Satellite Ground System Cost Benefit Trade-Offs of Commercial Off-The-Shelf Items Using Parametric Cost Models

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Topics

- Satellite Ground Station Architecture
- Non Developmental Items
- Commercial Off-The-Shelf (COTS) Items
  - COTS Criteria
  - COTS Decision Making
- COTS and Software Development
- Estimating COTS Integration Using Parametric Cost Models
- Cost/Schedule Benefit Trade-Offs
- Summary

Satellite Ground Station Architecture

Todays World

- Low life cycle costs mandatory for ground station operations
  - Needed for Classified, DOD, NASA, and commercial satellites
  - Covers all phases: Acquisition, Operations, and Sustainment

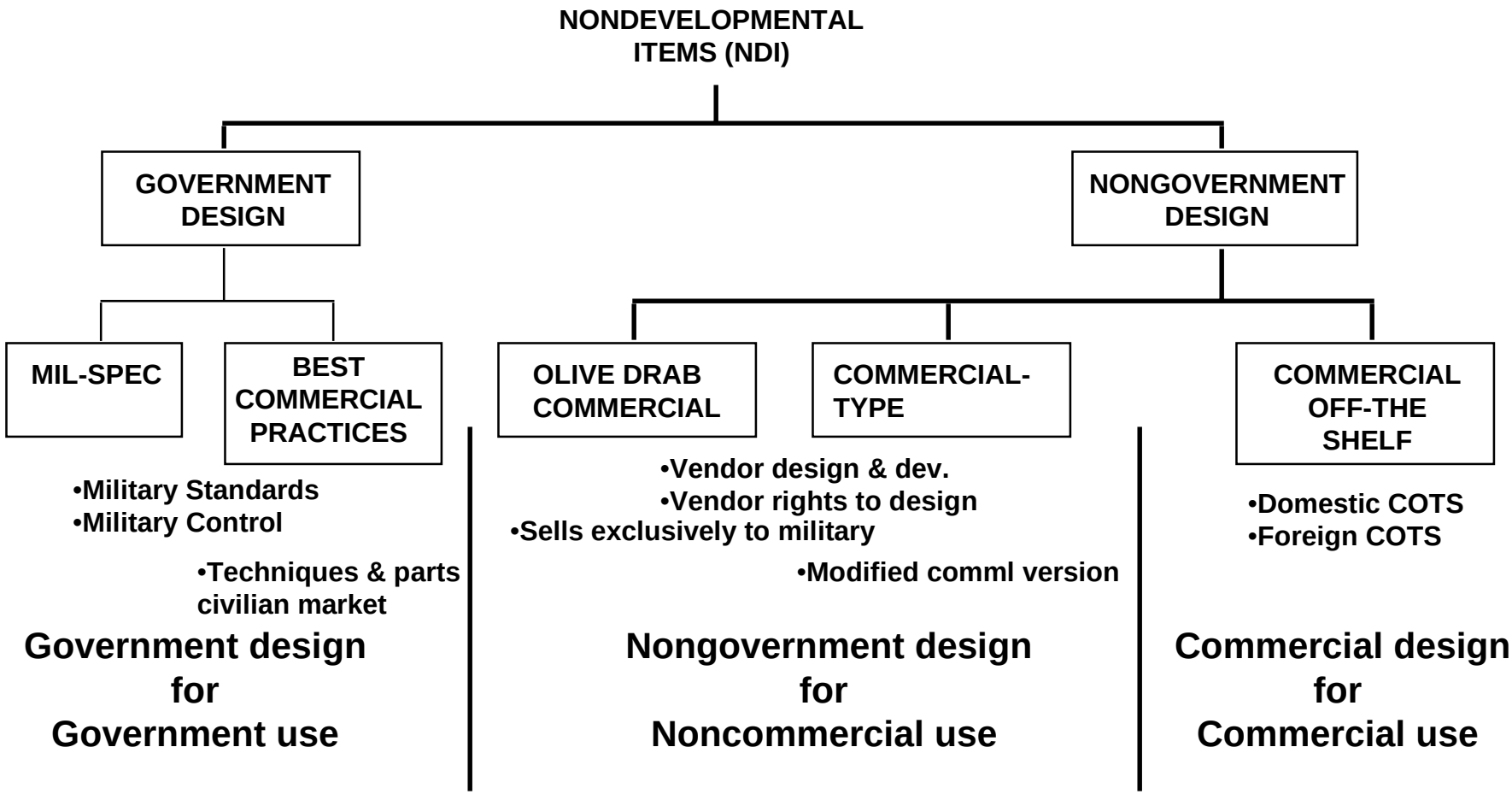
Features Desired:

- Multiple missions controlled by a single control center
- Multi-constellation controlled from single workstation
- Automated ground resource management
- Standard Human Computer Interface
- Open, distributed object oriented architecture, COTS
  - Plug'n Play from different vendors
- Database table driven

Ground Station Architecture and Use of Commercial Items

- More and more commercial equipment and software are being mandated by the military for integration into ground station architecture
- Front-end acquisition advantages of lower research and development cost and less time to field than MIL-SPEC designs
  - Benefit from the economies of dealing in a high-volume civilian market
- However, improper handling of COTS can cause long-term problems in mission performance and support that may more than erase initial advantages
- Evaluation criteria can assist in deciding when to use commercial products and when to develop MIL-SPEC items

Non Development Item Hierarchy



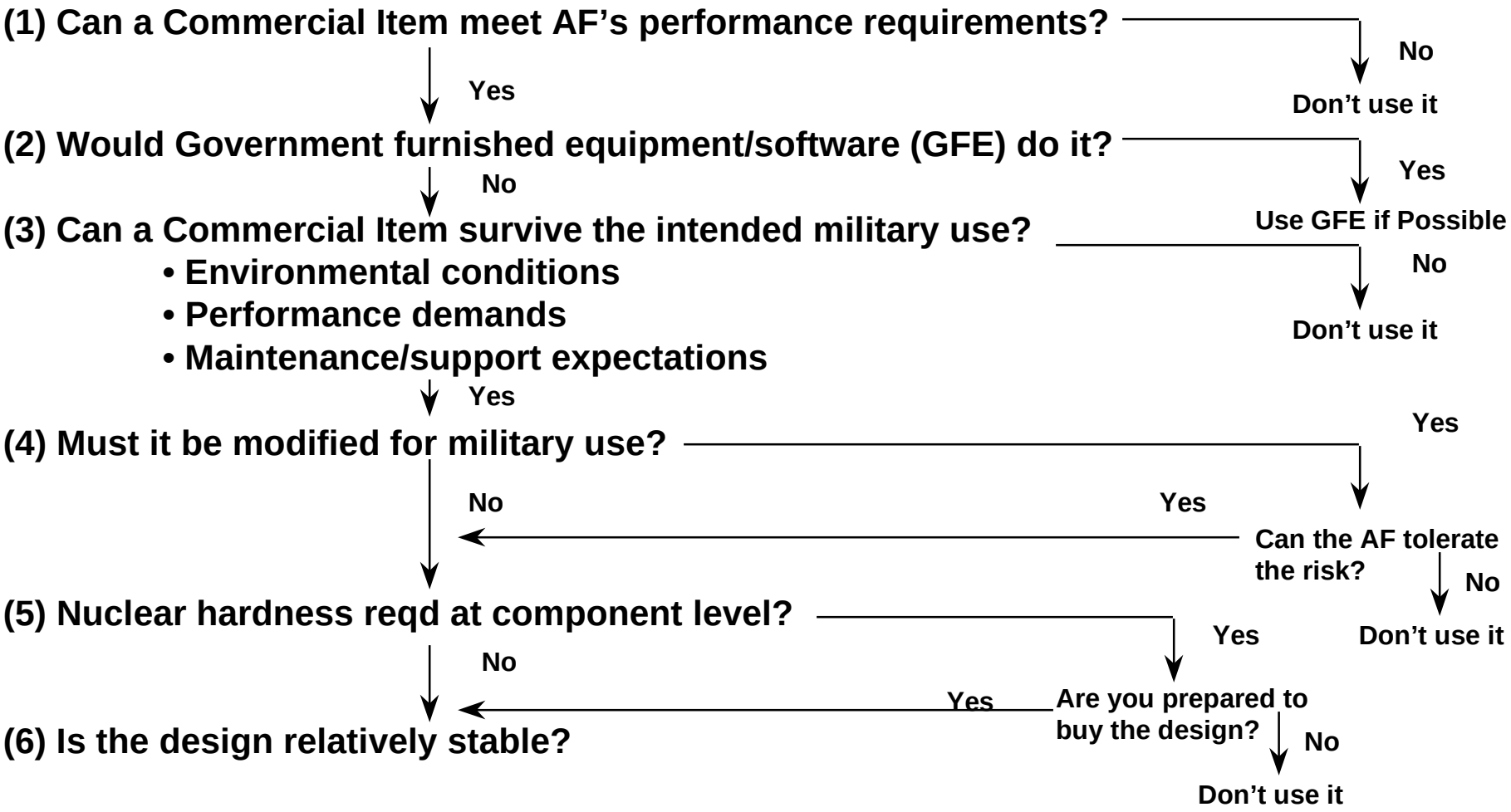
The Commercial Spectrum

	MIL-SPEC	BEST COMMERCIAL PRACTICES	OLIVE DRAB COMMERCIAL	COMMERCIAL-TYPE ("Special")	COTS
DESIGN FEATURES	Govt: Militarized	Govt: Not Militarized	Commmercial: Just for Govt	COTS: Mod for Govt	For Civil Market
EXAMPLES	Fighter Aircraft	Fixed Ground Radio	Tactical Radio	Embedded Computer	Television Monitor
% OF SALES TO GOVT	100%	100%	Probably 100%	Small (of basic items)	Small
DESIGN DISCLOSURE	Full (piece part)	Full (piece part)	F3 (Form, Fit and Function) & Full	F3 with some disclosure	F3
CONFIG. AUTHORITY	Government	Government	Vendor	Vendor	Vendor
DESIGN STABILITY/ RISK	Low	Low	Moderate to low	Low to High	Low to High
LONG-TERM SUPPORT/ COST RISK	Low	Low	Moderate	Low to High	Low to High

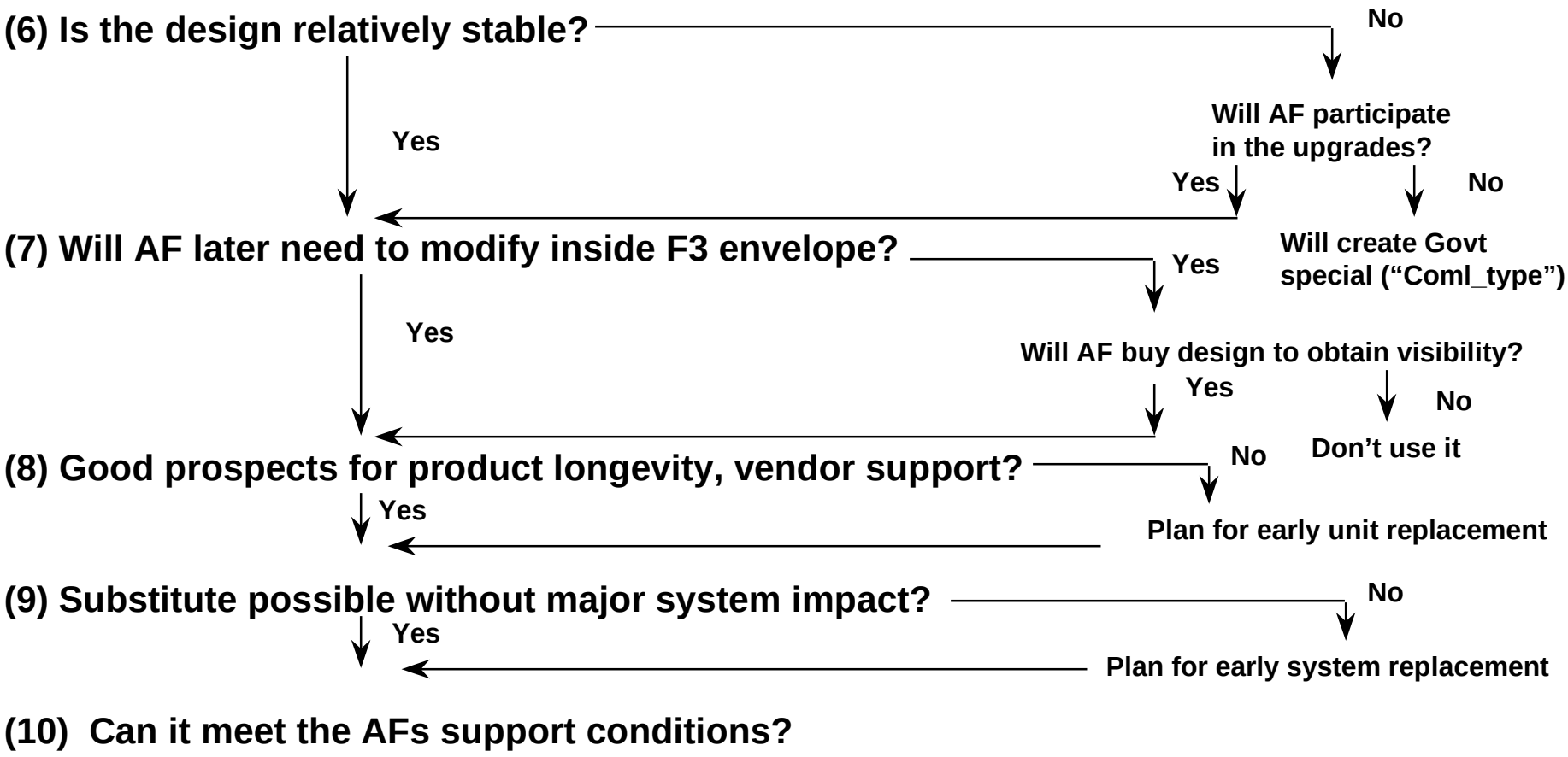
COTS Evaluation Criteria

- Can a commercial item meet ground station performance requirements? (Will it do the job or only partially?)
- Would government furnished equipment (GFE) do the job?
- Must it be modified for military use?
- Can it survive intended military use?
- Is the design relatively stable?
- Good prospect for product longevity, vendor support?
- Is product replacement possible without a major system impact?
- Is a COTS product the lowest-cost alternative?

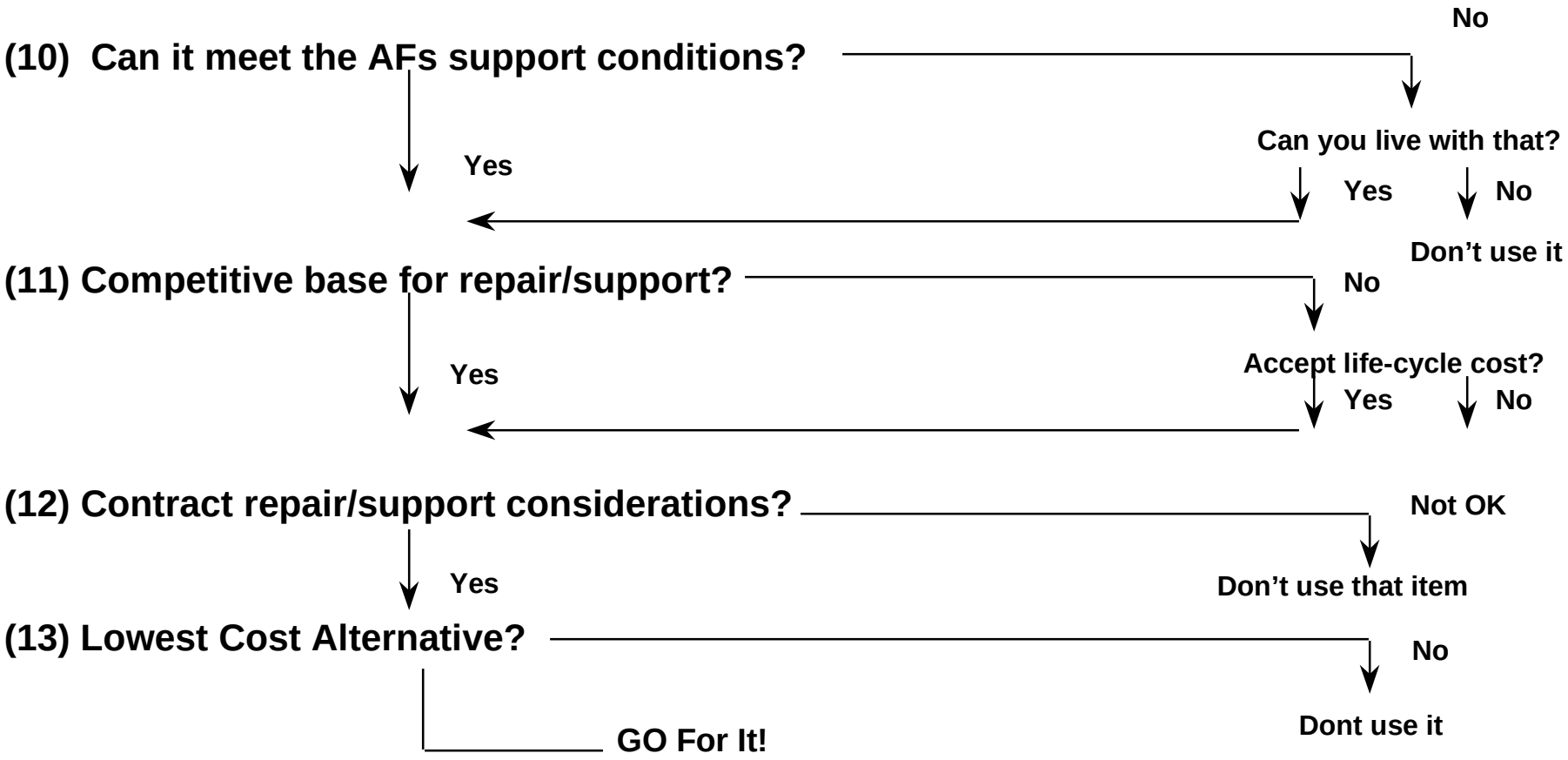
COTS Decision Making
Page 1 of 3



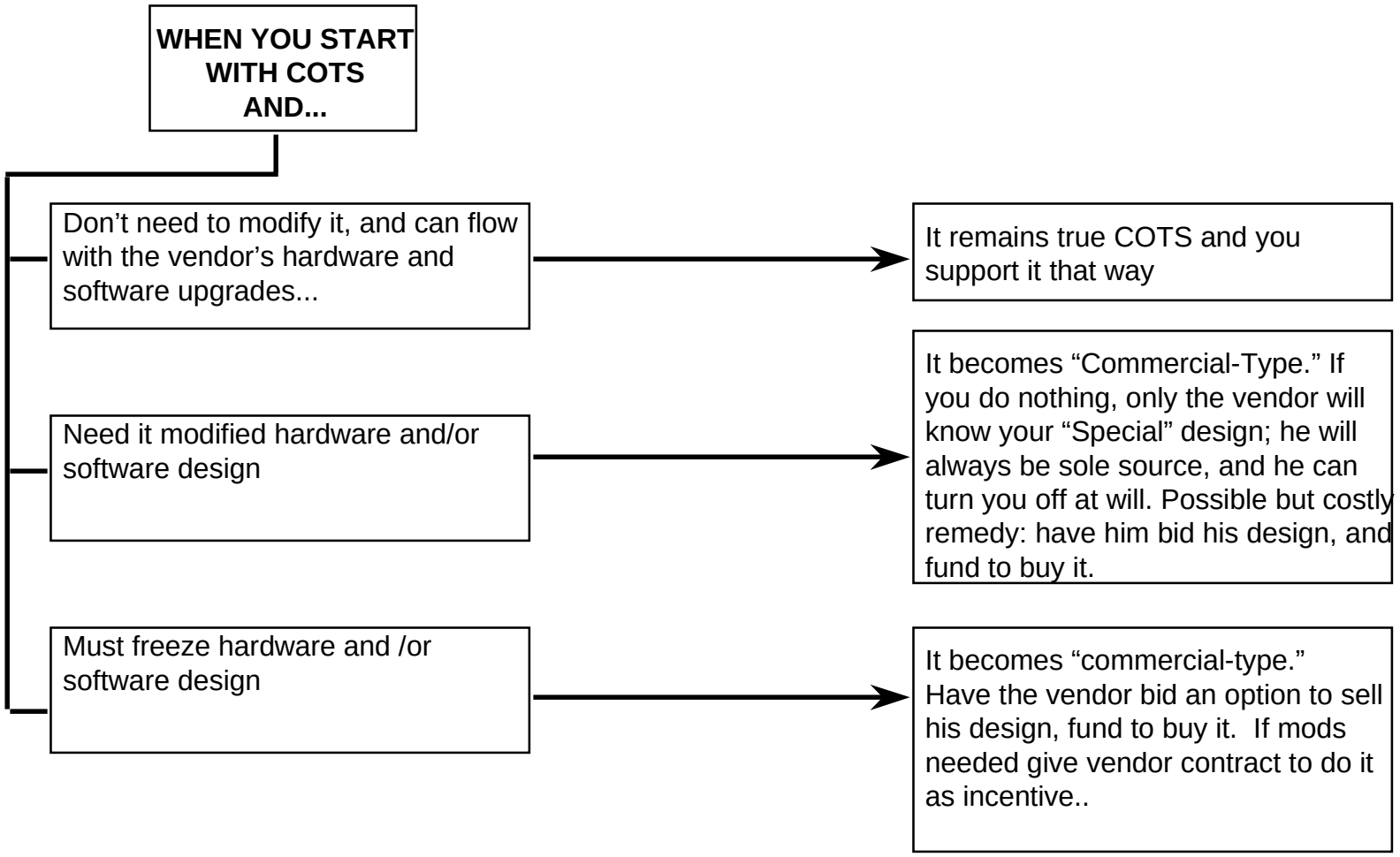
COTS Decision Making
Page 2 of 3



COTS Decision Making
Page 3 of 3



What Happens To Support When COTS Stops Being COTS

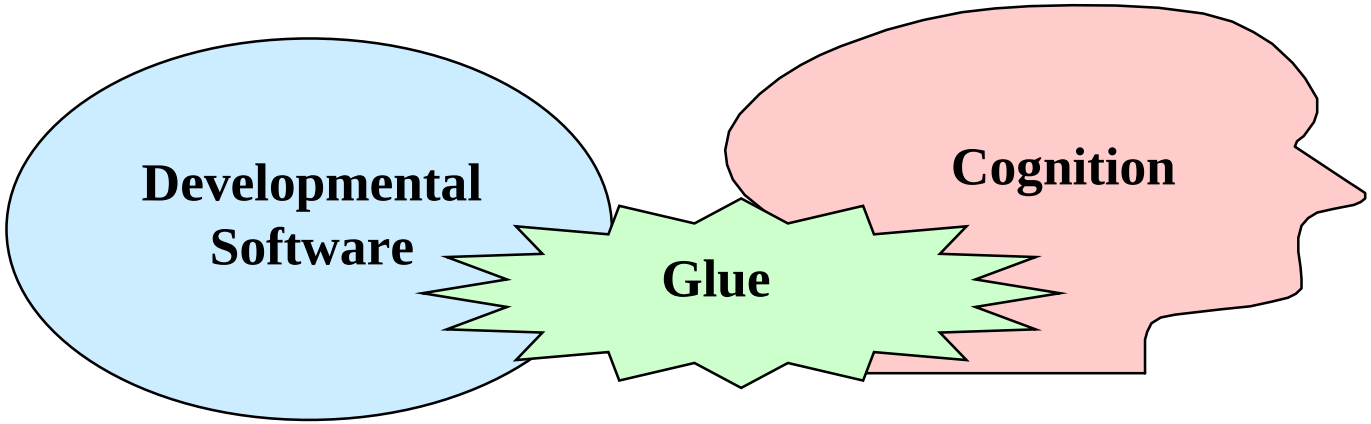


Types of Development Code

- Development Code
  - New if no legacy or pre-existing software being used
  - Pre-existing/Not designed for reuse if legacy code is being used
- Glue Code
  - New if no legacy code exists
  - Pre-existing/Not designed for reuse if package has been integrated before and code is being reused
- COTS Cognition
  - New if the COTS package has not been used before
  - Pre-existing/Designed for reuse if the package has been integrated before by the same team or organization. Use COTS I&T Kbase to assess rework

Integrating COTS Software

- Commercial Off-The-Shelf (COTS) Software
  - Glue Code
    - Software code that binds COTS software with developmental software
  - Cognition
    - The functionality of the COTS software as it relates to the system software integration. If it has not used before then it is new. If the COTS package has been used before by the same team, then it is pre-existing designed for reuse, and an integration and test knowledge base needs to be addressed and reviewed.



Commercial Off-The-Shelf Software (COTS) Page 1 of 2

- Definitions:
  - COTS software are products available in the commercial marketplace that may be used either as stand-alone or may be embedded within some larger application
  - Advantages of COTS
  - Predictable license costs
  - Broadly used, mature technology
  - Availability is always “there”
  - Dedicated support organization
  - Frequent upgrades
  - Functionality is great but there are constraints

Commercial Off-The-Shelf Software (COTS) Page 2 of 2

- Disadvantages of COTS
  - Licensing and property issues
  - No access to source code is available
  - Changes occur within a two year period with feature growth or obsolescence
  - Integrating a COTS software system within a larger application requires “application program interfaces” (API)
- Risk on the use of COTS
  - Due to the growing software product and platform diversity, COTS software integration may become a major performance, cost and quality “set back” that most contractors and organizations must address and resolve in an effective manner.

Identification of Risks in Cost Benefit Trade-Offs

- Software Size
  - Inability to size the software product accurately
    - Often caused by unconstrained requirements growth during the software development life cycle
  - Calibration of cost models depend heavily on delivered source lines of code to a historical knowledge base

- Development Environment
  - Often incorrectly driven by “quick fixes” or “tweaking” the model to justify an outcome
  - Should be based on the company’s ability and willingness to “bear risk” (e.g., Cost Plus vs. Firm Fixed Price contracts)

Identification of Risks Continued

- Staffing
  - Highly complex projects have highly complex interdependencies with regard to the order in which engineering problems can be solved and become exceedingly difficult when more people are added
  - Using a smaller and more capable staff can often result in less effort lost to inefficiencies in communication and team integration, so an actual cost benefit can be achieved, although the schedule length typically increases

Parametric Model Sensitivity Analysis Plotting Worksheet

PARAMETER ANALYSIS			
Set the SEER-SEM parameter settings for analysis			
	Low	Nominal	High
ACAP	Lo	Hi	Hi
AEXP	Lo	Hi	Hi
PCAP	Lo	Hi	Hi
LEXP			
HEXP			
TEXP			
PMEXP			
MODP	Lo	Hi	Hi
TOOL	VL	Hi	Hi
TURN			
TIME			
SITE			
RDED			
RLOC			
HVOL			
PVOL			
RQVT*	Lo	Nom	VH
RELY			
TEST			
QA			
RDEV			
etc.			

INPUTS FROM SEER-SEM RUN

Fill in from SEER-SEM risk display (nominal schedule)			
	-3 σ	Nominal	+3 σ
EFFORT	636.87	722.70	810.27

Set ratings as follows:

VLo
VLo+
Lo-
Lo
Lo+
Nom-
Nom
Nom+
Hi-
Hi
Hi+
VHi-
VHi
VHi+

CHANGE SENSITIVITY		
% change from nominal if the factor is:	Lower	Higher
ACAP	38.4%	
AEXP	31.3%	
PCAP	36.1%	
LEXP		
HEXP		
TEXP		
PMEXP		
MODP	20.9%	
TOOL	36.3%	
TURN		
TIME		
SITE		
RDED		
RLOC		
HVOL		
PVOL		
RQVT*	-8.3%	35.7%
RELY		
TEST		
QA		
RDEV		

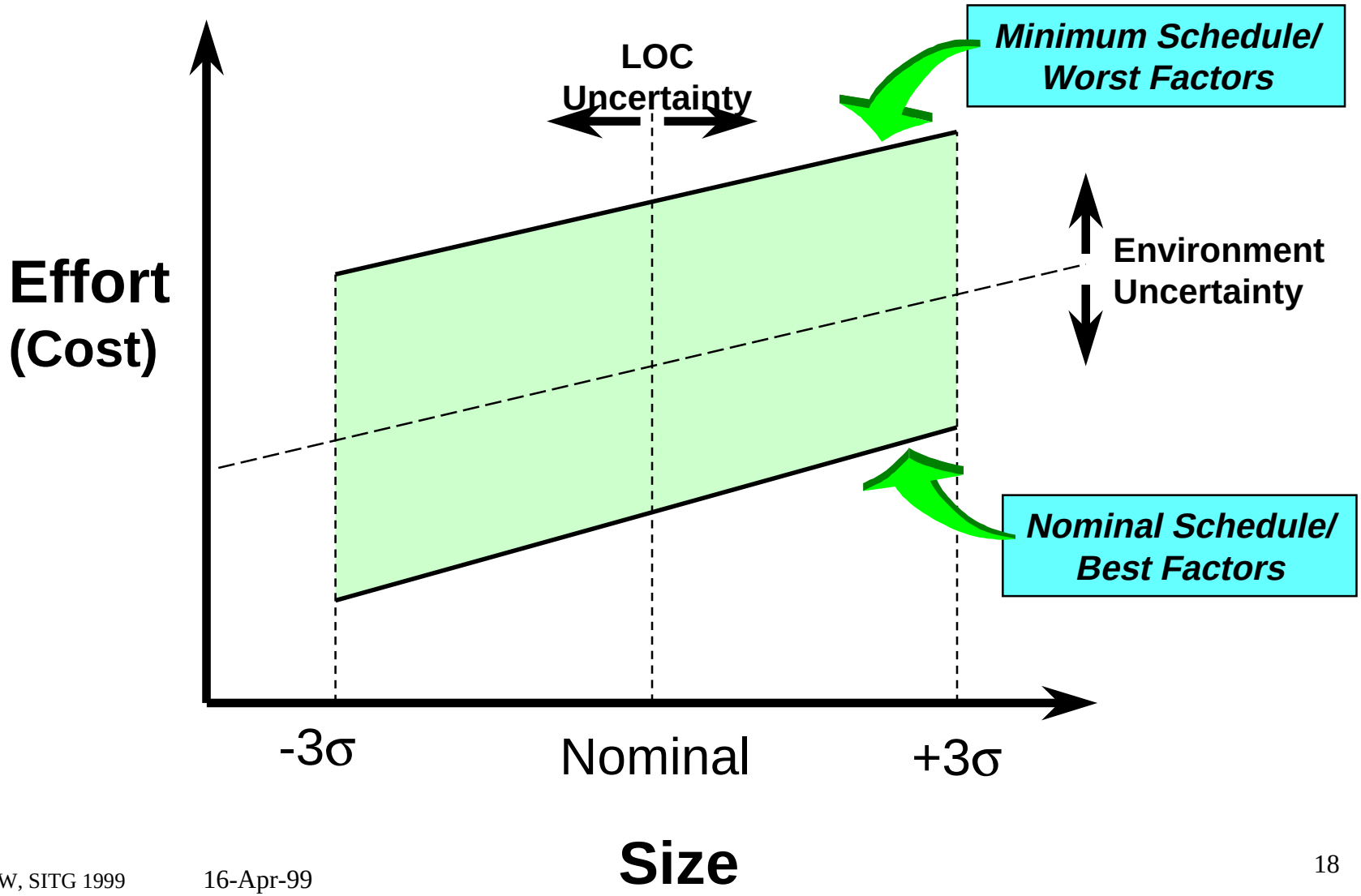
SENSITIVITY ANALYSIS SOLUTION

		-3 σ	Nominal	+3 σ
EFFORT (Manmonths)	Nominal Schedule/Worst Factors = [w]	3,122.1	3,542.9	3,972.2
	Nominal Schedule/Nominal Factors	636.9	722.7	810.3
	Nominal Schedule/Best Factors	583.8	662.4	742.7

TOTAL POTENTIAL INCREASE IN PROGRAM EFFORT = **198.6%** [w]

TOTAL POTENTIAL DECREASE IN PROGRAM EFFORT = **-8.3%**

Cost/Schedule Benefit Sensitivity

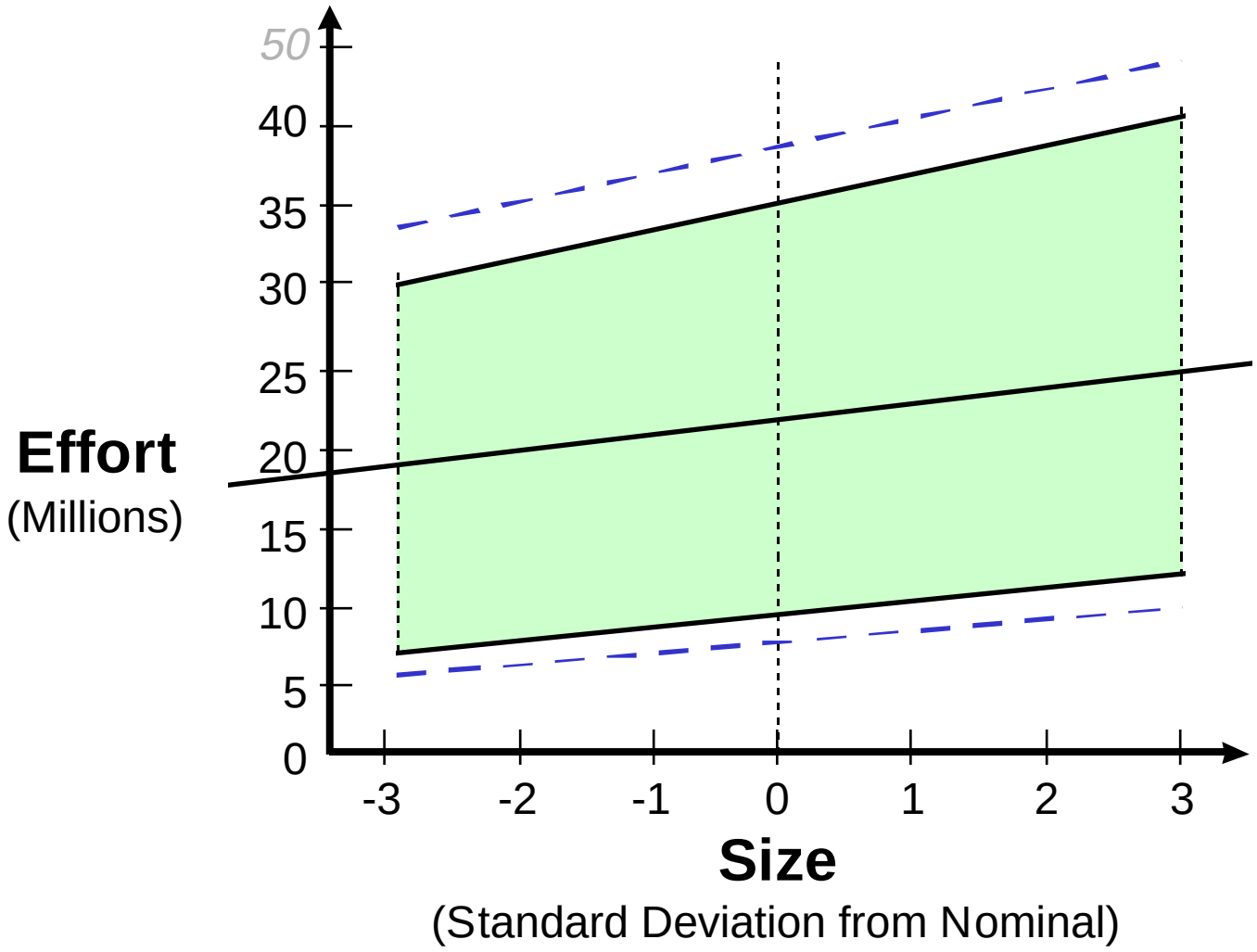


COTS for Schedule and Staff

The following questions need to be addressed:

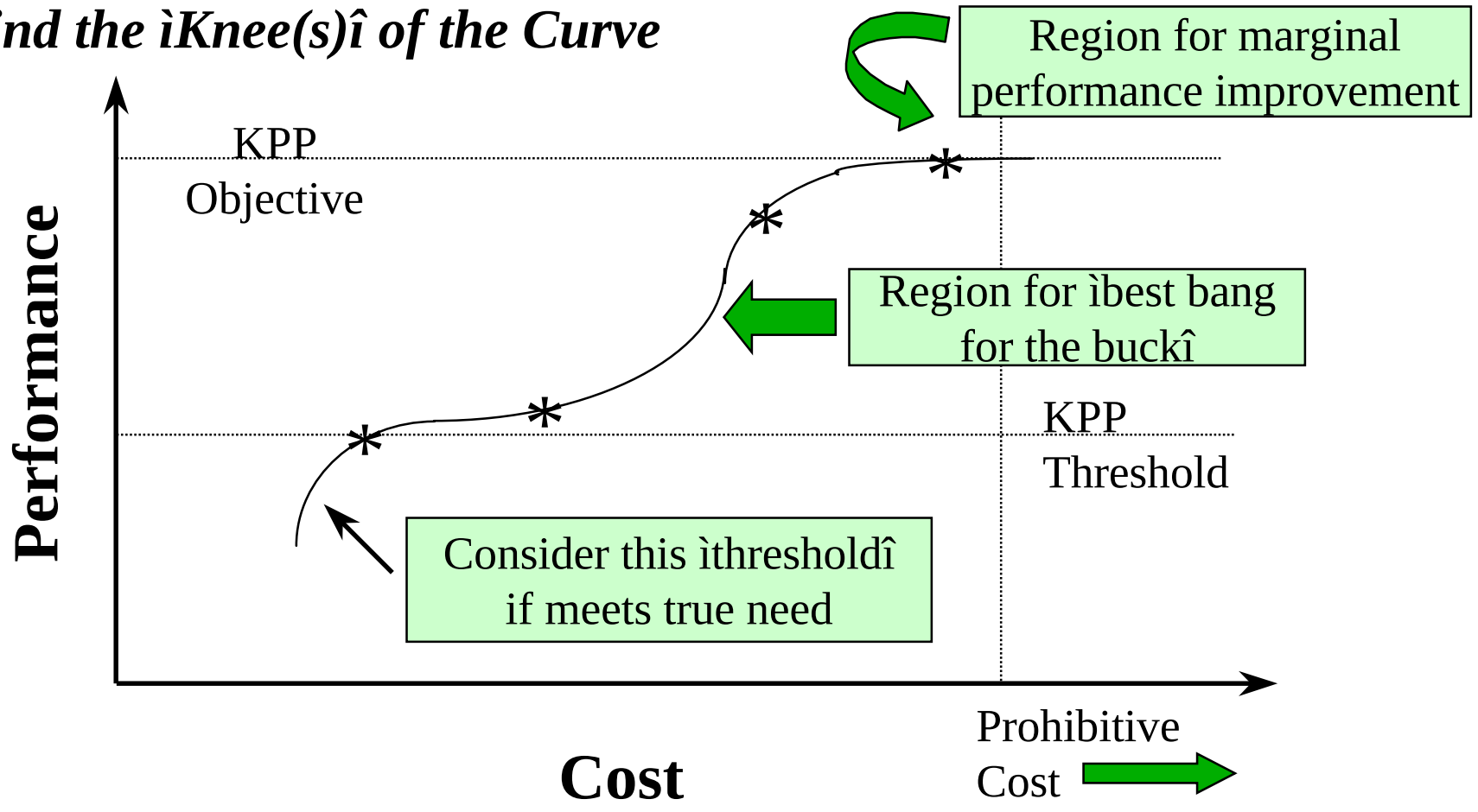
- Does integration costs increase with COTS?
- Does the use of COTS cause a delay in the schedule?
- What is the cost impact if COTS is not tested properly to fit the entire system?

Risk Chart Example



The Cost/Performance Tradeoff

Find the ìKnee(s)î of the Curve



Summary
Page 1 of 2

- Ground station architecture development must consider equally HW, SW and commercial items throughout all design and implementation phases
- Conduct early market investigation of available commercial items that can support mission needs
  - Design several preliminary architectures which could be acceptable
  - Based upon preliminary architectures prototype and evaluate hardware, software and commercial items together
  - During implementation of selected architecture continue to evaluate new and improved commercial items
- Failure to consider commercial items early can lead to an architecture which is
  - Inferior

Summary
Page 2 of 2

- Size uncertainty while contributing to overruns is a component of risk
- Environmental differences specified during trade-offs
  - Analyst experience exemplified by the project team accounts for a large percentage of uncertainty
- COTS can play a major role in cost overruns, or maybe underruns in some cases
  - Cognition software using function points plays a major role in this uncertainty