Early SE Determination of Best-Fit System Life Cycle Processes

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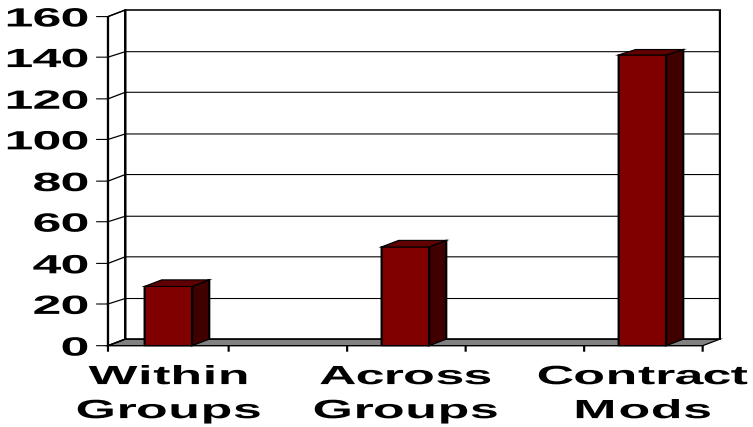
Outline

- Life cycle process goals and challenges
  - Too much versus too little process
- Balancing process goals and challenges via the Incremental Commitment Model
  - ICM nature and risk-driven framework
  - Decision table for common special cases
    - Including pure agile, pure rigorous, hybrids
    - Example: Architected Agile
- Conclusions and references

Need for SE Agility and Rigor

- Future need for agility
  - Rapid change; turning within adversaries' OODA loop
- Future need for rigor
  - Secure, safe, always-on systems
- Risky to overemphasize agility
  - Easiest-first, unscalable, unsecurable systems
- Risky to overemphasize rigor

Average workdays to process changes, 2 large systems of systems



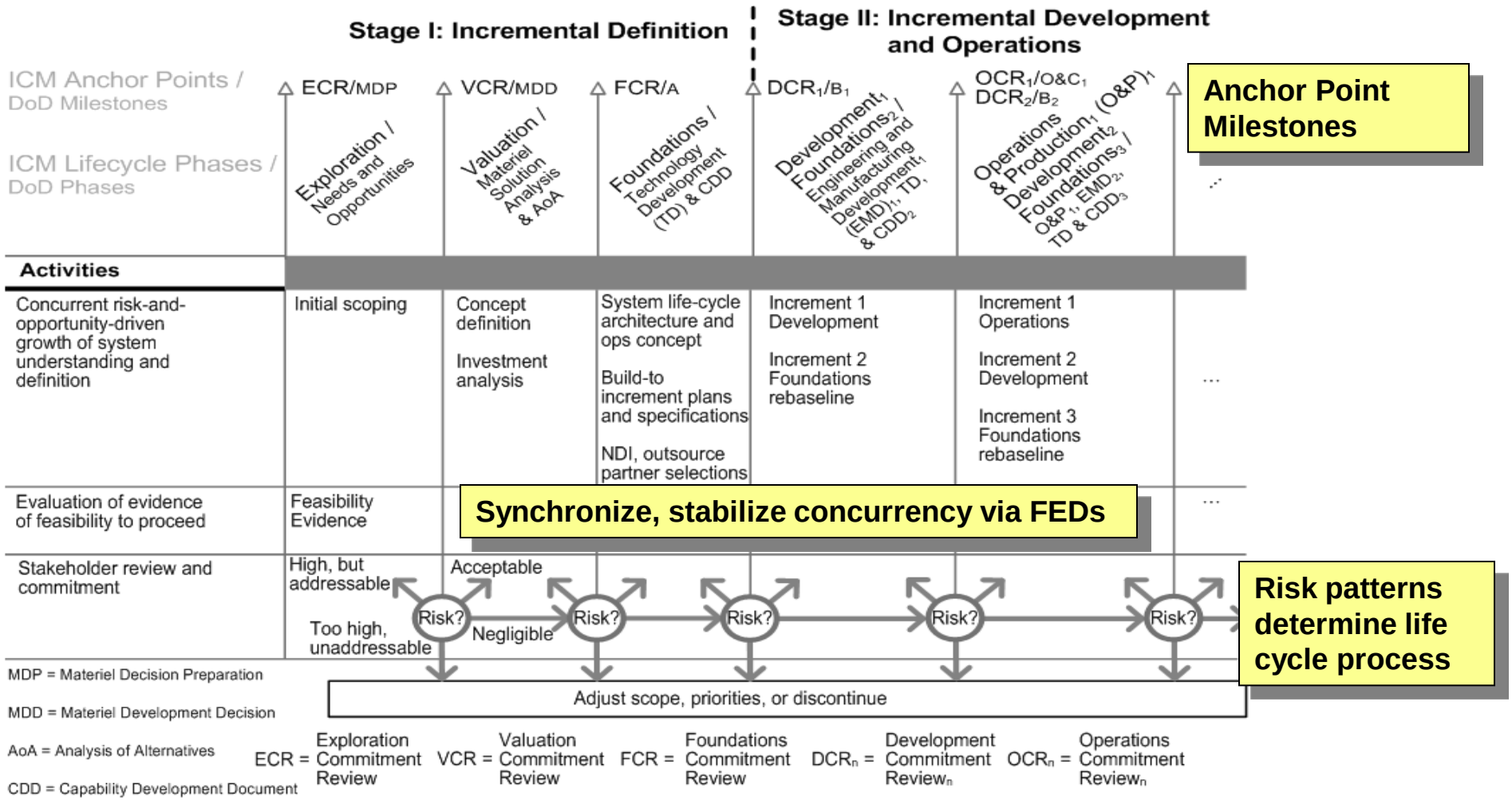
What is the ICM?

- **Risk-driven framework for determining and evolving best-fit system life-cycle process**
- **Integrates the strengths of phased and risk-driven spiral process models**
- **Synthesizes together principles critical to successful system development**
  - **Commitment and accountability of system sponsors**
  - **Success-critical stakeholder satisficing**
  - **Incremental growth of system definition and stakeholder commitment**
  - **Concurrent engineering**
  - **Iterative development cycles**
  - **Risk-based activity levels and anchor point milestones**

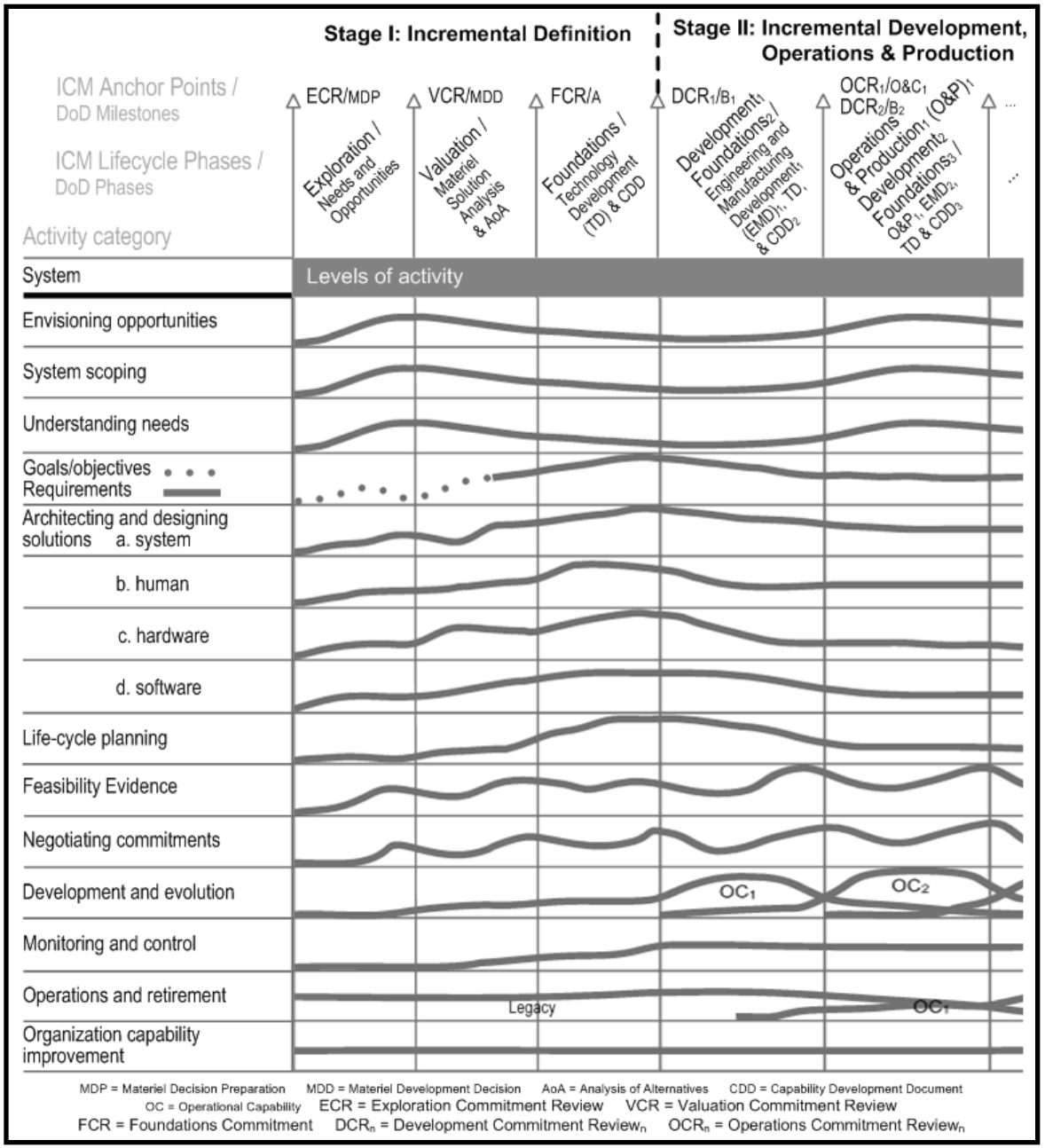
Principles trump diagrams…

Principles used by 60-80% of CrossTalk Top-5 projects, 2002-2005

The Incremental Commitment Life Cycle Process: Overview



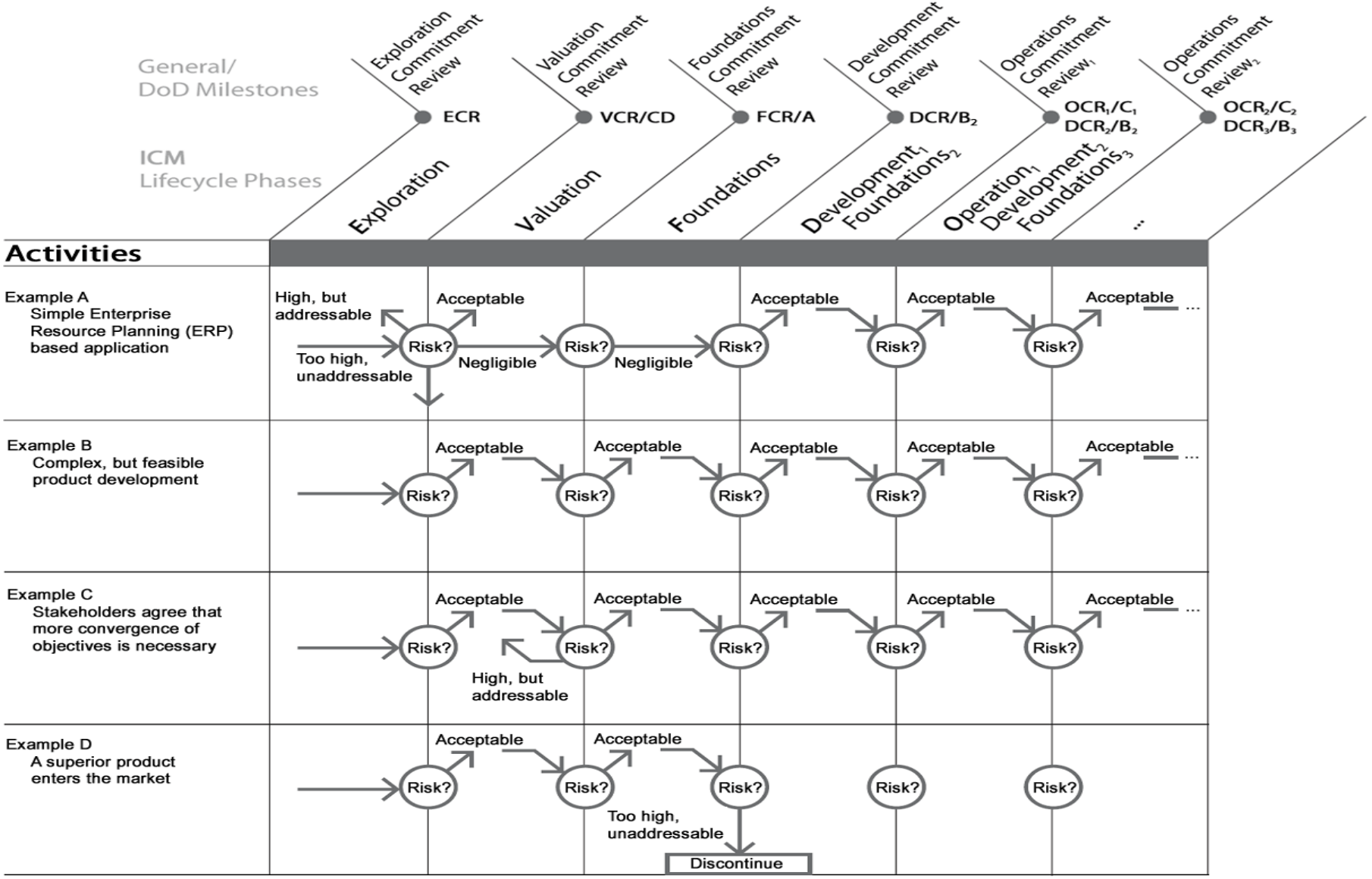
ICM Activity Levels for Complex Systems



The ICM as Risk-Driven Process Generator

- Stage I of the ICM has 3 decision nodes with 4 options per node
  - Culminating with incremental development in Stage II
  - Some options involve go-backs
  - Results in many possible process paths
- Can use ICM risk patterns to generate frequently-used processes
  - With confidence that they fit the situation
- Can generally determine this in the Exploration phase
  - Develop as proposed plan with risk-based evidence at VCR milestone
  - Adjustable in later phases

Different Risk Patterns Yield Different Processes



The ICM Process Decision Table

- **Key Decision Inputs**
  - Product and project size and complexity
  - Requirements volatility
  - Mission criticality
  - Nature of any Non-Developmental Item (NDI) support
    - Commercial, open-source, reused components
  - Organizational and Personnel Capability
- **Key Decision Outputs**
  - Key Stage I activities: incremental definition
  - Key Stage II activities: incremental development and operations
  - Suggested calendar time per build, per deliverable increment

In most cases, can characterize these in the early very early in the system Exploration and Valuation phases (early SE)...

Common Risk-Driven Special Cases of the ICM (Cases 1-4)

Case 1: Use NDI

Example: Small accounting system
Size, Complexity: Size variable, complexity low
Typical Change Rate/Month: Negligible
Criticality: n/a
NDI Support: Complete
Organizational Personnel Capability: NDI-experienced (medium)
Key Stage I Activities (Incremental Definition): Acquire NDI
Key Stage II Activities (Incremental Development/Operations): Use NDI
Time/Build: n/a
Time/Increment: Vendor-driven

Case 2: Agile

Example: E-services
Size, Complexity: Low
Typical Change Rate/Month: 1-30%
Criticality: Low to medium
NDI Support: Good, in place
Organizational Personnel Capability: Agile-ready, medium-high experience
Key Stage I Activities (Incremental Definition): Skip Valuation and Architecting phases
Key Stage II Activities (Incremental Development/Operations): Scrum plus agile methods of choice
Time/Build: <= 1 day
Time/Increment: 2-6 weeks

Case 3: Architected Agile

Example: Business data processing
Size, Complexity: Medium
Typical Change Rate/Month: 1-10 %
Criticality: Medium to high
NDI Support: Good, most in place
Organizational Personnel Capability: Agile-ready, medium to high experience
Key Stage I Activities (Incremental Definition): Combine Valuation, Architecting phases. Complete NDI preparation.
Key Stage II Activities (Incremental Development/Operations): Architecture-based Scrum of Scrums
Time/Build: 2-4 weeks
Time/Increment: 2-6 months

Case 4: Formal Methods

Example: Security kernel; Safety-critical LSI chip
Size, Complexity: Low
Typical Change Rate/Month: 0.3%
Criticality: Extra high
NDI Support: None
Organizational Personnel Capability: Strong formal methods experience
Key Stage I Activities (Incremental Definition): Precise formal specification
Key Stage II Activities (Incremental Development/Operations): Formally-based programming language; formal verification
Time/Build: 1-5 days
Time/Increment: 1-4 weeks

Common Risk-Driven Special Cases of the ICM (Cases 5-8)

Case 5: Hardware with Embedded Software Component

Example: Multi-sensor control device
Size, Complexity: Low
Typical Change Rate/Month: 0.3 - 1 %
Criticality: Medium to very high
NDI Support: Good, in place
Organizational Personnel Capability: Experienced, medium-high
Key Stage I Activities (Incremental Definition): Concurrent hardware/software engineering. CDR-level ICM DCR
Key Stage II Activities (Incremental Development/Operations): IOC development, LRIP, FRP. Concurrent version N+1 engineering
Time/Build: Software 1-5 days
Time/Increment: Market-driven

Case 6: Indivisible IOC

Example: Complete vehicle platform
Size, Complexity: Medium to high
Typical Change Rate/Month: 0.3 – 1%
Criticality: High to very high
NDI Support: Some in place
Organizational Personnel Capability: Experienced, medium to high
Key Stage I Activities (Incremental Definition): Determine minimum-IOC likely, conservative cost. Add deferrable software features as risk reserve
Key Stage II Activities (Incremental Development/Operations): Drop deferrable features to meet conservative cost. Strong award free for features not dropped.
Time/Build: Software: 2-6 weeks
Time/Increment: Platform: 6-18 months

Case 7: NDI-Intensive

Example: Supply chain management
Size, Complexity: Medium to high
Typical Change Rate/Month: 0.3 – 3%
Criticality: Medium to very high
NDI Support: NDI-driven architecture
Organizational Personnel Capability: NDI-experienced, medium to high
Key Stage I Activities (Incremental Definition): Thorough NDI-suite life cycle cost-benefit analysis, selection, concurrent requirements/architecture definition
Key Stage II Activities (Incremental Development/Operations): Pro-active NDI evolution influencing, NDI upgrade synchronization
Time/Build: Software: 1-4 weeks
Time/Increment: Systems: 6-18 months

Case 8: Hybrid Agile/Plan-Driven System

Example: C4ISR system
Size, Complexity: Medium to very high
Typical Change Rate/Month: Mixed parts; 1-10%
Criticality: Mixed parts; Medium to very high
NDI Support: Mixed parts
Organizational Personnel Capability: Mixed parts
Key Stage I Activities (Incremental Definition): Full ICM, encapsulated agile in high change, low-medium criticality parts (Often HMI, external interfaces)
Key Stage II Activities (Incremental Development/Operations): Full ICM, three-team incremental development, concurrent V&V, next-increment rebaselining
Time/Build: 1-2 months
Time/Increment: 9-18 months

Common Risk-Driven Special Cases of the ICM (Cases 9-11)

Case 9: Multi-Owner Directed System of Systems

Example: Net-centric military operations
Size, Complexity: Very high
Typical Change Rate/Month: Mixed parts; 1-10 %
Criticality: Very high
NDI Support: Many NDIs, some in place
Organizational Personnel Capability: Related experience, medium to high
Key Stage I Activities (Incremental Definition): Full ICM; extensive multi-owner team building, negotiation
Key Stage II Activities (Incremental Development/Operations): Full ICM; large ongoing system/software engineering effort
Time/Build: 2-4 months
Time/Increment: 18-24 months

Case 10: Family of Systems

Example: Medical device product line
Size, Complexity: Medium to very high
Typical Change Rate/Month: 1-3%
Criticality: Medium to very high
NDI Support: Some in place
Organizational Personnel Capability: Related experience, medium to high
Key Stage I Activities (Incremental Definition): Skip Valuation and Architecting phases
Key Stage II Activities (Incremental Development/Operations): Scrum plus agile methods of choice
Time/Build: 1-2 months
Time/Increment: 9-18 months

Case 11: Brownfield

Example: Incremental legacy phaseout
Size, Complexity: High to very high
Typical Change Rate/Month: 0.3-3%
Criticality: Medium-high
NDI Support: NDI as legacy replacement
Organizational Personnel Capability: Legacy re-engineering
Key Stage I Activities (Incremental Definition): Re-engineer/refactor legacy into services
Key Stage II Activities (Incremental Development/Operations): Incremental legacy phaseout
Time/Build: 2-6 weeks/refactor
Time/Increment: 2-6 months

Common Risk-Driven Special Cases of the ICM (Cases 12a/b)

Case 12a: Net-Centric Services – Community Support

Example: Community services or special interest group
Size, Complexity: Low to medium
Typical Change Rate/Month: 0.3-3%
Criticality: Low to medium
NDI Support: Tailorable service elements
Organizational Personnel Capability: NDI-experienced
Key Stage I Activities (Incremental Definition): Filter, select, compose, tailor NDI
Key Stage II Activities (Incremental Development/Operations): Evolve tailoring to meet community needs
Time/Build: <= 1 day
Time/Increment: 2-12 months

Case 12b: Net-Centric Services – Quick Response Decision Support

Example: Response to competitor initiative
Size, Complexity: Medium to high
Typical Change Rate/Month: 3-30%
Criticality: Medium to high
NDI Support: Tailorable service elements
Organizational Personnel Capability: NDI-experienced
Key Stage I Activities (Incremental Definition): Filter, select, compose, tailor NDI
Key Stage II Activities (Incremental Development/Operations): Satisfy quick response; evolve or phase out
Time/Build: <= 1 day
Time/Increment: Quick response-driven

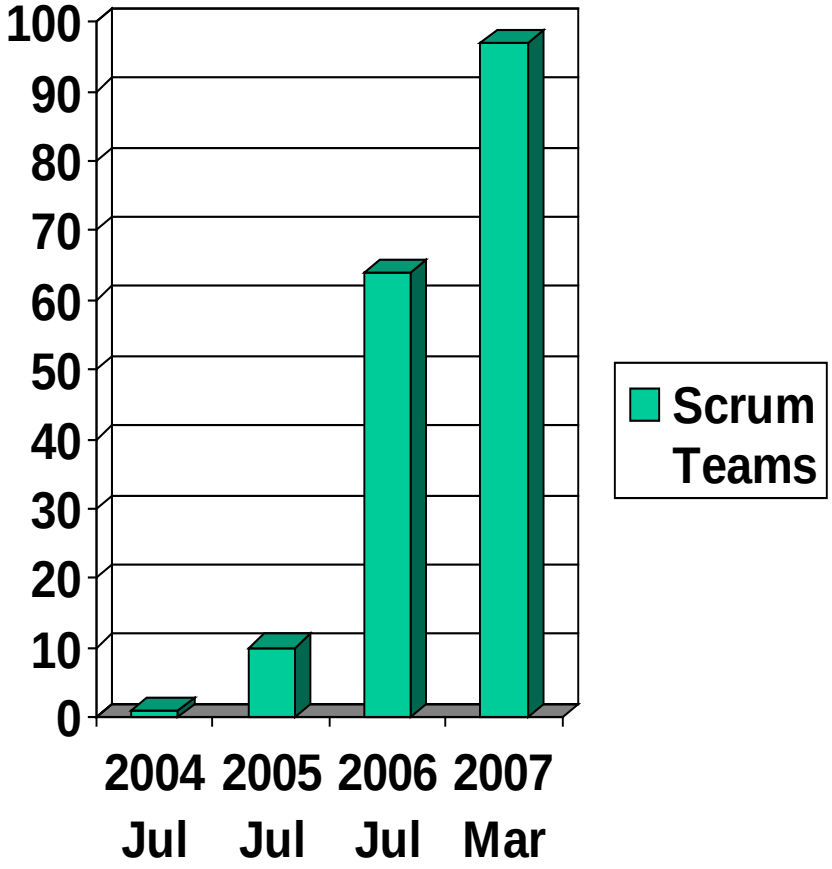
LEGEND

C4ISR: Command, Control, Computing, Communications, Intelligence, Surveillance, Reconnaissance.
CDR: Critical Design Review.
DCR: Development Commitment Review.
FRP: Full-Rate Production.
HMI: Human-Machine Interface.
HW: Hard ware.
IOC: Initial Operational Capability.
LSI: Large Scale Integration.
LRIP: Low-Rate Initial Production.
NDI: Non-Development Item.
SW: Software

USA Medical Case Study

- 1400 software people; 7M SLOC; 7 sites
  - 4 in Europe, 2 in India
- 500 medical applications; 500 financial; others
- Survivability-critical software problems
  - Reliability, productivity, performance, interoperability
  - Sarbanes-Oxley requirements
  - Management receptive to radical change
- Some limited experimental use of agile methods
  - Led by top software technologist/manager
- Committed to total change around Scrum and XP

USA Medical Process Adoption Profile



- **July 2004 - July 2005**
  - **Recruit top people from all sites into core team(s)**
  - **Get external expert help**
  - **Develop architecture**
  - **Early Scrum successes with infrastructure**
  - **Revise policies and practices**
  - **Train, reculture everyone**
  - **Manage expectations**
- **July 2005 – July 2006**
  - **Begin full-scale development**
  - **Core teams as mentors**

USA Medical Development Process Characteristics

- Include customers and marketers
  - New roles; do's/don'ts/opportunities; CRACK personnel; full collaboration and teamwork; expectations management
- Scrum; most XP practices; added company practices
  - 6-12 person teams with team rooms, dedicated servers
  - Hourly smoke test; nightly build and regression test
  - Just-in-time analysis; story-point estimates; fail fast; detailed short-term plans; company architecture compliance
  - Embrace change in applications and practices
  - Global teams: wikis, daily virtual meetings, act as if next-door
- Release management
  - 2-12 week architecting Sprint Zero; 3-10 1-month Sprints; Release Sprint; 1-6 month beta test
  - Next Sprint Zero concurrent with Release Sprint
- Initiative manager and team
  - Define practices; evolve infrastructure; provide training; guide implementation; evaluate compliance/usage; continuous improvement

Best Fit: Case 3—Architected Agile

- Exploration phase determines
  - Need to accommodate fairly rapid change, emergent requirements, early user capability
  - Low risk of scalability up to 100 people
  - NDI support of growth envelope
  - Nucleus of highly agile-capable personnel
  - Moderate to high loss due to increment defects
- Example: Supply chain management
- Size/complexity: Medium
- Anticipated change rate (% per month): 1-10%
- Criticality: Medium to high
- NDI support: Good, most in place
- Organizational and personnel capability: Agile-ready, med-high capability
- Key Stage I activities: Combined Valuation and Architecting phase, complete NDI preparation
- Key Stage II activities: Architecture-based scrum of scrums
- Time/build: 2-4 weeks Time/increment: 2-6 months

Why is Early Determination and Tailoring Important?

- One-size-fits-all processes can be
  - Overly heavy-weight, requiring teams to perform too many non-value adding tasks that increase costs and schedule
  - Not rigorous enough in identifying and managing risks early on, leading to failed programs
- Forces an early understanding of scope, complexity, and risks associated with proposed system development
- Through early engineering, may find opportunities to simplify and reduce risks, allowing development team to proceed with more agile processes

Conclusions

- Future systems increasingly need both agility and rigor
- Risk analysis helps determine how much of each is enough
  - Balancing risks of doing too little, too much of each
  - Can vary across subsystems
- Increasingly risky to use one-size-fits-all process models
  - Waterfall, V model, risk-insensitive spiral model
  - Associated inflexible contractual frameworks
- ICM provides tailorable risk-driven framework
  - And decision table for common special-case processes
  - Typically tailorable in early SE stages
  - Compatible with new evolutionary US DoDI 5000.02

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