3rd OSD Conference on the Acquisition of Software-Intensive Systems

Software Acquisition Best Practices: 2004 Edition

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Acknowledgements

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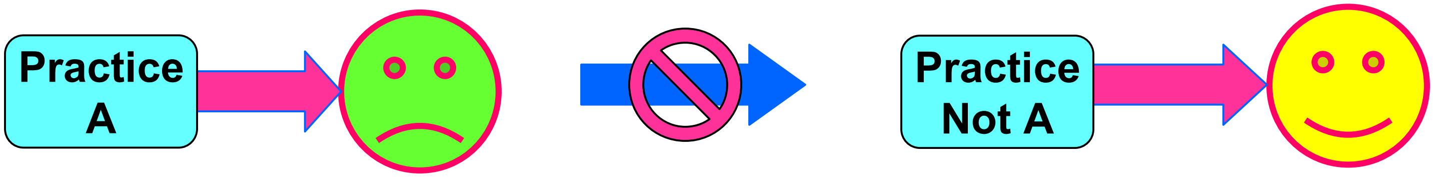
Outline

- **Background and Definitions**
- **Scope**
  - ❖ Software Acquisition Best Practices 2003 Reviewed
  - ❖ Scope of Software Acquisition Best Practices 2004
- **Software Acquisition Best Practices 2004**
  - ❖ Early Acquisition Life Cycle Phases
  - ❖ Evolutionary Acquisition
- **Conclusion**

Best Practices

- **Definition: Best Practices are practices that people with recognized expertise in the subject area have identified through experience as being significant contributors to project success**
- **Negative experience or positive experience may identify Best Practices**
  - ❖ However, one must not be trapped by logical fallacies



- **Note that Best Practices (both individually and collectively)**
  - ❖ Have not necessarily undergone detailed study
  - ❖ Have almost never been analytically determined to be “best”
  - ❖ Never form an exhaustive set (There is always the possibility of more)
  - ❖ Are not static (They change with new experiences and new technologies)
  - ❖ Are dependent on the context and environment

Software Acquisition (SA) Best Practices

- **Software Acquisition (SA) Best Practices are, therefore, practices that people with recognized software acquisition expertise have identified through experience as being significant contributors to the successful acquisition of software-intensive systems**

- **The SA Best Practices presented derive from the research team's collective experience in the acquisition of software-intensive space systems**
  - ❖ Over 60 collective years of software acquisition experience spanning approximately 20 years duration
  - ❖ Many additional years of experience in developing software, managing software development projects, and leading software process improvement efforts

Characteristics of Space Systems (SS)

- **Large software-intensive systems**
  - ❖ SLOC order of magnitude: 10^5 onboard and 10^6 – 10^7 on the ground
  - ❖ Multi-satellite constellations
  - ❖ Multiple ground elements, frequently worldwide
- **Complex combinations of hardware and software**
- **Complex external and internal interfaces**
- **Usually unprecedented**
- **High reliability and integrity requirements**
- **Developed by large teams of multiple contractors**

Space Systems Software Acquisition Best Practices must support these characteristics.

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- **Background and Definitions**
- **Best Practice Scope**
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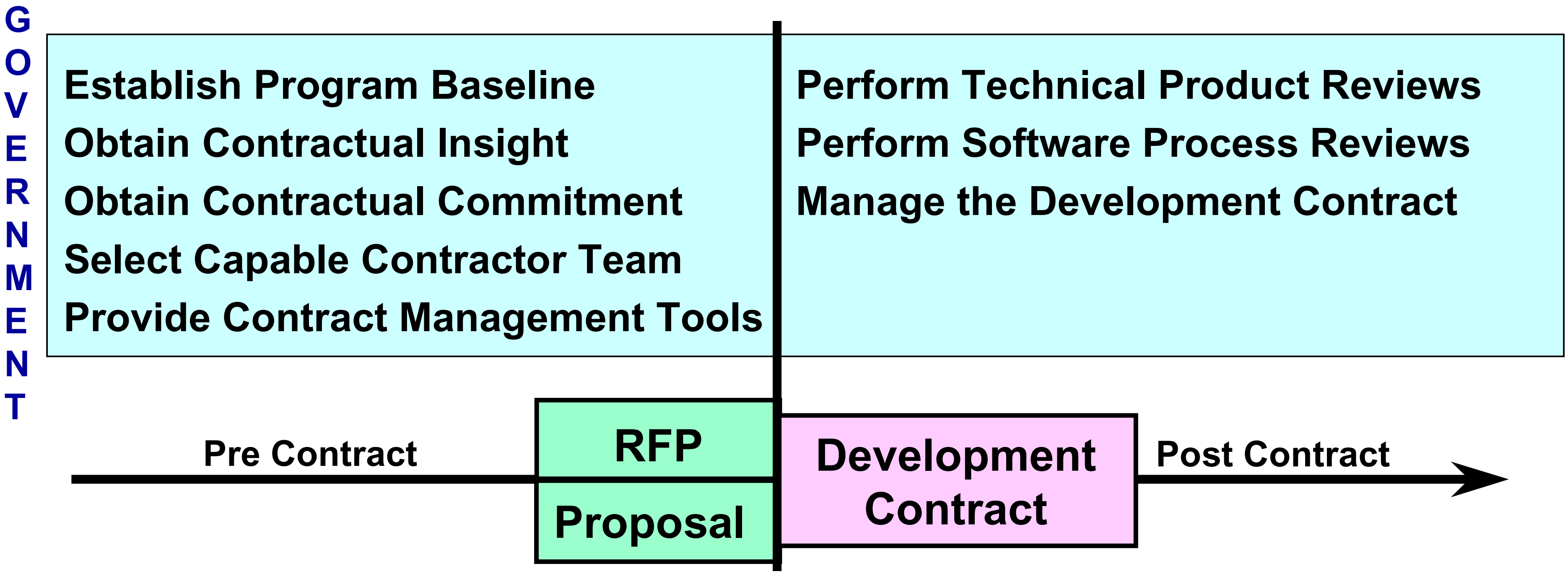
SS SA Best Practice Scope

- **Single system development contract for a software-intensive system**
- **Pre- and post-contract award software acquisition activities for the system development contract**
- **Full life cycle software acquisition activities spanning the contract award boundary**
  - ❖ Software Risk Management
  - ❖ Software Systems Acquisition

SS SA Best Practices for a System Development Contract

Software Acquisition Domain



GOVERNMENT

Establish Program Baseline
Obtain Contractual Insight
Obtain Contractual Commitment
Select Capable Contractor Team
Provide Contract Management Tools

Perform Technical Product Reviews
Perform Software Process Reviews
Manage the Development Contract

Pre Contract

RFP

Proposal

Development Contract

Post Contract

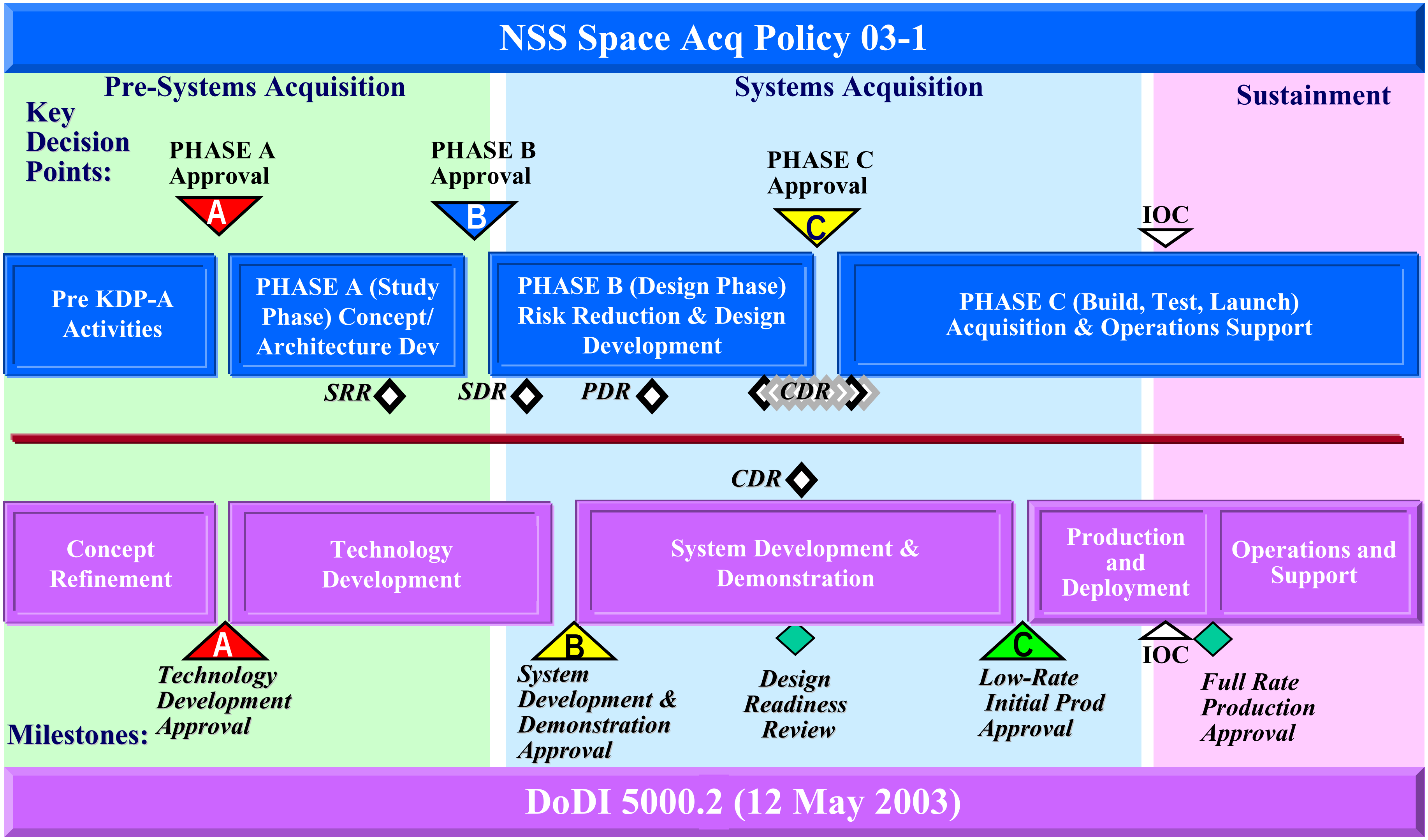
Contractor

Software Engineering Domain

SS SA Best Practice Scope

- Software acquisition activities for the full DoD and National Security Space (NSS) acquisition life cycle
- Pre- and post-contract award software acquisition activities for early DoD and NSS life cycle phases
- Evolutionary acquisition

DoD and NSS Acquisition Models*



NSS Space Acq Policy 03-1

Pre-Systems Acquisition

Systems Acquisition

Sustainment

Key Decision Points:

PHASE A Approval

PHASE B Approval

PHASE C Approval

IOC

Pre KDP-A Activities

PHASE A (Study Phase) Concept/ Architecture Dev

PHASE B (Design Phase) Risk Reduction & Design Development

PHASE C (Build, Test, Launch) Acquisition & Operations Support

SRR

SDR

PDR

CDR

CDR

Concept Refinement

Technology Development

System Development & Demonstration

Production and Deployment

Operations and Support

Milestones:

Technology Development Approval

System Development & Demonstration Approval

Design Readiness Review

Low-Rate Initial Prod Approval

IOC

Full Rate Production Approval

DoDI 5000.2 (12 May 2003)

* From National Security Space Acquisition Policy #03-01, 6 October 2003.

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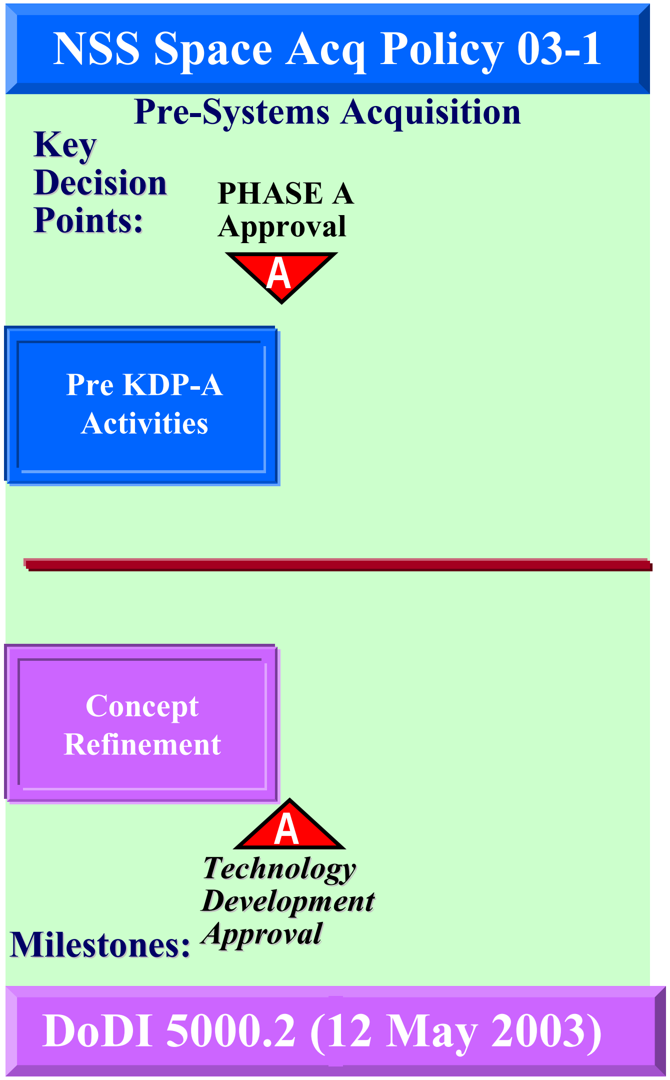
Concept Refinement Best Practices (Pre KDP-A Activities)



NSS Space Acq Policy 03-1

Pre-Systems Acquisition

Key Decision Points:

PHASE A Approval

A

Pre KDP-A Activities

Concept Refinement

A

Technology Development Approval

Milestones:

DoDI 5000.2 (12 May 2003)

Defining:

- Program life cycle
- Initial Government architecture concepts
- Initial Government cost and schedule baselines
- Executable program evolutions
- Global acquisition strategy

Best Practices for Defining the Program Life Cycle

Use a software-friendly acquisition model

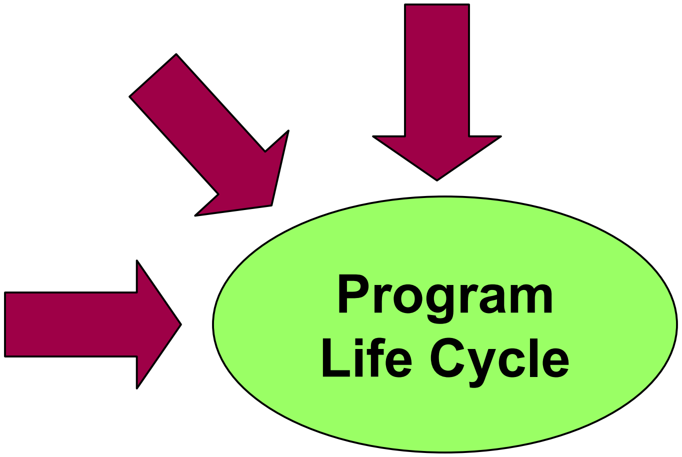
- Evolutionary acquisition is more suited to large, complex software-intensive systems, such as space systems

Choose software-friendly points in the life cycle for contract actions

- Avoid contract actions in the middle of software development spirals (e.g., post System PDR)
- Develop firm basis for software costing before MS B/KDP-B

Tailor the acquisition model for software-intensive system

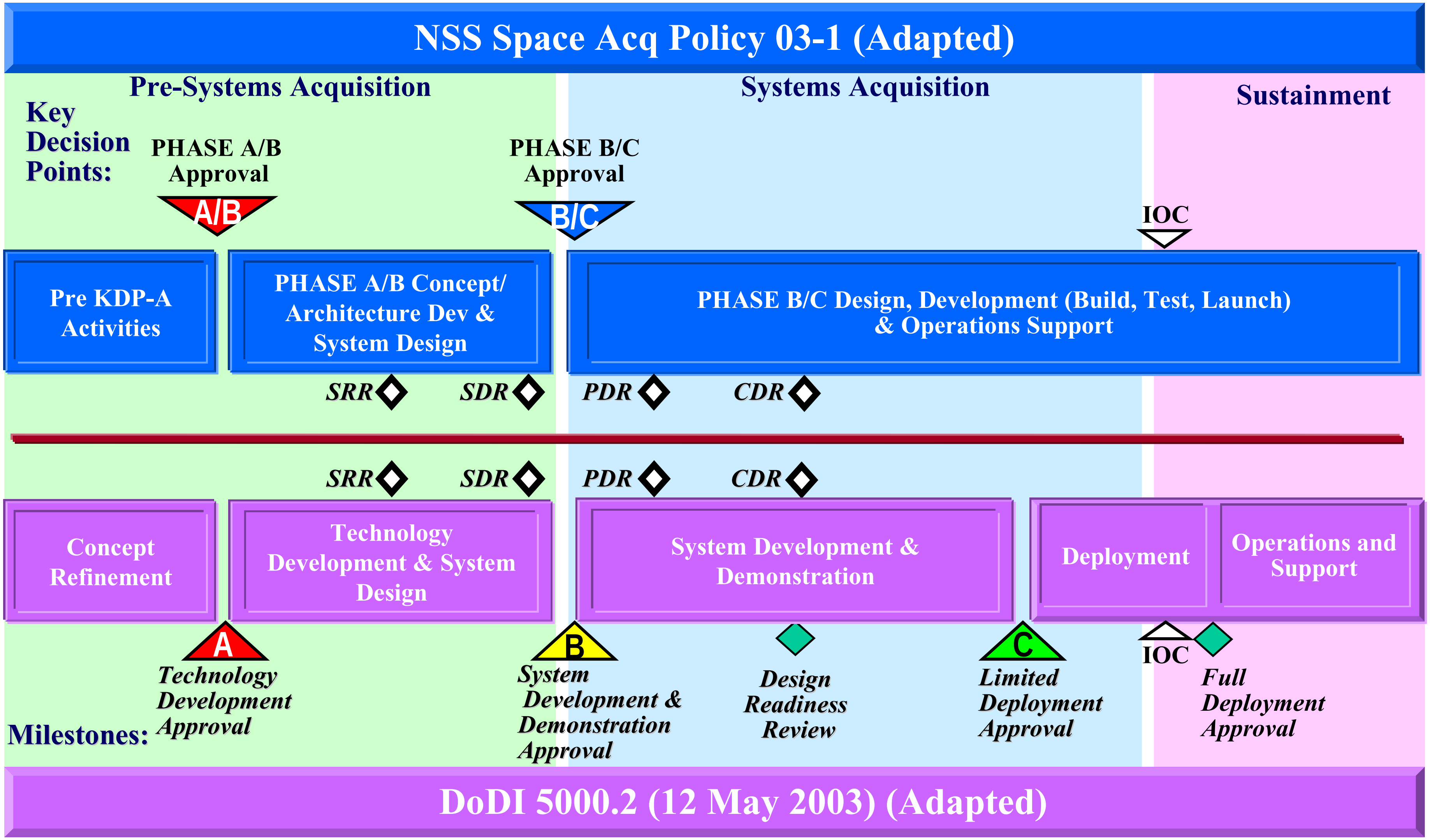
- SDR level of maturity before MS B/KDP-B
- Selection of a single contractor at appropriate point in software development life cycle
- With or without production phase



Program Life Cycle

Example DoD and NSS Acquisition Models

Tailored for Software-Intensive Systems without Production



NSS Space Acq Policy 03-1 (Adapted)

Pre-Systems Acquisition

Systems Acquisition

Sustainment

Key Decision Points:

PHASE A/B Approval

A/B

PHASE B/C Approval

B/C

IOC

Pre KDP-A Activities

PHASE A/B Concept/ Architecture Dev & System Design

PHASE B/C Design, Development (Build, Test, Launch) & Operations Support

SRR *SDR* *PDR* *CDR*

SRR *SDR* *PDR* *CDR*

Concept Refinement

Technology Development & System Design

System Development & Demonstration

Deployment

Operations and Support

A

B

C

IOC

Milestones:

Technology Development Approval

System Development & Demonstration Approval

Design Readiness Review

Limited Deployment Approval

Full Deployment Approval

DoDI 5000.2 (12 May 2003) (Adapted)

Best Practices for Developing the Initial Government Architecture Concepts

Perform software-inclusive architecture trade studies

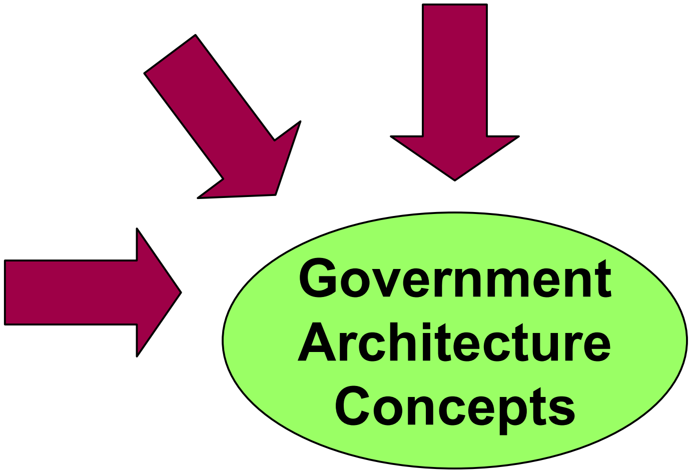
- With system architecture trades
- Identify and address critical HW/SW architecture issues
- Include major legacy components and COTS software

Select a set of integrated HW/SW architecture concepts

- Able to grow with each successive evolution with little expected rework
- Able to integrate each successive evolution with previous evolutions (and legacy system, as applicable)

Include software in evaluation of architecture concepts

- Evaluate software evolution and growth capability
- Include software in life cycle cost analysis (COTS software refresh, legacy and new software re-engineering and maintenance)



Government Architecture Concepts

Best Practices for Developing the Initial Government Cost and Schedule Baseline

Determine realistic SW size estimates for each evolution

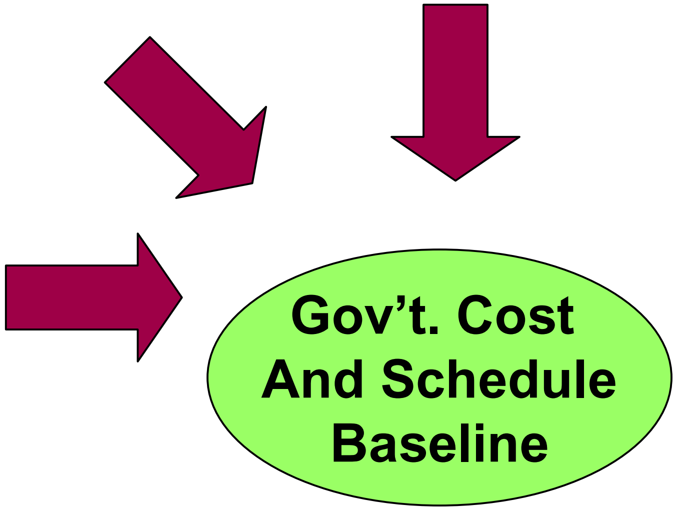
- Use Gov't. HW/SW architecture concept
- Include all SW functionality and infrastructure needed
- Use historical data from similar past programs & early concept study data

Determine realistic SW schedule estimates for each evolution

- Include all software effort in schedule
- Never compress software schedule >20% off nominal*

Determine realistic SW effort & cost estimates for each evolution

- Include COTS, reuse and newly developed software
- Include tasks not reflected in cost models (e.g., integration of SW components costed separately, COTS)



* Software Program Manager's Network, The Program Manager's Guide to Software Acquisition Best Practices, Version 2.31, p. 22.

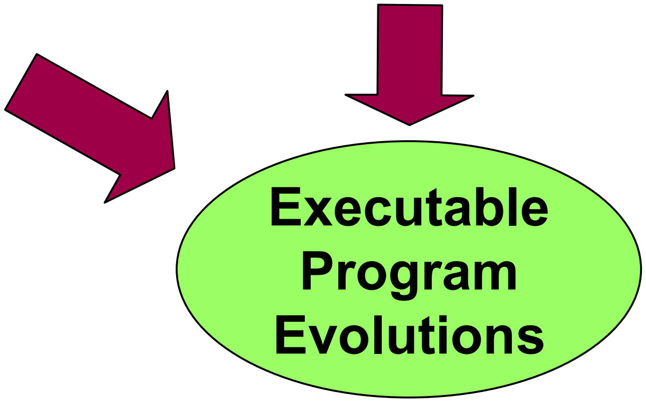
Best Practices for Defining Executable Program Evolutions

Consider <u>SW implications when defining evolution capabilities</u>

- Analyze feasibility of developing the required software for each evolution
  - Based on realistic software size, effort, cost and schedule estimates
  - Include software cost and schedule estimation risk
- Analyze feasibility of integrating the software in each evolution with all previous evolutions (and legacy system(s), as applicable)
  - Based on integrated hardware/ software architecture
- Analyze impacts of COTS software refresh and legacy software upgrades

Consider <u>SW implications when defining evolution schedules</u>

- Analyze feasibility of overlapping software development schedules for closely spaced evolutions
- Avoid plans that require developing subsequent evolutions on unknown software baselines
- Analyze feasibility of COTS refresh and legacy SW upgrade schedules



Executable Program Evolutions

Best Practices for Developing the Global Acquisition Strategy

Develop plans for computer system technology insertion

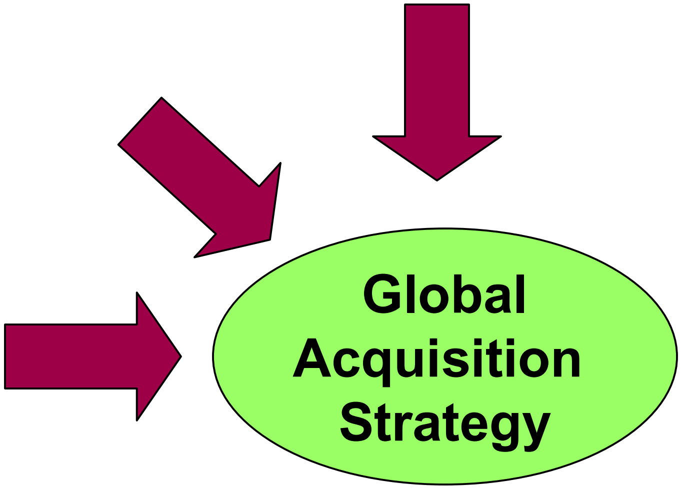
- Include COTS HW and SW refresh in each successive evolution
- Understand new computer HW & SW technologies needed for each evolution and study their readiness

Develop plans for evaluation of contractor software capability

- Perform a Government evaluation of contractor team software capability
- Prior to or part of selection of a single development contractor

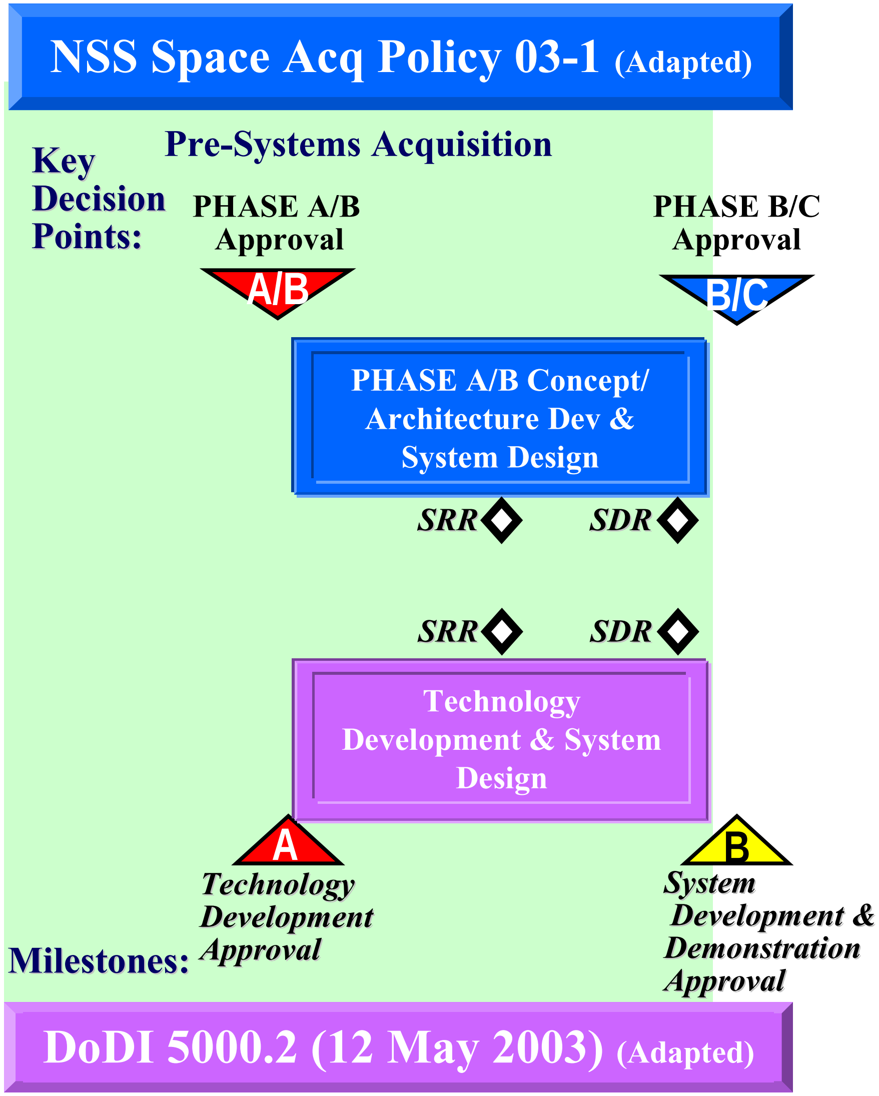
Develop plans for software support

- Plan for managing multiple baselines (operations and development)
- Plan for integrating software maintenance actions on operational evolutions into evolutions under development



Global Acquisition Strategy

Concept/Technology/Architecture Development (Phase A/B) Best Practices


NSS Space Acq Policy 03-1 (Adapted)
Pre-Systems Acquisition
Key Decision Points:
PHASE A/B Approval
A/B
PHASE B/C Approval
B/C
PHASE A/B Concept/ Architecture Dev & System Design
SRR
SDR
SRR
SDR
Technology Development & System Design
A
Technology Development Approval
B
System Development & Demonstration Approval
Milestones:
DoDI 5000.2 (12 May 2003) (Adapted)

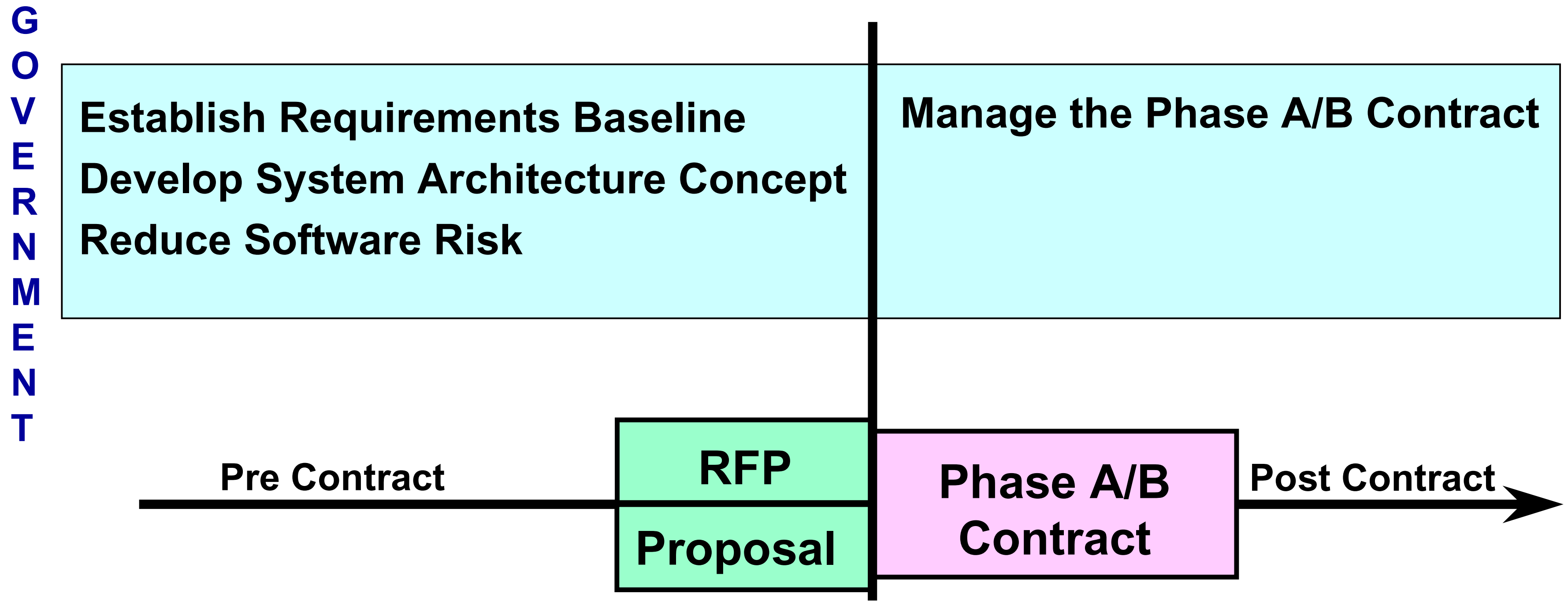
Principal objective of Phase A/B contract(s)* is to develop the information needed for the Government to:

- Solidify the program definition to establish an executable program
- Update the global acquisition strategy, including acquisition plans and products for this and all future evolutions

* Space systems usually have multiple parallel contracts in this phase, with selection of a single development contractor in the next phase (B/C).

SS SA Best Practices for a Phase A/B Contract

Software Acquisition Domain



Establish Requirements Baseline

Develop System Architecture Concept

Reduce Software Risk

Manage the Phase A/B Contract

Contractor

Software Engineering Domain

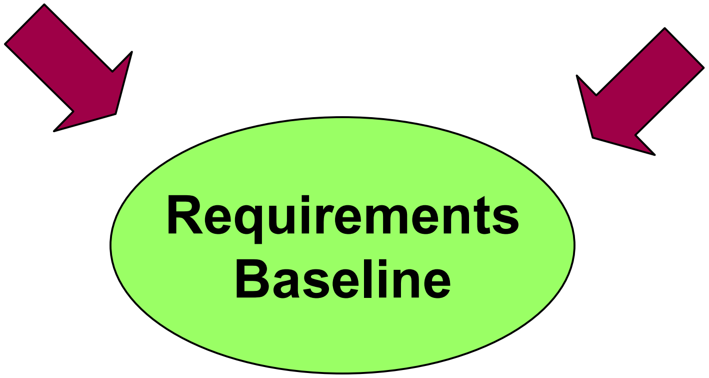
Best Practices for Establishing the Requirements Baseline

Include software in Gov't. system performance requirements

- Specialty engineering, especially RMA
- Key Performance Parameters
- Open system architecture
- Design for evolution and growth

Contract for delivery of SW-inclusive reqs. specifications

- Require System and Segment Specifications as CDRL items
- Use System/Subsystem Specification DID (DI-IPSC-81431a)



Requirements Baseline

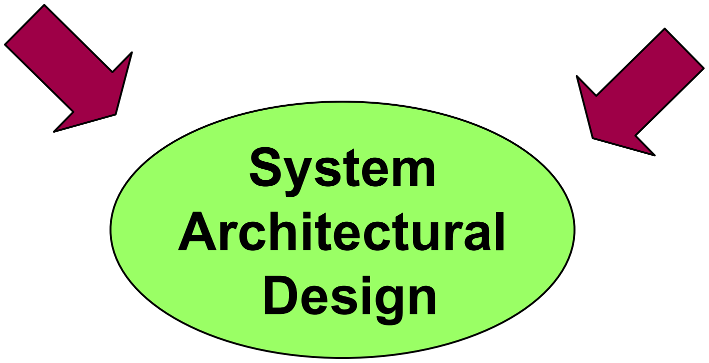
Best Practices for Developing the System Architectural Design

Contract for software architecture trade studies

- With system architecture trades
- Include major software legacy components and COTS software

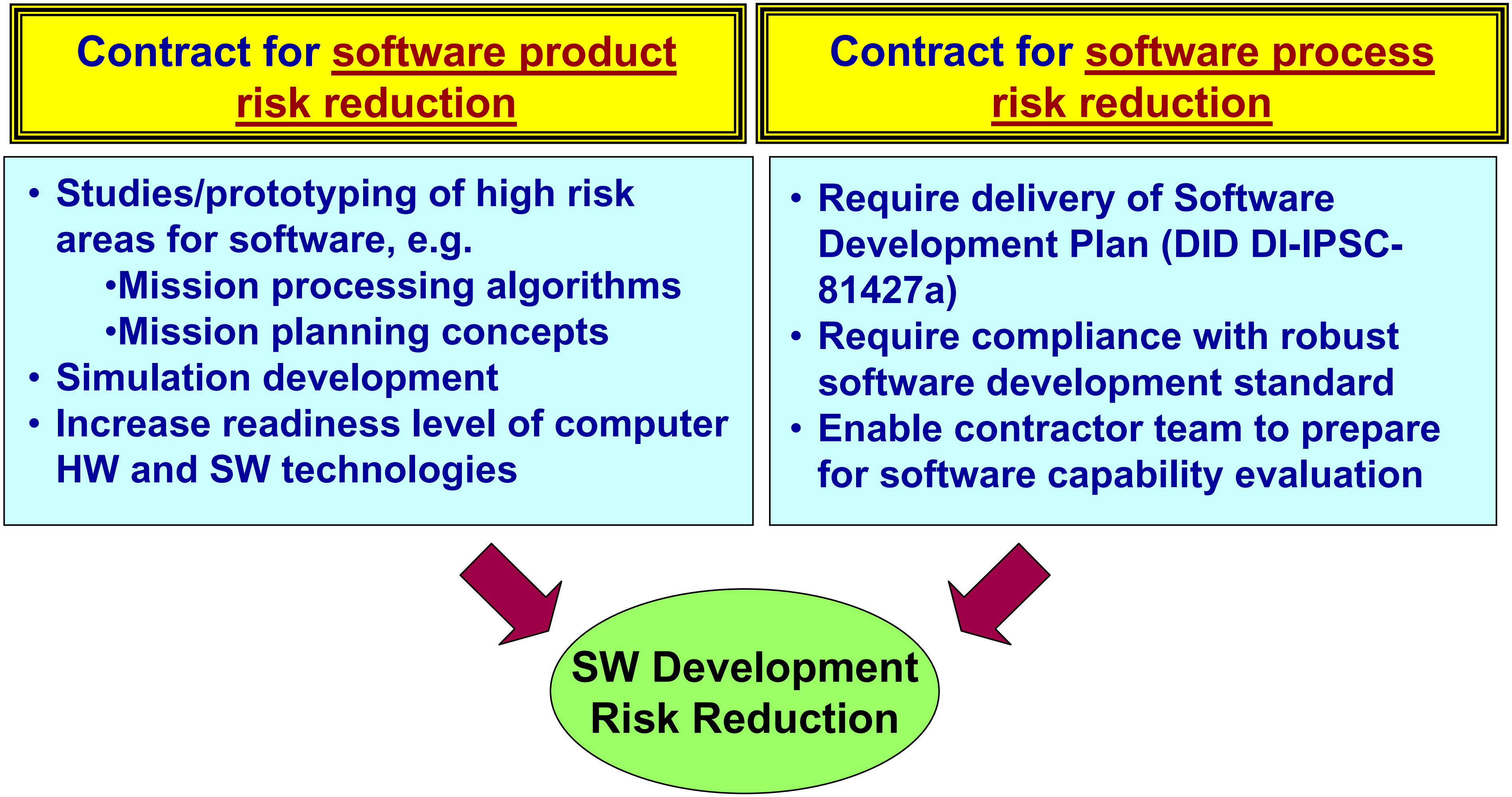
Contract for delivery of system architecture

- Require system architecture as a CDRL item
- Require an integrated HW/SW architecture, defined by multiple architecture views
- Include newly developed, reuse and COTS software



System Architectural Design

Best Practices for Reducing Software Development Risk



Contract for software product risk reduction

- Studies/prototyping of high risk areas for software, e.g.
  - •Mission processing algorithms
  - •Mission planning concepts
- Simulation development
- Increase readiness level of computer HW and SW technologies

Contract for software process risk reduction

- Require delivery of Software Development Plan (DID DI-IPSC-81427a)
- Require compliance with robust software development standard
- Enable contractor team to prepare for software capability evaluation

SW Development Risk Reduction

Best Practices for Managing the Phase A/B Contract

Ensure contractor(s) define software-inclusive reqs. specs.

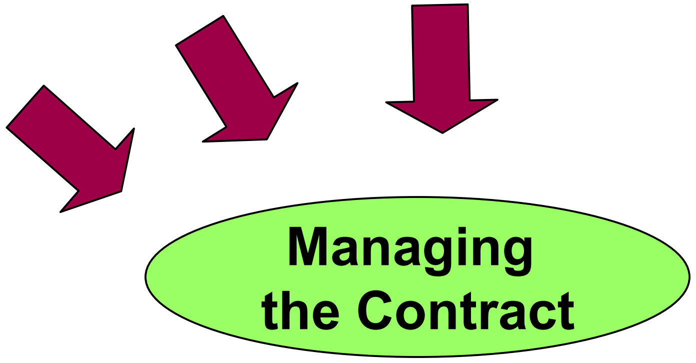
- Software systems engineers (contractor and Government) must participate with contractor and Gov't. systems engineers

Participate with contractor in software risk reduction

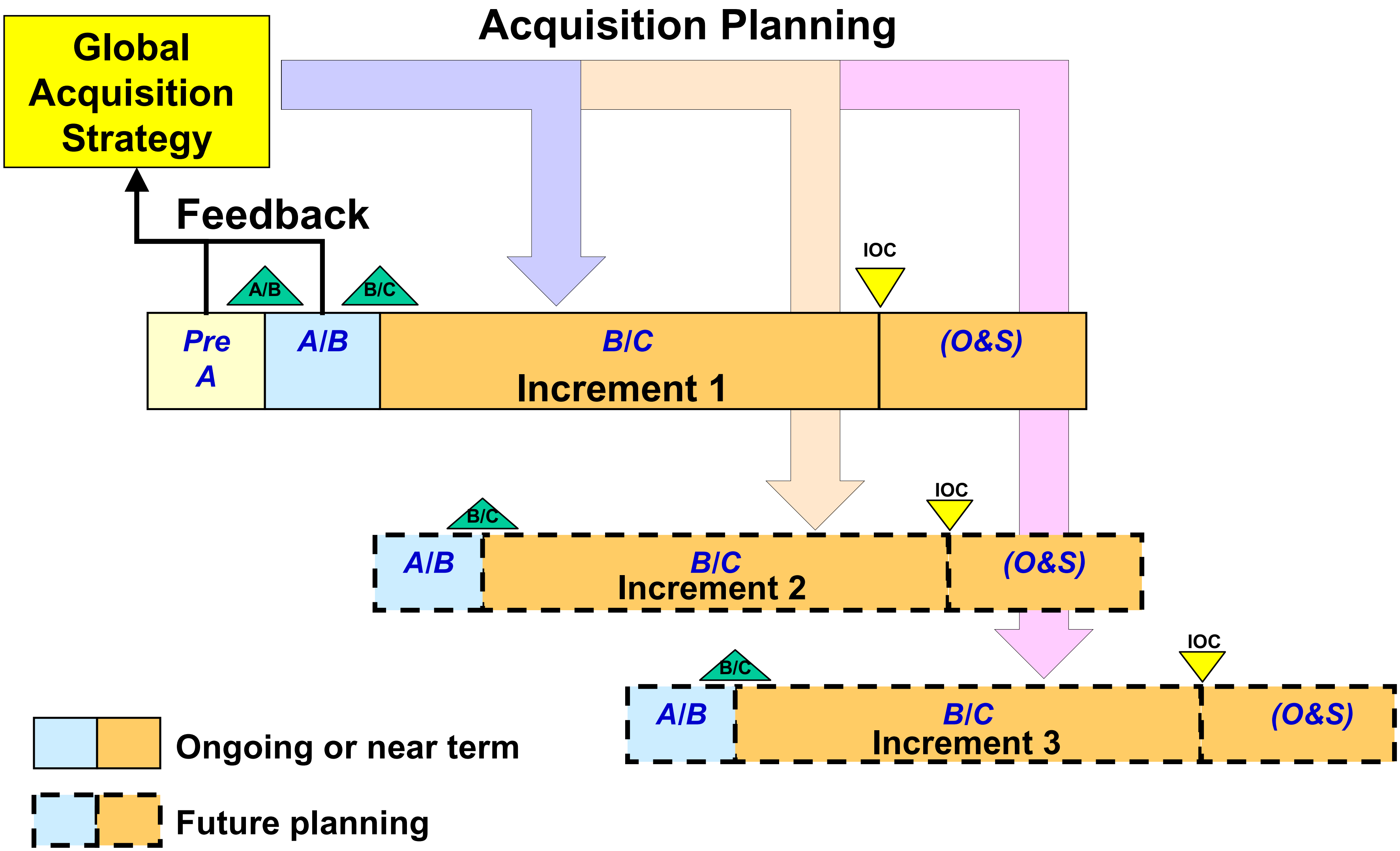
- Government software acquisition personnel with technical expertise in software product and process engineering must participate

Ensure contractor(s) define integrated HW/SW architecture

- Software systems engineers (contractor and Government) must participate with contractor and Gov't. systems engineers



Evolutionary Acquisition Strategy - 1



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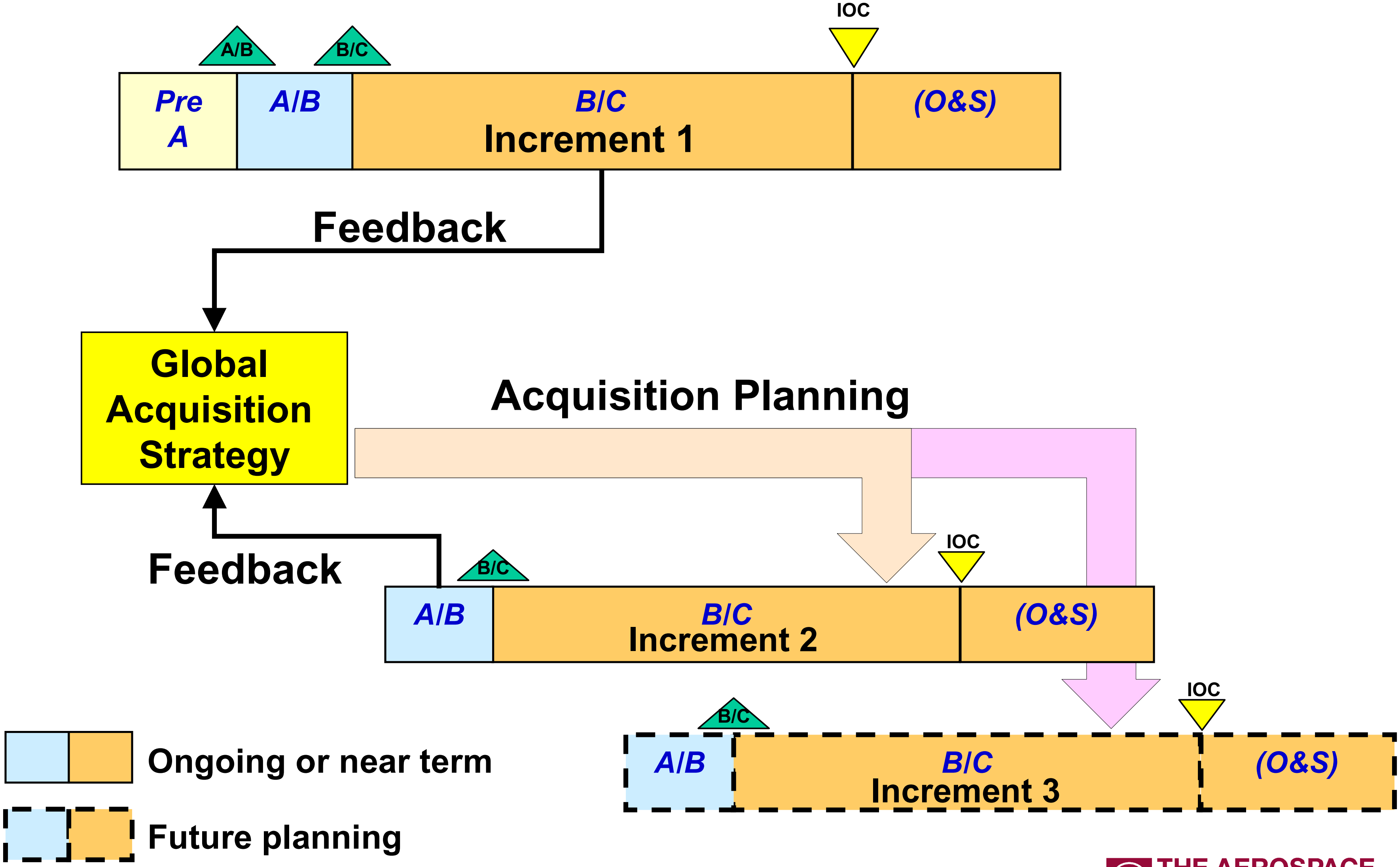
Evolutionary Acquisition Strategy - 2



Best Practices for Updating the Global Acquisition Strategy

Update SW-inclusive program baseline

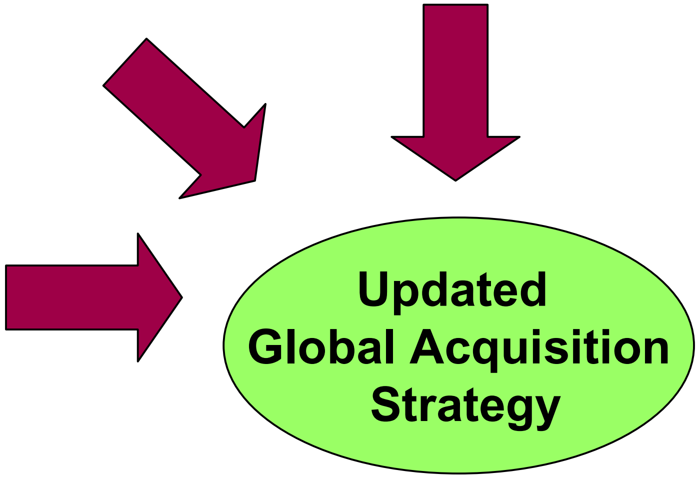
- Software-inclusive system requirements
- Integrated HW/SW architecture
- Realistic software size, effort, cost & schedule estimates for each evolution

Update software-specific plans

- Software support strategy
- Contractor team software capability evaluations
- Software technology insertion
- Software transition to operations

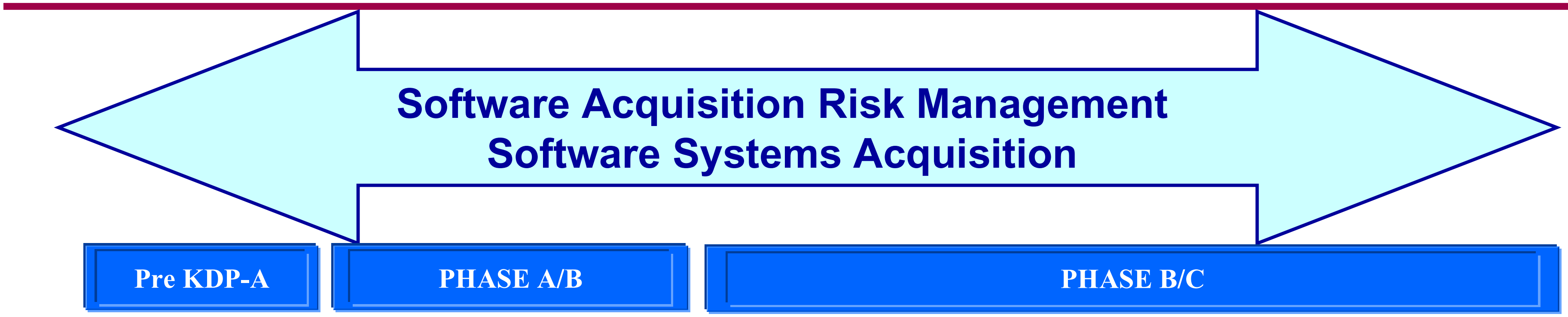
Update definition of SW-friendly evolutions

- Evolution capabilities, schedules and integration strategies
- COTS software refresh and legacy software upgrades



Updated Global Acquisition Strategy

Best Practices that Span the DoD and NSS Acquisition Life Cycle



Software Acquisition Risk Management
Software Systems Acquisition

Pre KDP-A

PHASE A/B

PHASE B/C

Software Acquisition Risk Management

- Continuous software acquisition risk management
  - Across the entire acquisition life cycle
  - Across all evolutions
  - Within each ongoing evolution
- Program level risk management and contractor development risk management are necessary but not sufficient

Software Systems Acquisition

- Integrate software acquisition with the system acquisition process
  - From capability needs identification through system retirement
  - Especially during early acquisition life cycle phases

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- **Conclusion**

Conclusion

- **Software acquisition best practices do not guarantee success**
  - ❖ They are not a panacea!
- **Using best practices, however, can reduce risk in complex software-intensive system acquisitions**
- **Evolutionary acquisition, in particular, is a complex strategy that requires careful planning and execution in order to achieve its anticipated benefits**
- **Software acquisition best practices will be most effectively implemented if done in the context of a software acquisition process improvement program**
  - ❖ Based on experiences with software development

Section 804 of the FY03 Defense Authorization Act requires the establishment of software acquisition process improvement programs.

Back-Up Charts

- Software Acquisition Best Practices 2003
- Acronym List
- Author Contact Information

Best Practices for Establishing the Program Baseline

Perform software architecture-inclusive trade studies

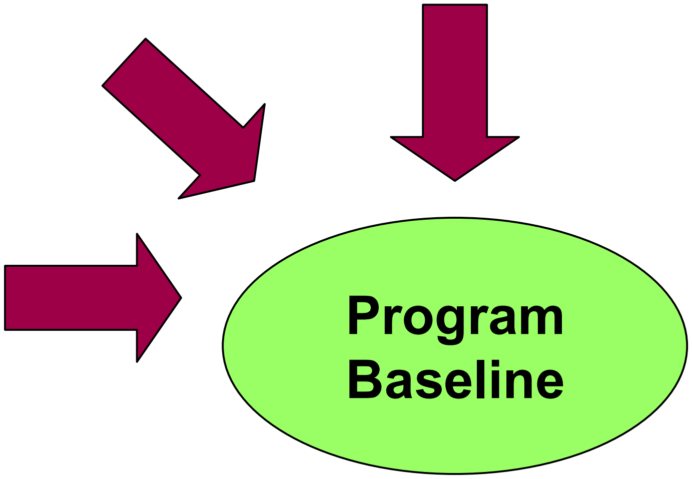
- With system architecture trades
- Include major legacy components
- Supports Government software architecture baseline selection

Include software in system performance requirements

- Specialty engineering, esp. RMA
- Key Performance Parameters
- Open system architecture

Determine realistic, independent baseline software estimates

- Size, effort, cost and schedule
- COTS, reuse and newly developed
- Tasks not reflected in cost models
- Realism especially critical for evolutionary acquisition



Best Practices for Obtaining Contractual Insight

Require key software technical & management deliverables

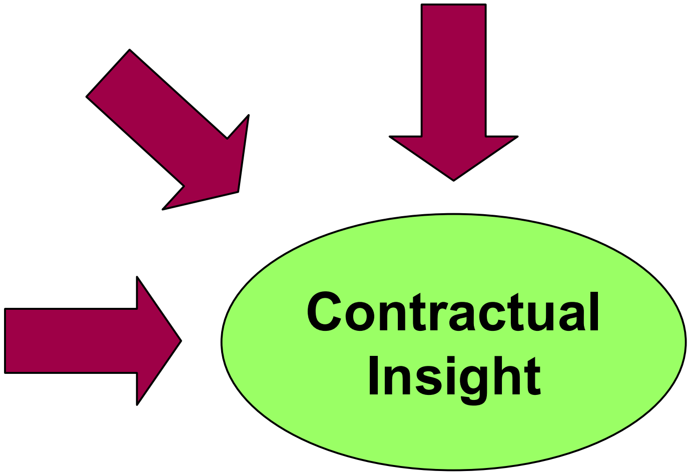
- Highest risk reduction potential:
  - Plans (development, build, transition)
  - Requirements & Architecture
  - Test plans, procedures & reports
  - Metrics reports
  - Delivery, installation & maintenance documentation
- Use electronic delivery

Require timely electronic access to all software products

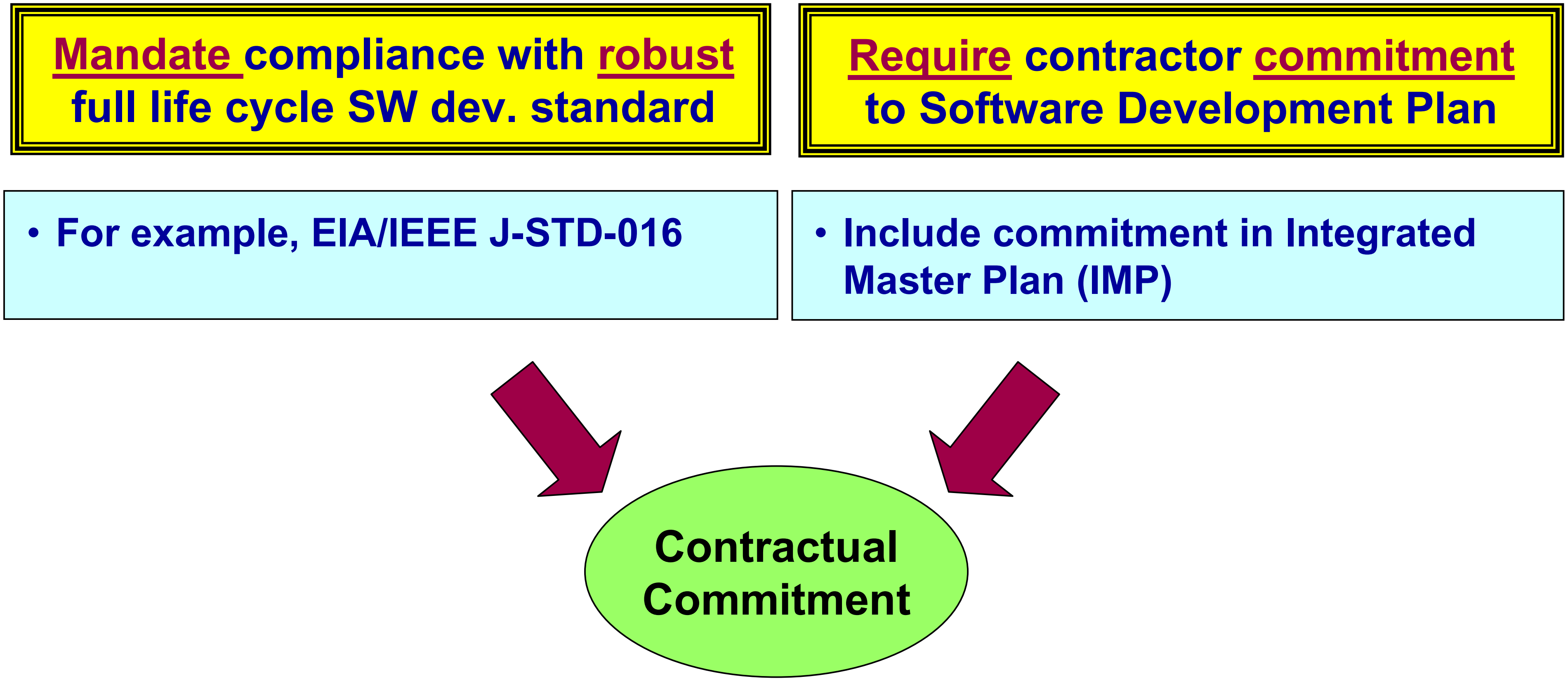
- Requirements
- Architecture, Design
- Implementation (including code)
- Integration and Verification Testing
- Intermediate and Final Products

Require software level technical & management reviews

- In addition to system reviews



Best Practices for Obtaining Contractual Commitment



Mandate compliance with **robust** full life cycle SW dev. standard

- For example, EIA/IEEE J-STD-016

Require contractor **commitment** to Software Development Plan

- Include commitment in Integrated Master Plan (IMP)

Contractual Commitment

Best Practices for Selecting a Capable Software Contractor Team

Evaluate software capability as part of source selection

- Evaluate software capability of offeror teams
  - Individual team member evaluation insufficient
- Evaluate software capability/ processes as subfactor
  - Under Mission Capability factor
  - Weight according to software risk
- Evaluate teams' proposed software processes
  - Corporate and past project process evaluation insufficient

Evaluate software architecture with system design

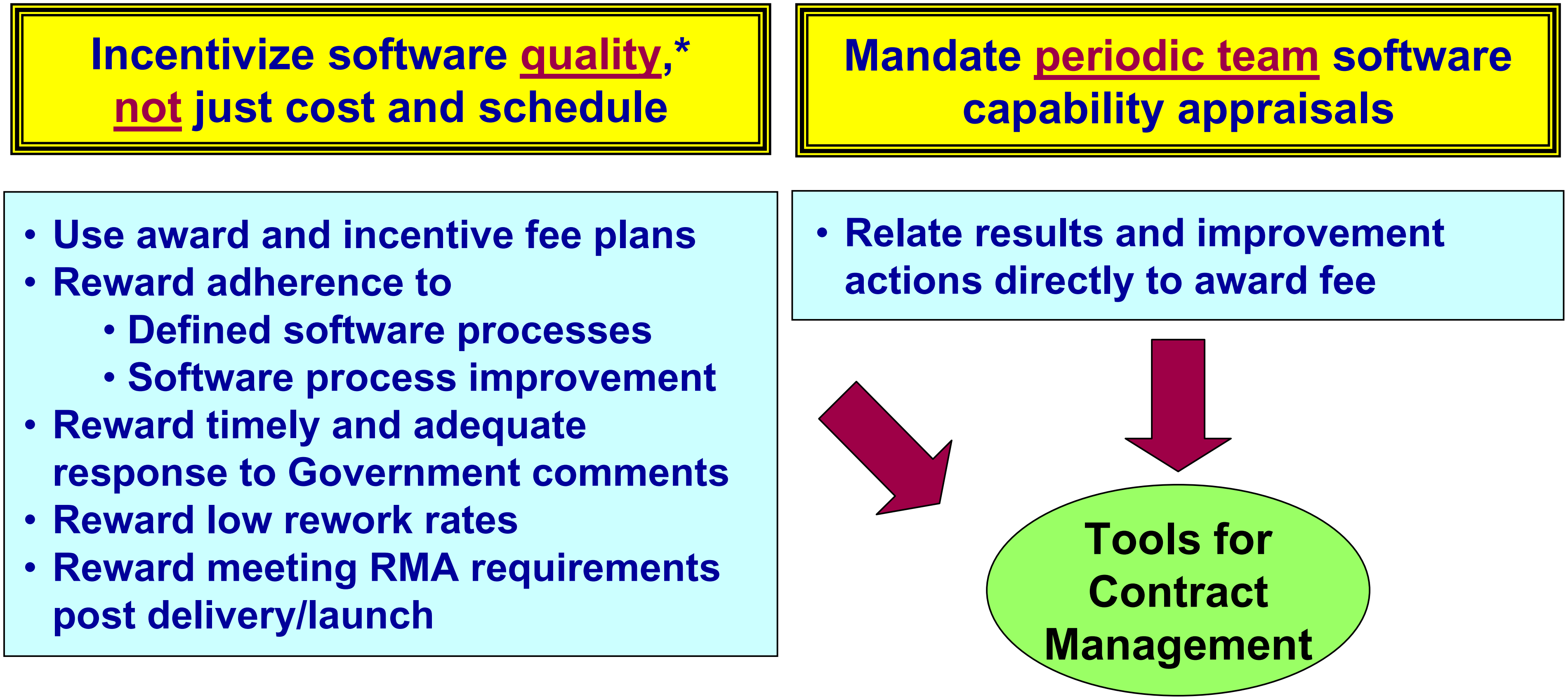
- Evaluate major HW/SW architecture issues (e.g., space-ground trades, reuse of legacy components)

Evaluate realism of cost and schedule bids

- Suspect extremes of productivity, COTS & reuse, & low lines of code

Capable Software Contractor Team

Best Practices for Providing Tools for Contract Management



Incentivize software quality,* not just cost and schedule

- Use award and incentive fee plans
- Reward adherence to
  - Defined software processes
  - Software process improvement
- Reward timely and adequate response to Government comments
- Reward low rework rates
- Reward meeting RMA requirements post delivery/launch

Mandate periodic team software capability appraisals

- Relate results and improvement actions directly to award fee

Tools for Contract Management

* Quality in this context is producing work products that do not require rework in successor activities.

Best Practices for Performing Technical Product Reviews

Perform in-depth technical reviews of software products

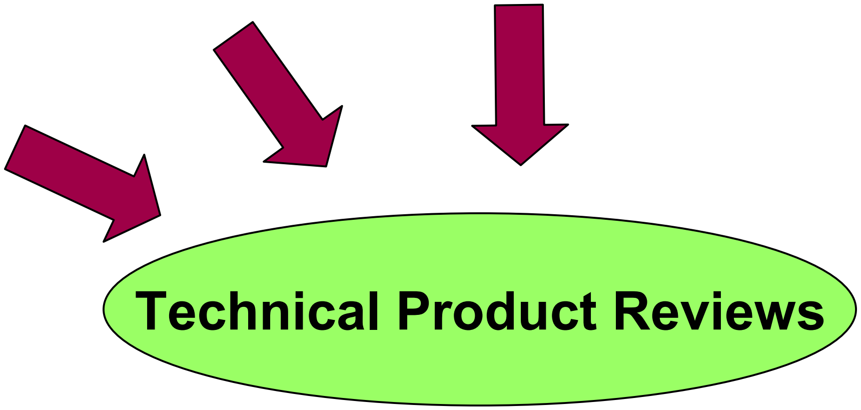
- IPTs, TIMs, working groups, peer reviews, etc.
- Software Level Technical Reviews
- High risk/critical software products
- Key software technical deliverables
- Focus on areas of highest risk

Monitor software integration and verification adequacy

- Begin at the build level
- Focus on areas of highest risk
- Focus on early performance analysis results and meeting KPPs

Include users/operators in all technical review activities

- Focus on operational suitability of evolving software-intensive system



Best Practices for Performing Software Process Reviews

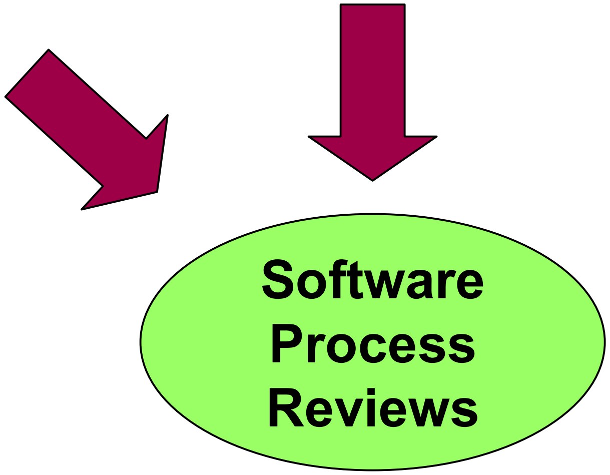
2003

Review effectiveness of contractor team’s SW processes

- Review team’s adherence to defined software processes
  - Identify adherence deficiencies
  - Assist in deficiency correction
- Evaluate effectiveness of defined SW processes
  - Identify process deficiencies
  - Assist with process improvement
- Level 2 & 3 CMMI®/CMM® adherence for an individual team member may not be sufficient*

Perform periodic team software capability appraisals

- During contract performance
- Support for significant program or award fee milestones



Software Process Reviews

* CMM and CMMI are registered trademarks of Carnegie Mellon University.

Best Practices for Managing the Development Contract

2003

Use incentive/award fees aggressively

- Motivate good software practices
- Focus on quality

Ensure satisfaction of software –inclusive requirements

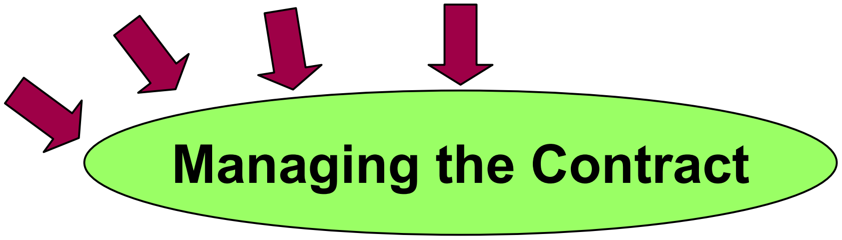
- Especially RMA

Apply proactive quantitative management

- Ensure a comprehensive software/ system metrics program balanced across information categories
  - Include leading quality indicators (e.g., rework)
- Perform cross-metric analysis
- Earned value alone is insufficient

Perform periodic independent assessments

- Support for significant program or award fee milestones
- Act aggressively on findings



Managing the Contract

Acronyms and Abbreviations - 1

Acq	Acquisition
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CMM®	Capability Maturity Model®
CMMI®	Capability Maturity Model® Integration^{SM}
COTS	Commercial Off the Shelf
DB	Database
Dev	Development
DID	Data Item Description
DoD	Department of Defense
DoDI	DoD Instruction
EIA	Electronic Industries Alliance
FY	Fiscal Year
Gov't.	Government
GUI	Graphical User Interface
HW	Hardware
IEEE	Institute of Electrical and Electronics Engineers

Acronyms and Abbreviations - 2

IMP	Integrated Management Plan
IPT	Integrated Product Team
IOC	Interim Operational Capability
J	Joint
KDP	Key Decision Point
KPP	Key Performance Parameter
MOIE	Mission-Oriented Investigation and Experimentation
MS	Milestone
NSS	National Security Space
O&S	Operations and Support
OSD	Office of the Secretary of Defense
PDR	Preliminary Design Review
RFP	Request for Proposal
RMA	Reliability, Maintainability, Availability
SA	Software Acquisition
SDP	Software Development Plan
SDR	System Design Review

Acronyms and Abbreviations - 3

SLOC	Source Lines of Code
SM	Service Mark
SRR	System Requirements Review
SS	Space System
STD	Standard
SW	Software
TIM	Technical Interchange Meeting
USAF	United States Air Force

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