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*Teaching the Elephant to Dance:
Agility Meets Systems of Systems Engineering
and Acquisition*

Keynote, GSAW 2005

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Outline

- Nature of systems of systems engineering and acquisition
 - Particularly, network-centric systems of systems (NCSOS)
 - Acquisition is more like doing C4ISR than buying fruitcake
- Agile methods and NCSOS: strengths and difficulties
 - Helpful, but not a silver bullet
- Integrating agile and plan-driven methods
 - Workshop results and integration framework
- Critical success factors
 - Evolutionary, risk-driven spiral framework and plan-driven builds
 - Compatible acquisition and contracting methods and skills
 - Knowing when not to system engineer
- Conclusions, references



The Need for NetCentric Systems of Systems (NCSOS)

- Lack of integration among stovepiped systems causes
 - Unacceptable delays in service
 - Uncoordinated and conflicting plans
 - Ineffective or dangerous decisions
- NCSOS can strongly boost performance of
 - National Defense
 - Supply Chain Management
 - National Air Traffic Control
 - Crisis Management



System Acquisition Trends

Traditional Acquisition

- Standalone systems
- Stable requirements
- Rqts. determine capabilities
- Control over evolution
- Enough time to keep stable
- Failures locally critical
- Reductionist systems
- Repeatability-oriented process, maturity models

Current/Future Trends

- Everything connected (maybe)
- Rapid requirements change
- COTS capabilities determine rqts.
- No control over COTS evolution
- Ever-decreasing cycle times
- Failures globally critical
- Complex, adaptive, emergent systems of systems
- Adaptive process models



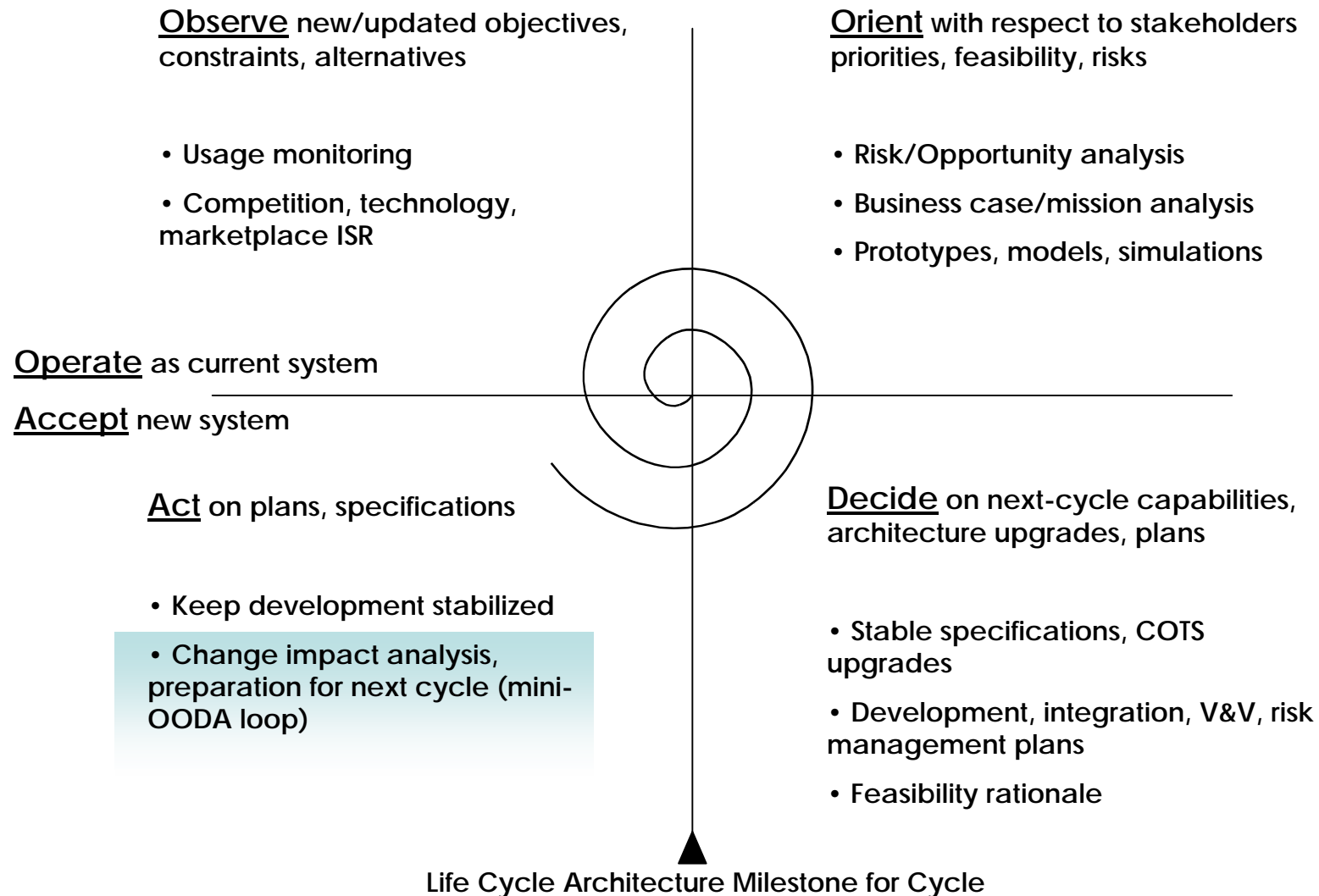
NCSOS Acquisition is More Like Doing C4ISR – than buying fruitcake

- No detailed plan survives the first engagement
- Acquisition C4ISR via spiral OODA loops
 - Observe, Orient, Decide, Act
 - Vs. Requirements, Delay, Surprise
- Concurrent tasking, collaboration technology essential
 - Spanning deep chains of command
 - *Customer, LSI, IPT's (C4ISR), Decision Support, COP Refresh, Sensor Fusion, Sensors, Sensor components*
- Common strategy essential; microplanning risky
- Competition, technology, marketplace ISR essential
- Rapid adaptability essential



Acquisition C4ISR Via Spiral OODA Loops

- Example: ARPANet/Internet Spiral





NCSOS Acquisition Practice Implications

- Need to stimulate agility during Observe, Orient, Decide sectors
 - With flexibility-oriented contract, award fee provisions
- Need to stimulate stability during Act sector
 - Current stability-oriented contract provisions a good match
- Risk-driven spiral process generator accommodates both
- Waterfall and V-models have their risk-driven place
 - Acquiring precedented systems in stable marketplace
 - Executing stable Act sector



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The Agile Manifesto

We are uncovering better ways of developing software by doing it and helping others do it.

Through this work we have come to value:

- **Individuals and interactions** over processes and tools
- **Working software** over comprehensive documentation
- **Customer collaboration** over contract negotiation
- **Responding to change** over following a plan

That is, while there is value in the items on the right, we value the items on the *left* more.



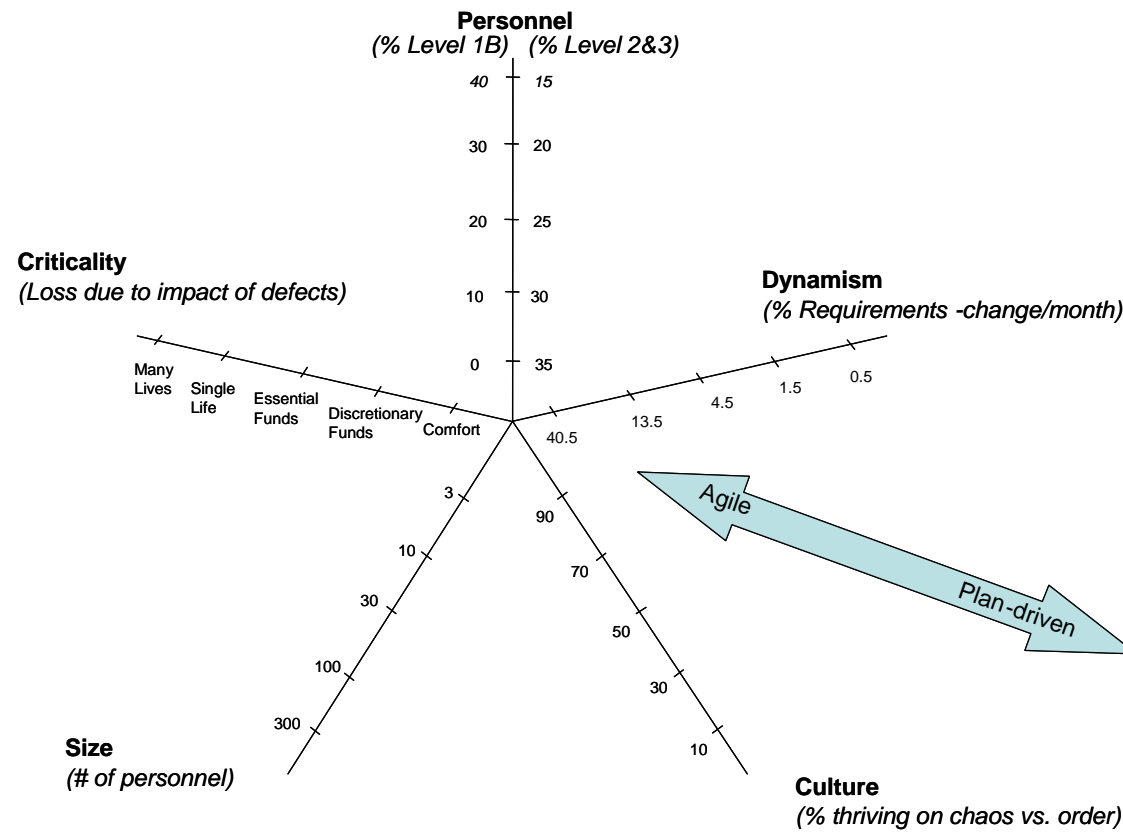
NCSOS-Relevant Agile Practices

- Short stabilized increments (+)
 - Prioritized feature backlog
- Continuous customer-developer participation (+)
- Early test; continuous integration (+)
- Tacit interpersonal vs. explicit documented knowledge (+)
- Welcome changing requirements (+)
- Simple design (-)
 - Just for current increment
 - Refactor to accommodate later capabilities



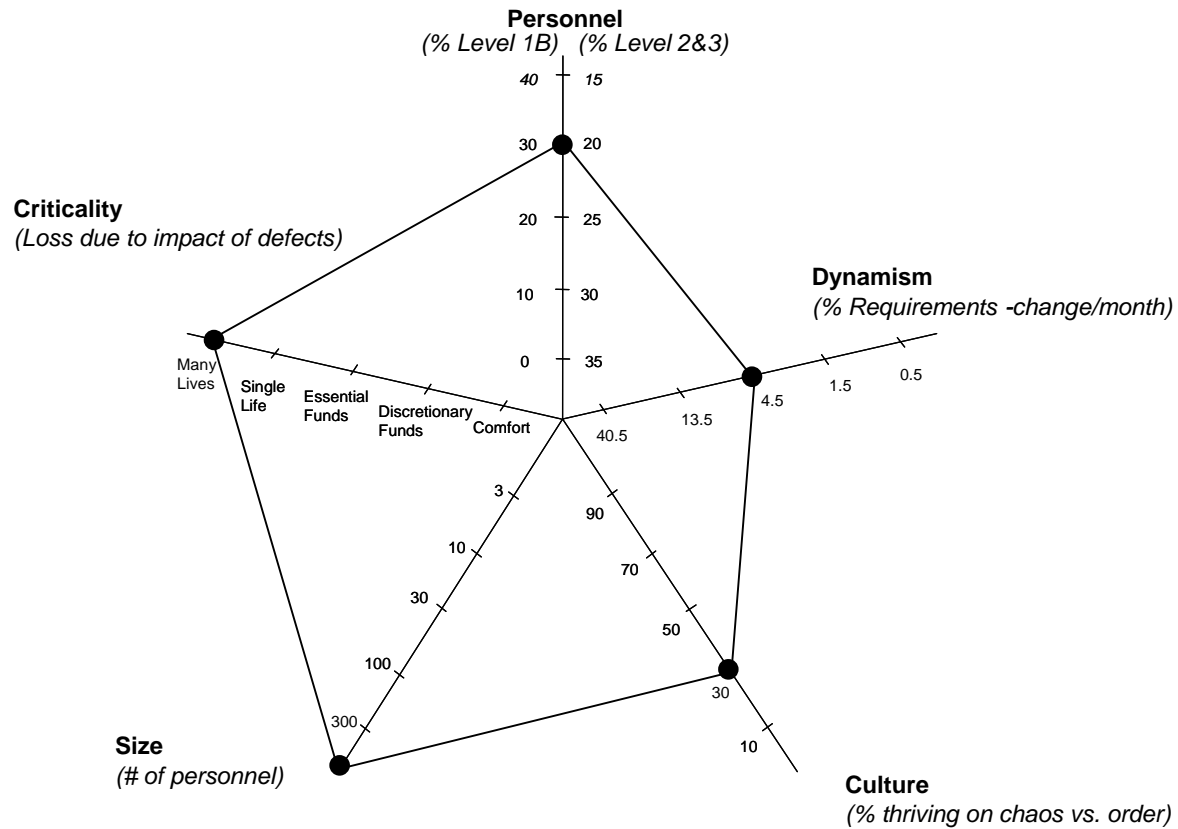
Agile and Plan-Driven Home Grounds: Five Critical Decision Factors

- Size, Criticality, Dynamism, Personnel, Culture





NCSOS Agile/Plan-Driven Profile





Conclusions So Far

- Large global enterprises need NCSOS
- NCSOS acquisition is more like doing C4ISR
 - Acquisition C4ISR via spiral OODA loops
 - Need more adaptive vs. build-to-spec acquisition practices
- Key agile practices help, but scalability is difficult
- NCSOS acquisition needs to balance agility and discipline
 - Integrating agile and plan-driven methods



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USC-CSE Agile/Plan-Driven Workshops, 2002-2005

- Large companies having success with small agile pilot projects
 - ABB, Daimler Chrysler, IBM, LMCO, Motorola, Northrop Grumman, Raytheon, SAIC
 - Generally higher productivity, customer satisfaction, morale
- Some perceived agile problems were non-issues
 - Agile is monolithic, disorganized
 - No framework for quantitative management, quality assurance
- Some perceived agile problems were real issues



Large-Company Agile Assimilation Issues

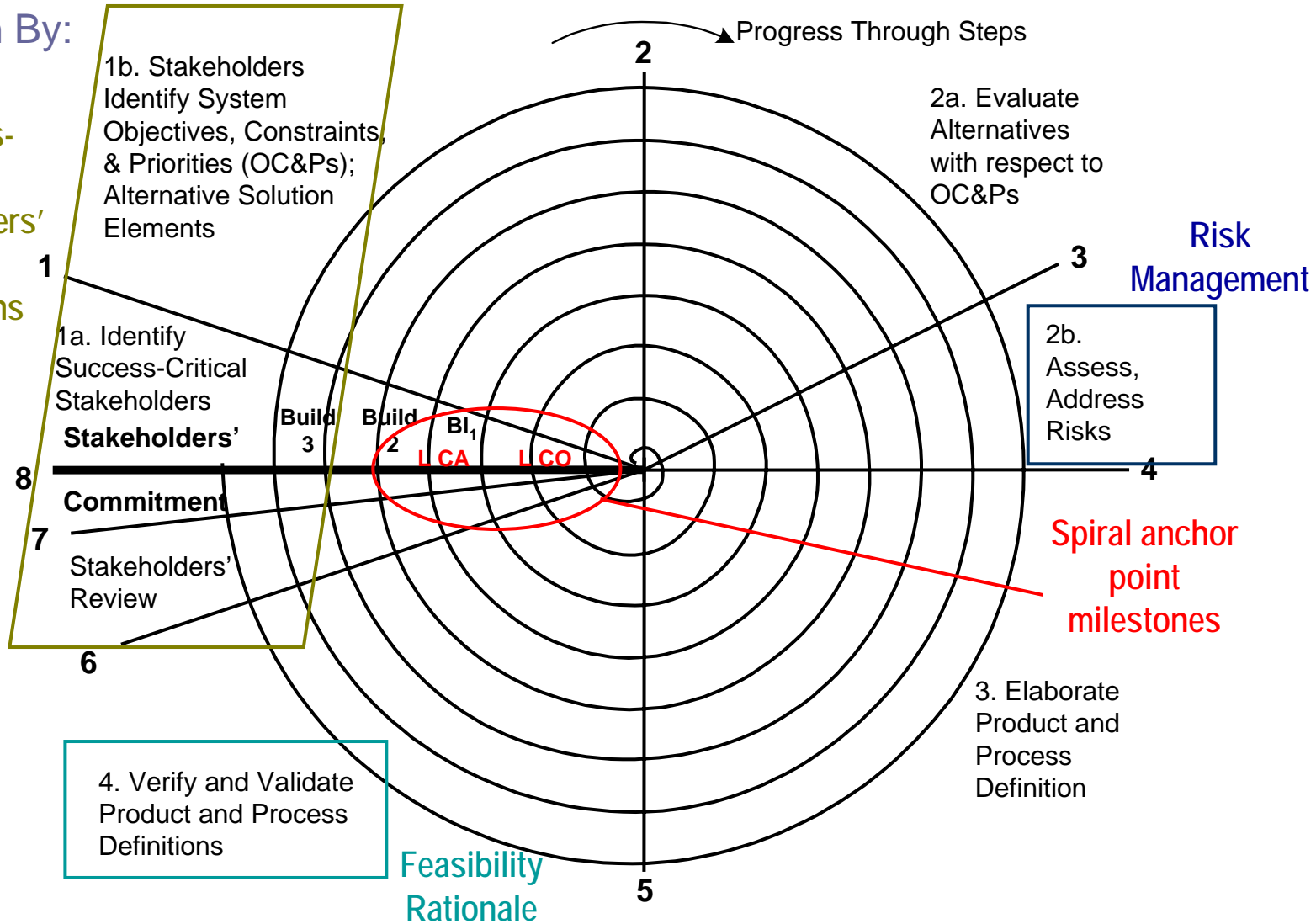
- Scalability of agile methods
 - Tacit knowledge (propagation; personnel turnover; 5,000 requirements)
 - Multi-team coordination
- Avoiding agile stovepipes
 - Limitations on freedom of choice
 - *COTS, interfaces, GUIs, legacy systems*
- Traditional business practices
 - Contracting; earned value systems; timekeeping; waterfall/V-model standard, HR practices
- Inflexible maturity model interpretations
- Customer collocation, access
- Architecture suboptimization on early increments
 - Example: key performance parameters
- Predictable vs. unpredictable change



Spiral Integration of Agile and Plan-Driven Processes

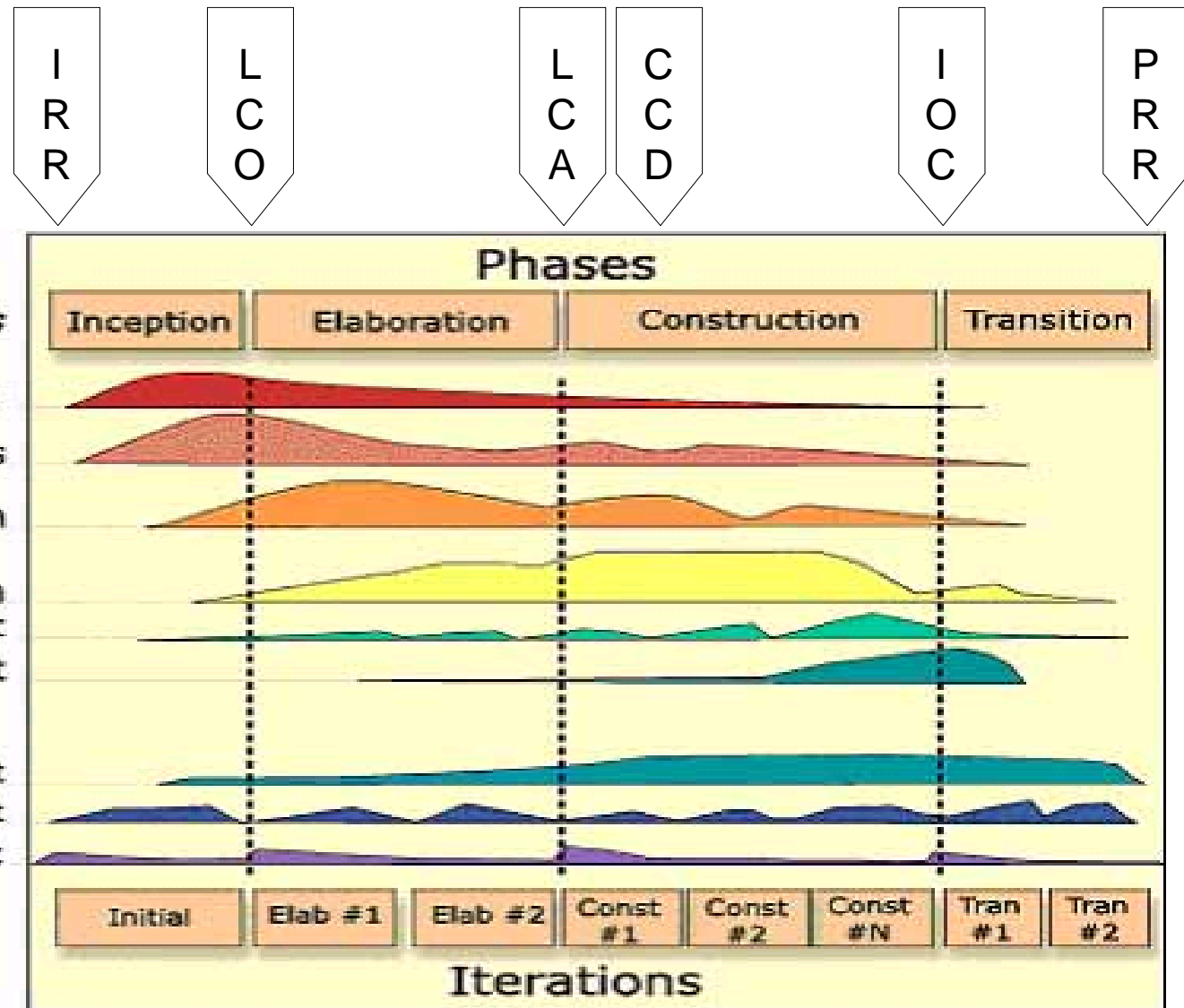
Driven By:

Success-critical stakeholders' win conditions





Spiral Anchor Points Enable Concurrent Engineering





Need Concurrently Engineered Milestone Reviews

Life Cycle Objectives (LCO); Life Cycle Architecture Package (LCA)

Operational Concept	<ul style="list-style-type: none">• Elaboration of system objectives and scope by increment• Elaboration of operational concept by increment
System Prototype(s)	<ul style="list-style-type: none">• Exercise range of usage scenarios• Resolve major outstanding risks
System Requirements	<ul style="list-style-type: none">• Elaboration of functions, interfaces, quality attributes, and prototypes by increment<ul style="list-style-type: none">- Identification of TBD's (to be determined items)• Stakeholders' concurrence on their priority concerns
System and Software Architecture	<ul style="list-style-type: none">• Choice of architecture and elaboration by increment<ul style="list-style-type: none">- Physical and logical components, connectors, configurations, constraints- COTS, reuse choices- Domain architecture and architectural style choices• Architecture evolution parameters



Need Concurrently Engineered Milestone Reviews

Life Cycle Objectives (LCO); Life Cycle Architecture Package (LCA)₂

Life-Cycle Plan	<ul style="list-style-type: none">• Elaboration of WWWWWHH* for Initial Operational Capability (IOC)• Partial elaboration, identification of key TBD's for later increments
Feasibility Rationale	<ul style="list-style-type: none">• Assurance of consistency among elements above• All major risks resolved or covered by risk management plan.

***WWWWHH: Why, What, When, Who, Where, How, How Much**



LCO (MS A) and LCA (MS B) Pass/Fail Criteria

- **A system built to the given architecture will**
 - Support the operational concept
 - Satisfy the requirements
 - Be faithful to the prototype(s)
 - Be buildable within the budgets and schedules in the plan
 - Show a viable business case
 - Establish key stakeholders' commitment to proceed

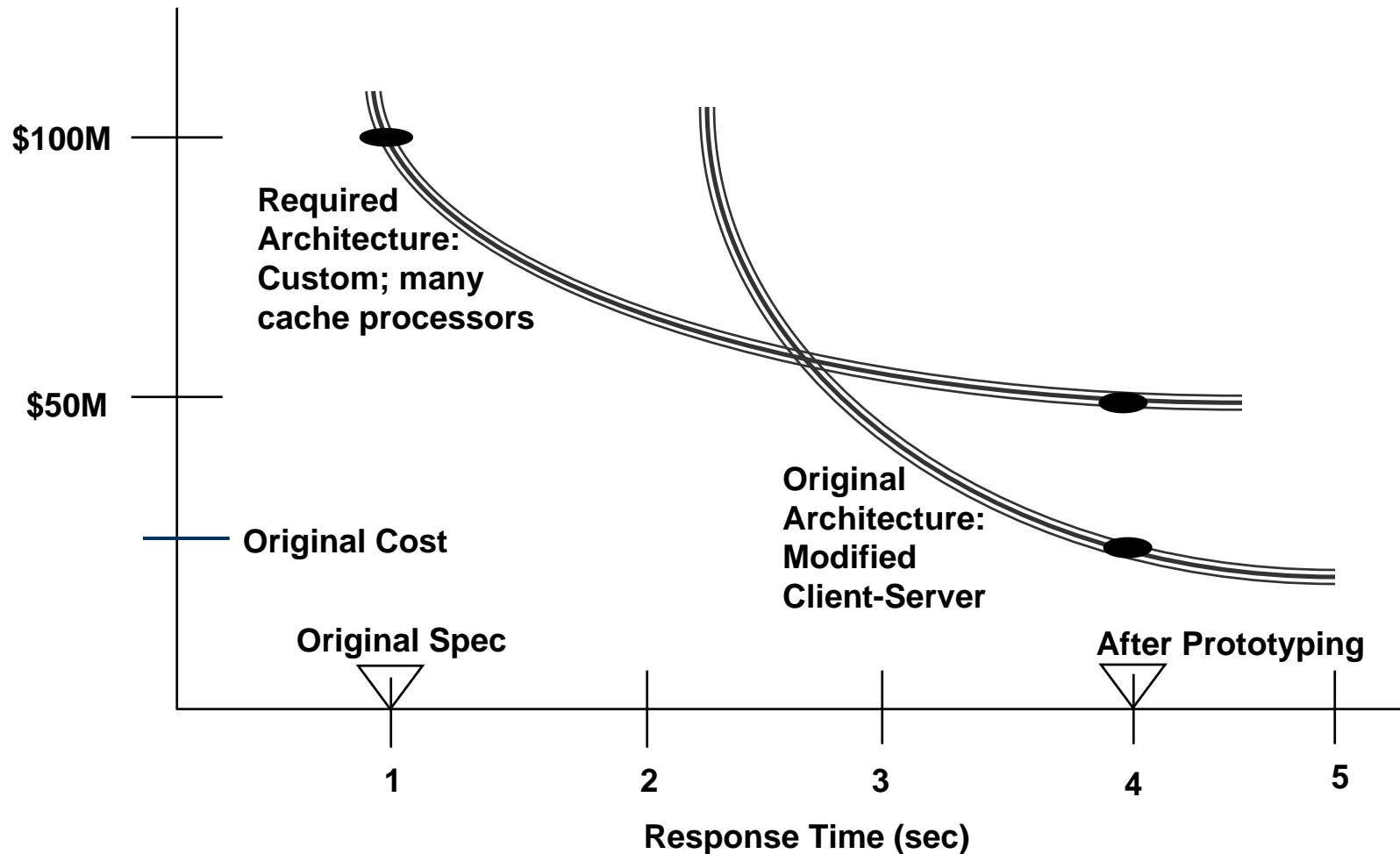
LCO: True for at least one architecture

LCA: True for the specific life cycle architecture;

All major risks resolved or covered by a risk management plan



The Cost of Hasty Fixed Requirements: 15-Month Architecture Rework Delay





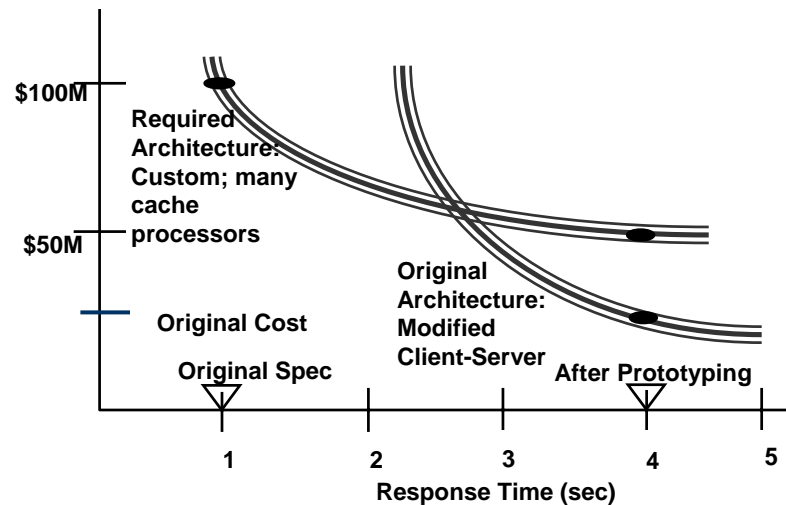
KPP Validation with Spiral Model

- Attempt to validate 1-second KPP
 - Architecture analysis: needs expensive custom solution
 - Prototype: 4-seconds OK 90% of the time
- Negotiate KPP ranges
 - 2 seconds desirable
 - 4 seconds acceptable with some 2-second special cases
- Benchmark client-server to validate feasibility
- Present solution and feasibility rationale at anchor point milestone review
 - Result: Acceptable solution with minimal delay



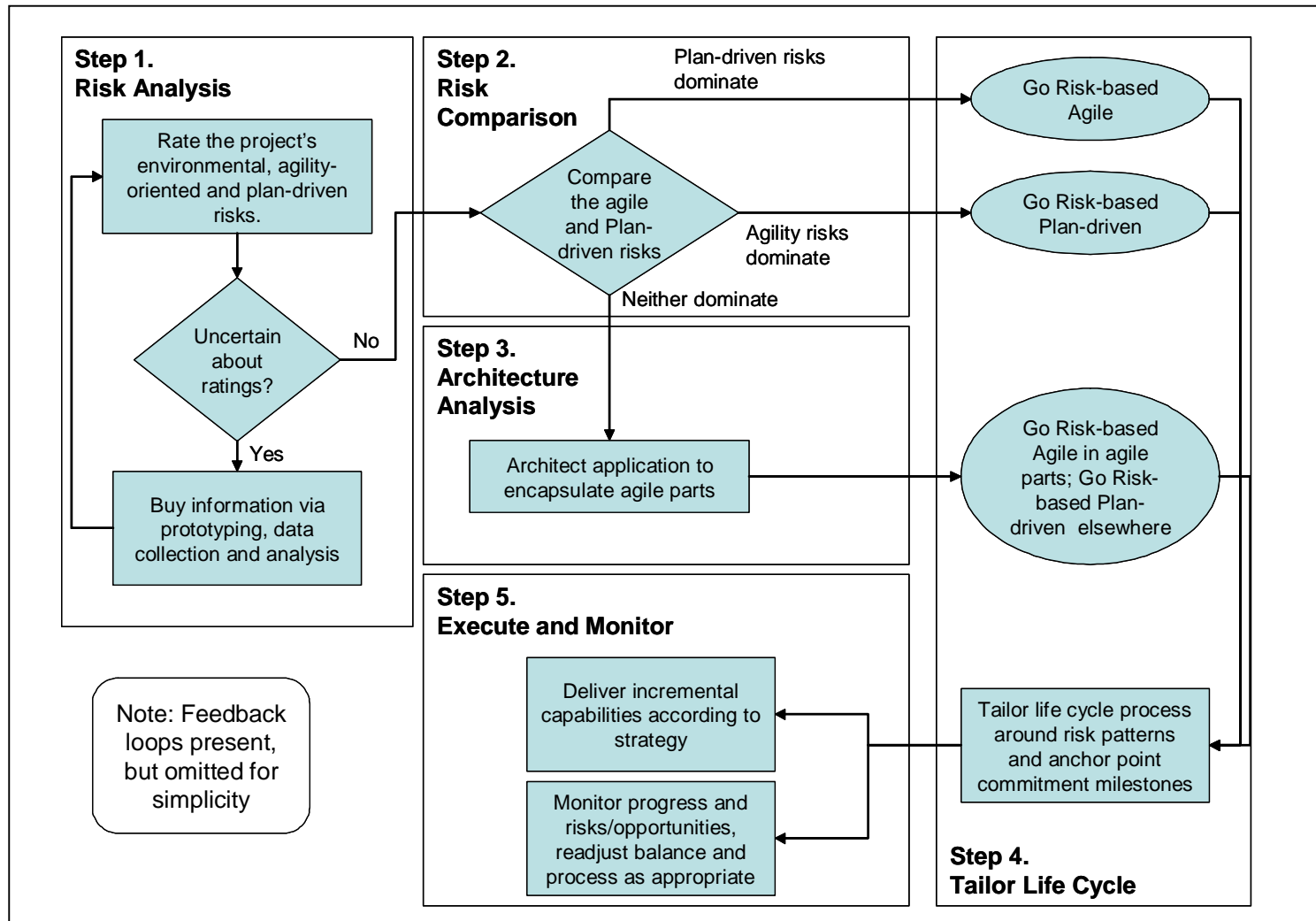
Key Points

- It's not a requirement if you can't afford it
 - Or fit it into your schedule
- Spiral approach avoids late rework
- Beware of sub-optimization on small-scale early iterations





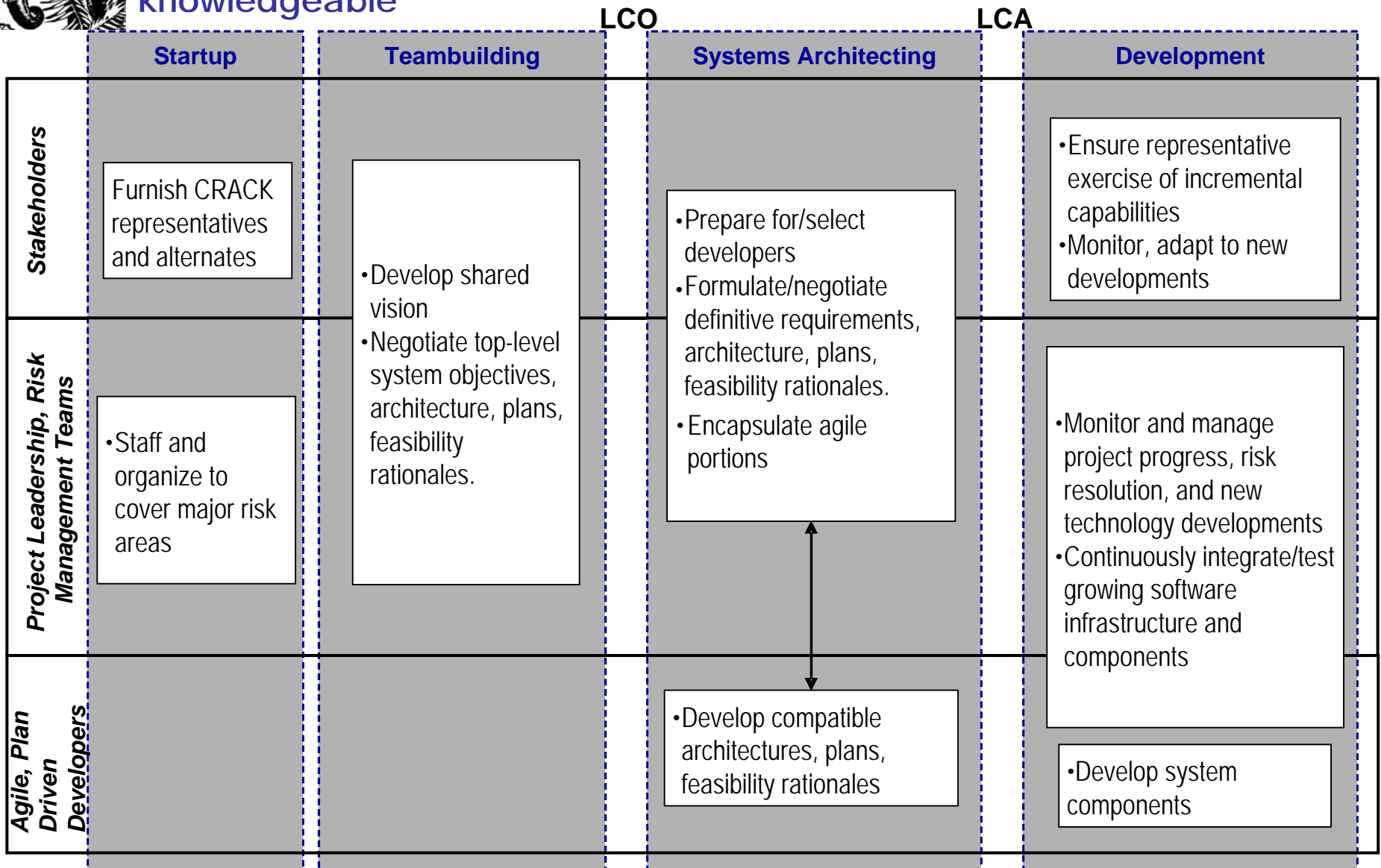
Using Risk to Balance Discipline and Agility - Overview





NCSOS Agile/Plan-Driven Strategy

- CRACK: collaborative, representative, authorized, committed, knowledgeable





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NCSOS Acquisition: Critical Success Factors

- Risk-driven spiral processes and organizations
 - Project manager's risk/opportunity team
- Stabilized evolutionary builds
 - Concurrent plan-driven construction, agile rebaselining
 - Anchor point milestones and Feasibility Rationales
- Rethinking supplier management
 - Teambuilding and plans/architecture participation
 - Balanced agile/plan-driven contracts, award fees
- Knowing when not to system engineer



Agile Rebaselining Mini OODA Loop

- Many sources of next-build volatility
 - Supplier chain slippages, changes in current build
 - External interface volatility
 - *COTS; interoperating systems*
 - New threats, technology, policies
 - Organizational, top-management volatility
- Next build needs to hit the ground running
- Requires critical-mass budget, talent, tools for
 - Change impact analysis (observe, orient)
 - Solution rebaselining (decide, act)
 - *Renegotiating future builds' content, associated plans and resources*
 - *Integrated COTS refresh preparation*



DoDI 5000.2 “Spiral Development”

Section 3.3.2.1

- Desired capability is identified
 - End-state requirements not initially known
- Requirements refined through demonstration and risk management
 - Continuous user feedback
 - Each increment provides user the best possible capability
- Requirements for future increments depend on feedback from users and technology maturation

NB: This section of 5000 is under revision and all reference to spiral may be removed



Knowing When Not to System Engineer – A multi-platform NCSOS example

- Customer system-engineers an optimized product line architecture for platform functions
 - Estimates cost savings from reuse
- Customer solicits best-of-breed platform suppliers
 - Contracts with most cost-effective bidders
- Customer discovers that supplier bids are based on product line – incompatible components
 - Too expensive to refit to product line architecture
- Better to risk-manage degree of product line achievability
 - Involve potential suppliers in product line option exploration



Conclusions

- Large global enterprises need NCSOS
- NCSOS acquisition is more like doing C4ISR
- Critical success factors include
 - Risk-driven spiral processes and organizations
 - Concurrent plan-driven builds, agile rebaselining
 - *And associated budgets, talent, tools*
 - Rethinking supplier management
 - *Balanced agile/plan-driven contracts, award fees*
 - *Teambuilding and plans/architecture participation*
 - *Knowing when not to system engineer*



References

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