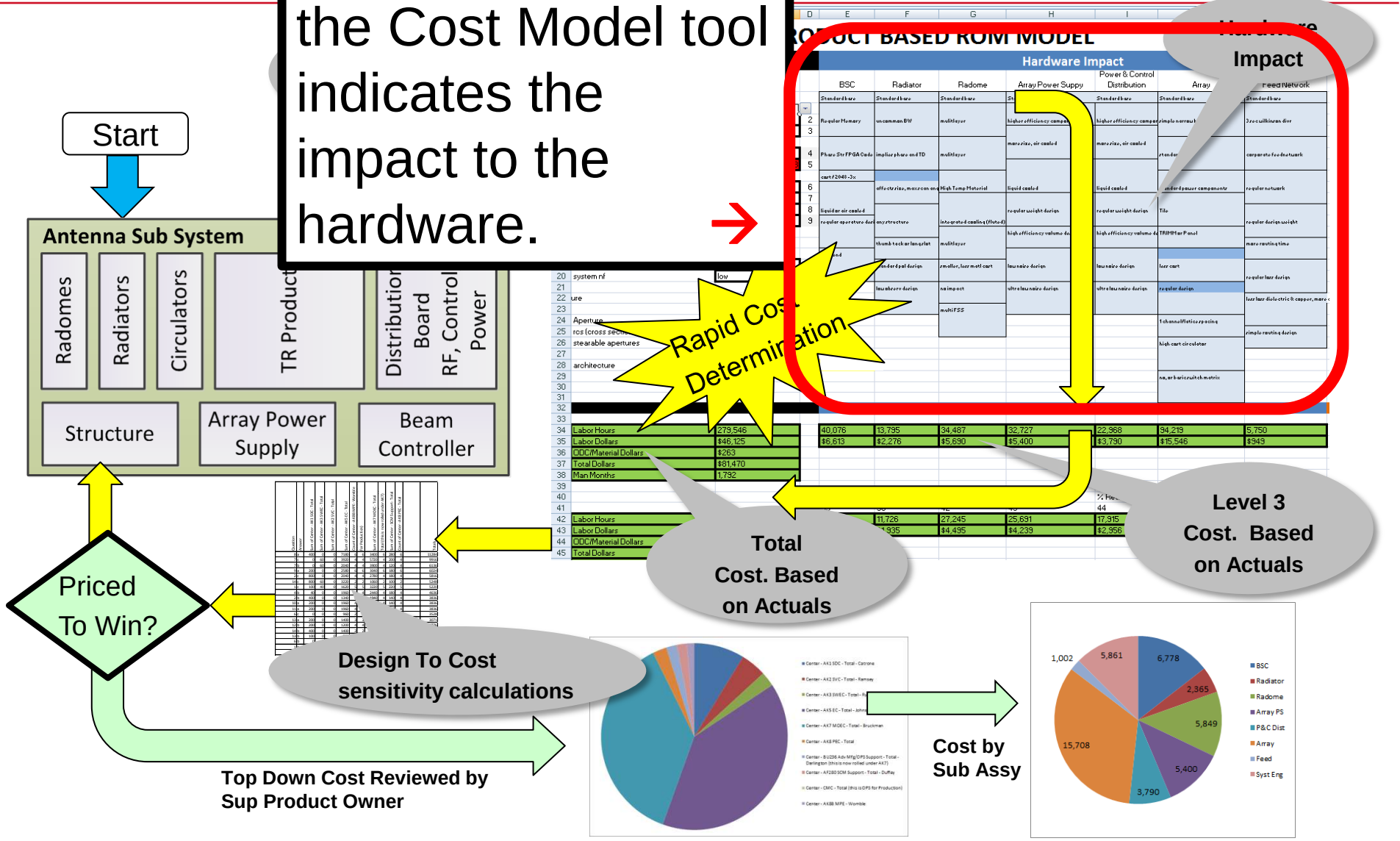


Cost by Sub Assy

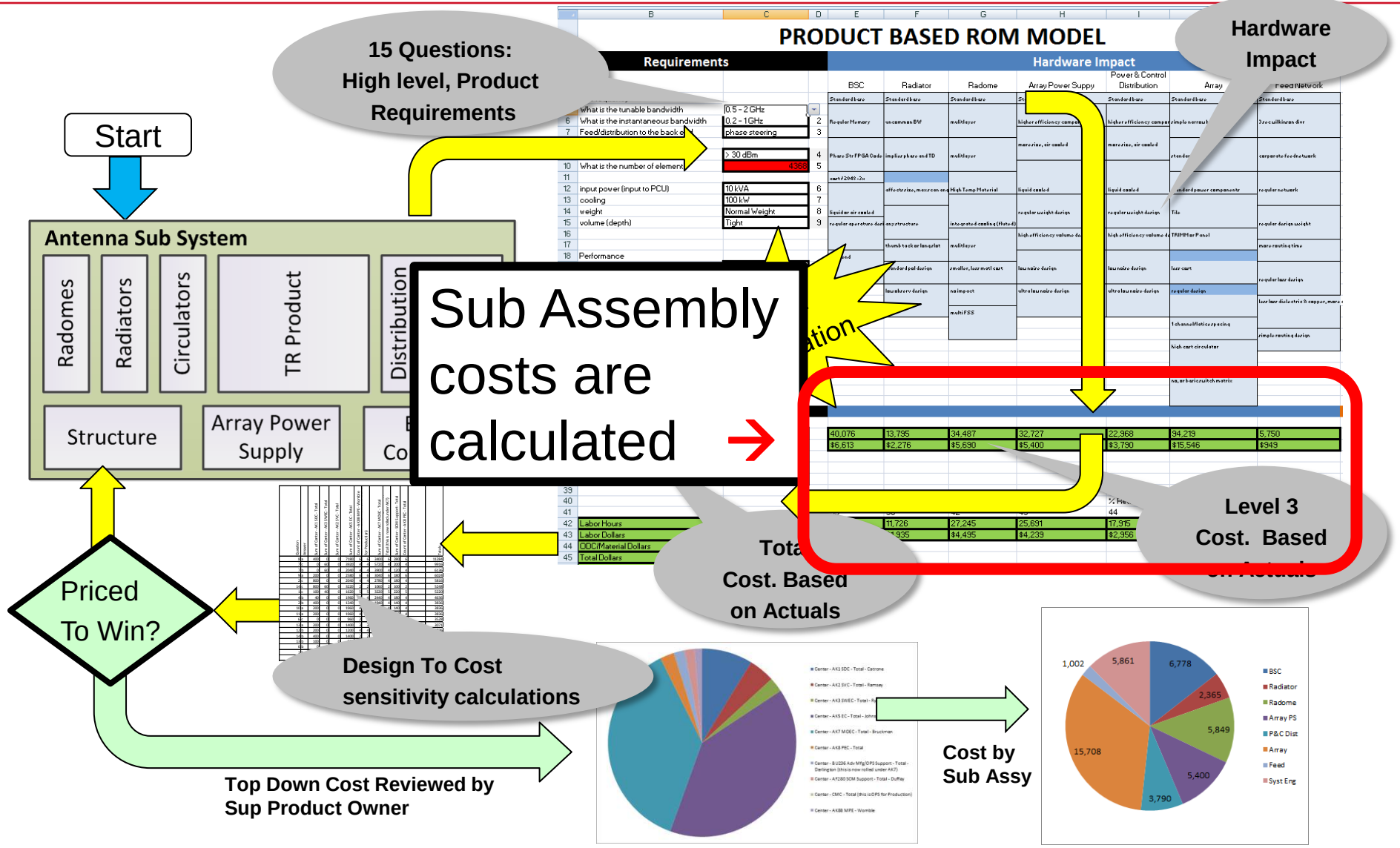


Cost Mod Model Based bidding

From the answers, the Cost Model tool indicates the impact to the hardware.



Cost Models – Tops Down, Model Based bidding



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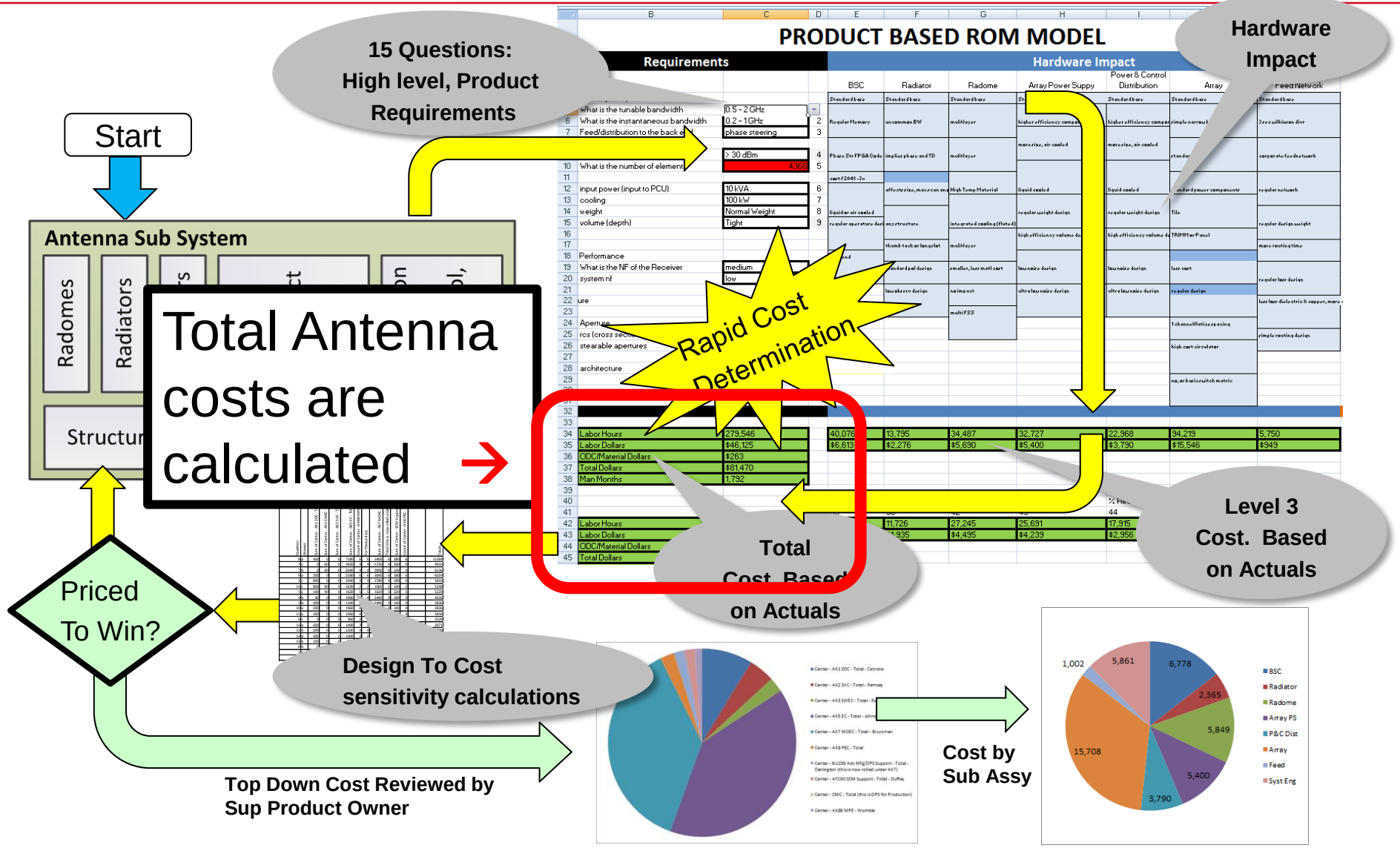
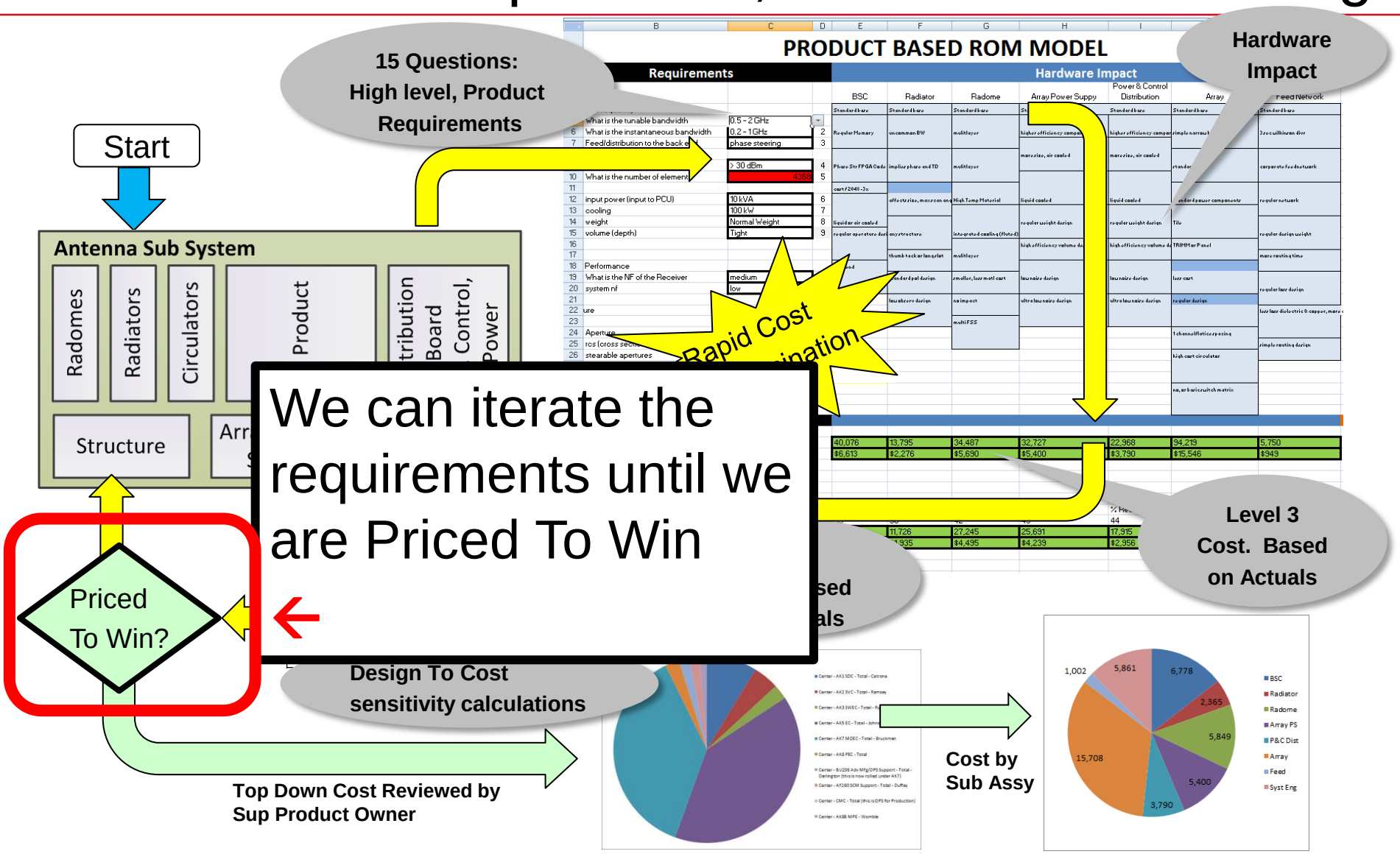


Cost Models – Tops Down, Model Based bidding



Concluding Comments

- Strengths
  - Integraded ROM/Final Bid/Execution planning
  - Historical Actuals based
  - Organizational roles accounted
  - Quantitative complexity factors
  - Very fast
  - Accuracy
- Weaknesses
  - Data collection burdensome
  - What is easy to use is also easy to abuse

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Backup and alternative slides