The Incremental Commitment Model and the CeBASE Method

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UMD Vic&Marv Symposium
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ICM and the CeBASE Method: Outline

• From the spiral model to the ICM
  – Principles and example

• Risk-driven incremental definition: ICM Stage I
  – Buying information to reduce risk

• Risk-driven incremental development: ICM Stage II
  – Achieving both rapid change and high assurance

• Multiple views of the ICM
  – Viewpoints and examples

• The ICM and the CeBASE Method
  – Result of UMD-USC Center for Empirical Software Engineering
  – Harmonization of UMD and USC process models
From the Spiral Model to the ICM

• Need for intermediate milestones
  – Anchor Point Milestones (1996)
• Avoid stakeholder success model clashes
• Avoid model misinterpretations
• Clarify usage in DoD Instruction 5000.2
  – Initial phased version (2005)
• Explain system of systems spiral usage to GAO
  – Underlying spiral principles (2006)
• Provide framework for human-systems integration
Process Model Principles

1. Commitment and accountability
2. Success-critical stakeholder satisficing
3. Incremental growth of system definition and stakeholder commitment
4, 5. Concurrent, iterative system definition and development cycles
   Cycles can be viewed as sequential concurrently-performed phases or spiral growth of system definition
6. Risk-based activity levels and anchor point commitment milestones
Shared Commitments are Needed to Build Trust

- **New partnerships are increasingly frequent**
  - They start with relatively little built-up trust
- **Group performance is built on a bedrock of trust**
  - Without trust, partners must specify and verify details
  - Increasingly untenable in a world of rapid change
- **Trust is built on a bedrock of honored commitments**
- **Once trust is built up, processes can become more fluid**
  - But need to be monitored as situations change
Incremental Commitment in Gambling

- Total Commitment: Roulette
  - Put your chips on a number
    - E.g., a value of a key performance parameter
  - Wait and see if you win or lose

- Incremental Commitment: Poker, Blackjack
  - Put some chips in
  - See your cards, some of others’ cards
  - Decide whether, how much to commit to proceed
Scalable remotely controlled operations
Total vs. Incremental Commitment – 4:1 RPV

• Total Commitment
  – Agent technology demo and PR: Can do 4:1 for $1B
  – Winning bidder: $800M; PDR in 120 days; 4:1 capability in 40 months
  – PDR: many outstanding risks, undefined interfaces
  – $800M, 40 months: “halfway” through integration and test
  – 1:1 IOC after $3B, 80 months

• Incremental Commitment
  – $25M, 6 mo. to VCR: may beat 1:2 with agent technology, but not 4:1
  – $75M, 8 mo. to ACR: agent technology may do 1:1; some risks
  – $225M, 10 mo. to DCR: validated architecture, high-risk elements
  – $675M, 18 mo. to IOC: viable 1:1 capability
  – 1:1 IOC after $1B, 42 months
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The Cone of Uncertainty: Usual result of total commitment

- Inadequate PDR
  - Better to buy information to reduce risk
  - 90% confidence limits:
    - Pessimistic
    - Optimistic

Phases and Milestones:
- Feasibility
- Plans and Rqts.
- Product Design
- Detail Design Spec.
- Devel. and Test
- Accepted Software

Relative Cost Range: 4x, 2x, 1.5x, 1.25x, 0.75x, 0.5x, 0.67x, 0.25x, 0.8x, 0.5x, 0.67x, 0.5x, 0.25x
The Incremental Commitment Life Cycle Process: Overview

Stage I: Definition
- Exploration Commitment Review
- Valuation Commitment Review
- Architecture Commitment Review

Stage II: Development and Operations
- Development Commitment Review
- Operations Commitment Review

Activities

| Concurrent Risk-and-
| opportunity-driven | Initial scoping | Concept definition investment analysis | System architecting | Increment 1 development | Increment 1 operations | ... |
| Growth of System | | | | | | |
| Understanding and Definition | | | | | | |

Evaluation of evidence of feasibility to proceed
- Feasibility rationales
- ... ...
- ... ...
- ... ...

Stakeholder review and commitment
- High, but addressable
- Acceptable
- Negligible
- Too high, unaddressable
- Risk?
- Risk?
- Risk?
- Risk?

Adjust scope, priorities, or discontinue
Anchor Point Feasibility Rationales

• Evidence provided by developer and validated by independent experts that:
  If the system is built to the specified architecture, it will
  – Satisfy the requirements: capability, interfaces, level of service, and evolution
  – Support the operational concept
  – Be buildable within the budgets and schedules in the plan
  – Generate a viable return on investment
  – Generate satisfactory outcomes for all of the success-critical stakeholders

• All major risks resolved or covered by risk management plans

• Serves as basis for stakeholders’ commitment to proceed
Incremental Commitment In Systems and Life: Stage I (Definition) Anchor Point Milestones

- **Common System/Software stakeholder commitment points**
  - Defined in concert with Government, industry organizations
  - Initially coordinated with Rational’s Unified Software Development Process
- **Exploration Commitment Review (ECR)**
  - Stakeholders’ commitment to support initial system scoping
  - Like dating
- **Validation Commitment Review (VCR)**
  - Stakeholders’ commitment to support system concept definition and investment analysis
  - Like going steady
- **Architecting Commitment Review (ACR)**
  - Stakeholders’ commitment to support system architecting
  - Like getting engaged
- **Development Commitment Review (DCR)**
  - Stakeholders’ commitment to support system development
  - Like getting married
The Incremental Commitment Life Cycle Process: Overview

<table>
<thead>
<tr>
<th>Activities</th>
<th>Stage I: Definition</th>
<th>Stage II: Development and Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concurrent risk-and-opportunity-driven</td>
<td>Initial scoping</td>
<td>Increment 1 development</td>
</tr>
<tr>
<td>growth of system understanding and definition</td>
<td>Concept definition</td>
<td>Increment 2 architecting rebaseline</td>
</tr>
<tr>
<td></td>
<td>investment analysis</td>
<td>Increment 3 architecting rebaseline</td>
</tr>
<tr>
<td>Evaluation of evidence of feasibility to proceed</td>
<td>Feasibility</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>rationales</td>
<td>...</td>
</tr>
<tr>
<td>Stakeholder review and commitment</td>
<td>High, but addressable</td>
<td>...</td>
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<tr>
<td></td>
<td>Acceptable</td>
<td>...</td>
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<tr>
<td></td>
<td>Risk?</td>
<td>Risk?</td>
</tr>
<tr>
<td></td>
<td>Too high, unaddressable</td>
<td>...</td>
</tr>
</tbody>
</table>

Adjust scope, priorities, or discontinue
There is Another Cone of Uncertainty:
Shorter increments are better

Uncertainties in competition, technology, organizations, mission priorities

Phases and Milestones:
- Feasibility
- Plans and Rqts.
- Rqts. Spec.
- Product Design Spec.
- Product Design
- Detail Design Spec.
- Detail Design
- Devel. and Test
- Accepted Software
### The Incremental Commitment Life Cycle Process: Overview

#### Stage I: Definition
- Exploration Commitment Review
- Valuation Commitment Review
- Architecture Commitment Review

#### Stage II: Development and Operations
- Development Commitment Review
- Operations Commitment Review

#### General/DoD Milestones
- ECR
- VCR/CD
- ACR/A
- DCR/B
- OCR/C
- OCR/C
- OCR/C

#### Lifecycle Phases
- Exploration
- Valuation
- Architecting
- Development
- Architecting
- Operations
- Architecting

#### Activities
- Concurrent risk-and-opportunity-driven growth of system understanding and definition
  - Initial scoping
  - Concept definition investment analysis
  - System architecting
  - Increment 1 development
  - Increment 2 architecting rebaseline
  - Increment 1 operations
  - Increment 2 development
  - Increment 3 architecting rebaseline

- Evaluation of evidence of feasibility to proceed
  - Feasibility rationales

- Stakeholder review and commitment
  - Risk?
  - Risk?
  - Risk?
  - Risk?
  - Risk?

  - Adjust scope, priorities, or discontinue
ICM Stage II: Increment View

- **Rapid Change**
  - Short Development Increments
  - Foreseeable Change (Plan)
  - Increment N Baseline

- **High Assurance**
  - Stable Development Increments

- **Short, Stabilized Development of Increment N**
  - Increment N Transition/O&M
ICM Stage II: Increment View

Rapid Change

Unforeseeable Change (Adapt)

Short Development Increments

Foreseeable Change (Plan)

Increment N Baseline

Agile

Rebaselining for Future Increments

Future Increment Baselines

Deferrals

Short, Stabilized Development of Increment N

Increment N Transition/O&M

Artifacts

Concerns

V&V of Increment N

Future V&V Resources

Current V&V Resources

Continuous V&V

High Assurance

Stable Development Increments

Unforeseeable Change

Resources

Foreseeable Change
Incremental Commitment In Systems and Life: Stage II (Development and Operations) Anchor Points

- **Increment N Operational Commitment Review (OCR)**
  - Stakeholders’ commitment to support operations
  - Like having children

- **Concurrent Increment N+1 Development Commitment Review (DCR)**
  - Stakeholders’ commitment to support Increment N+1 development
  - Based on feasibility-validated Increment N+1 architecture, plans
    - Rebaselined during Increment N development
    - Accommodating changes in requirements, priorities, NDI
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  – Viewpoints and examples

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RUP/ICM Anchor Points Enable Concurrent Engineering

Disciplines
- Business Modeling
- Requirements
- Analysis & Design
- Implementation
- Test
- Deployment
- Configuration & Change Mgmt
- Project Management
- Environment

Phases
- Inception
- Elaboration
- Construction
- Transition

Iterations
- Initial
- Elab #1
- Elab #2
- Const #1
- Const #2
- Const #N
- Tran #1
- Tran #2
### ICM HSI Levels of Activity for Complex Systems

#### General/DoD Milestones
- Exploration: ECR
- Valuation: VCR/CD
- Architecture: ACR/A
- Development: DCR/B
- Operations: OCR/C

#### ICM Lifecycle Phases

<table>
<thead>
<tr>
<th>Activity category</th>
<th>Levels of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Envisioning opportunities</td>
<td></td>
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<tr>
<td>System scoping</td>
<td></td>
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<tr>
<td>Understanding needs</td>
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<tr>
<td>Goals/objectives</td>
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<tr>
<td>Requirements</td>
<td></td>
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<tr>
<td>Architecting and designing solutions</td>
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</tr>
<tr>
<td>a. system</td>
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<tr>
<td>b. human</td>
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</tr>
<tr>
<td>c. hardware</td>
<td></td>
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<tr>
<td>d. software</td>
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<tr>
<td>Life-cycle planning</td>
<td></td>
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<tr>
<td>Evaluation</td>
<td></td>
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<tr>
<td>Negotiating commitments</td>
<td>OC1, OC2, OC3</td>
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<tr>
<td>Development and evolution</td>
<td>OC1, OC2, OC3</td>
</tr>
<tr>
<td>Monitoring and control</td>
<td></td>
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<tr>
<td>Operations and retirement</td>
<td>OC1, OC2</td>
</tr>
<tr>
<td>Organizational capability improvement</td>
<td>Legacy</td>
</tr>
</tbody>
</table>
Different Risk Patterns Yield Different Processes

<table>
<thead>
<tr>
<th>Activities</th>
<th>Exploration</th>
<th>Valuation</th>
<th>Architecture</th>
<th>Development</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example A.</td>
<td></td>
<td></td>
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<tr>
<td>Simple Enterprise Resource Planning (ERP) based application</td>
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<td>Example B.</td>
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<tr>
<td>Complex, but feasible product development</td>
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<tr>
<td>Example C.</td>
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<tr>
<td>Stakeholders agree that more convergence of objectives is necessary</td>
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<tr>
<td>Example D.</td>
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<tr>
<td>A superior product enters the market</td>
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</tr>
</tbody>
</table>

Note: Discontinue process if Too high, unaddressable risk.
### Common Risk-Driven Special Cases of the Incremental Commitment Model (ICM)

<table>
<thead>
<tr>
<th>Special Case</th>
<th>Example</th>
<th>Size, Complexity</th>
<th>Change Rate % /Month</th>
<th>Criticality</th>
<th>NDI Support</th>
<th>Org, Personnel Capability</th>
<th>Key Stage I Activities: Incremental Definition</th>
<th>Key Stage II Activities: Incremental Development, Operations</th>
<th>Time per Build; per Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use NDI</td>
<td>Small Accounting</td>
<td>Complete</td>
<td>Acquire NDI</td>
<td>Use NDI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Agile</td>
<td>E-services</td>
<td>Low</td>
<td>1 – 30</td>
<td>Low-Med</td>
<td>Good; in place</td>
<td>Agile-ready Med-high</td>
<td>Skip Valuation, Architecting phases</td>
<td>Scrum plus agile methods of choice</td>
<td>&lt;= 1 day; 2-6 weeks</td>
</tr>
<tr>
<td>4. SW embedded HW component</td>
<td>Multisensor control device</td>
<td>Low</td>
<td>0.3 – 1</td>
<td>Med-Very High</td>
<td>Good; in place</td>
<td>Experienced; med-high</td>
<td>Concurrent HW/SW engineering. CDR-level ICM DCR</td>
<td>IOC Development, LRIP, FRP. Concurrent Version N+1 engineering</td>
<td>SW: 1-5 days; Market-driven</td>
</tr>
<tr>
<td>5. Indivisible IOC</td>
<td>Complete vehicle platform</td>
<td>Med – High</td>
<td>0.3 – 1</td>
<td>High-Very High</td>
<td>Some in place</td>
<td>Experienced; med-high</td>
<td>Determine minimum-IQC likely, conservative cost. Add deferrable SW features as risk reserve</td>
<td>Drop deferrable features to meet conservative cost. Strong award fee for features not dropped</td>
<td>SW: 2-6 weeks; Platform: 6-18 months</td>
</tr>
<tr>
<td>6. NDI-intensive</td>
<td>Supply Chain Management</td>
<td>Med – High</td>
<td>0.3 – 3</td>
<td>Med-Very High</td>
<td>NDI-driven architecture</td>
<td>NDI-experienced; Med-high</td>
<td>Thorough NDI-suite life cycle cost-benefit analysis, selection, concurrent requirements/architecture definition</td>
<td>Pro-active NDI evolution influencing, NDI upgrade synchronization</td>
<td>SW: 1-4 weeks; System: 6-18 months</td>
</tr>
<tr>
<td>7. Hybrid agile / plan-driven system</td>
<td>C4ISR</td>
<td>Med – Very High</td>
<td>Mixed parts: 1 – 10</td>
<td>Mixed parts</td>
<td>Mixed parts</td>
<td>Mixed parts</td>
<td>Full ICM; encapsulated agile in high change, low-medium criticality parts (Often HMI, external interfaces)</td>
<td>Full ICM; three-team incremental development, concurrent V&amp;V, next-increment rebaselining</td>
<td>1-2 months; 9-18 months</td>
</tr>
<tr>
<td>8. Multi-owner system of systems</td>
<td>Net-centric military operations</td>
<td>Very High</td>
<td>Mixed parts: 1 – 10</td>
<td>Very High</td>
<td>Many NDI; some in place</td>
<td>Related experience, med-high</td>
<td>Full ICM; extensive multi-owner team building, negotiation</td>
<td>Full ICM; large ongoing system/software engineering effort</td>
<td>2-4 months; 18-24 months</td>
</tr>
</tbody>
</table>

**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. **LRIP**: Low-Rate Initial Production. **NDI**: Non-Development Item. **SW**: Software.
Spiral View of Incremental Commitment Model

Cumulative Level of Understanding, Cost, Time, Product, and Process Detail (Risk-Driven)

Concurrent Engineering of Products and Processes

STAKEHOLDER COMMITMENT REVIEW POINTS:

Opportunities to proceed, skip phases, backtrack, or terminate

EXPLORATION VALUATION ARCHITECTING DEVELOPMENT OPERATION

1. Exploration Commitment Review
2. Valuation Commitment Review
3. Architecture Commitment Review
4. Development Commitment Review
5. Operations, and Development, Commitment Review
6. Operations, and Development, Commitment Review

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Experience Factory Framework - III

Org. Shared Vision & Improvement Strategy
- Org. Improvement Goals
  - Goal-related questions, metrics
- Org. Improvement Strategies
  - Goal achievement models

Org. Improvement Initiative Planning & Control
- Initiative Plans
  - Initiative-related questions, metrics
- Initiative Monitoring and Control
  - Experience-Base Analysis

Achievables, Opportunities

Experience Base

Org. Goals

Models and data

Project Shared Vision and Strategy

Planning Context

Models and data

Project Planning and Control

Progress/Plan/ Goal Mismatches

Planning context

Initiatives

Analyzed experience, Updated models

Project experience
VBSE Experience Factory Example

• Shared vision: Increased market share, profit via rapid development
• Improvement goal: Reduce system development time 50%
• Improvement strategy: Reduce all task durations 50%
• Pilot project: Rqts, design, code reduced 50%; test delayed
  – Analysis: Test preparation insufficient, not on critical-path
• Experience base: OK to increase effort on non-critical-path activities, if it decreases time on critical-path activities
CeBASE Method Strategic Framework

- Applies to organization’s and projects’ people, processes, and products

Org-Portfolio Shared Vision
- Org. Value Propositions (VP’s)
  - Stakeholder values
- Current situation w.r.t. VP’s
- Improvement Goals, Priorities
- Global Scope, Results Chain
- Value/business case models

Org. Strategic Plans
- Strategy elements
- Evaluation criteria/questions
- Improvement plans
  - Progress metrics
  - Experience base

Org. Monitoring & Control
- Monitor environment
  - Update models
- Implement plans
- Evaluate progress
  - w.r.t. goals,
  - Determine, apply corrective actions
  - Update experience base

Project Shared Vision
- Project Value Propositions
- Stakeholder values
- Current situation w.r.t. VP’s
- Improvement Goals, Priorities
- Project Scope, Results Chain
- Value/business case models

Proj. Monitoring & Control
- Monitor environment
  - Update models
- Implement plans
- Evaluate progress
  - w.r.t. goals, models, plans
  - Determine, apply corrective actions
  - Update experience base

Shortfalls, opportunities, risks

DCR: Development Commitment Review
IOC: Initial Operational Capability
GQM: Goal-Question-Metric Paradigm
ICM: Incremental Commitment Model

Planning Context

Initiatives

Evaluation criteria/questions

Progress metrics

Plan/goal mismatches

Scoping context

Monitoring & Control Context

Plan/goal mismatches

Plan/Goal mismatches

Progress/Plan/goal mismatches

- Shortfalls, opportunities, risks

- Update experience base
# Incremental Commitment Model: Detailed

## Activities

<table>
<thead>
<tr>
<th>Lifecycle Phases</th>
<th>Exploration</th>
<th>Valuation</th>
<th>Architecture</th>
<th>Development, Architected</th>
<th>Operation, Development, Architected</th>
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<tr>
<td>General/DoD Milestones</td>
<td>ECR</td>
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<td>DCR/B</td>
<td>...</td>
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### Concurrent risk-and-opportunity-driven growth of system understanding and definition

- Exploration
  - Definition & analysis of scope & solution alternatives
    - Human, hardware, software factors
    - Mission analyses, business cases
    - Top level ops concept, requirements, architecture, life cycle plans

- Valuation
  - Detailed mission scenarios, business work flows, macro-ergonomics aspects
  - COTS, outsourcing partner selections
  - System/human/hardware/software build-to architecture
  - Detailed ops concept, requirements, architecture, plans (System, increment Life Cycle Architecture packages)

- Architecture
  - Use LCA, Package for stabilized development, V&V of increment 1
  - Concurrent, agile change processing, rebasing of LCA,...LCA_n packages

- Development, Architected
  - Use LCA, package for stabilized development, V&V of increment 2
  - Concurrent agile change processing, rebasing of LCA,...LCA_n packages
  - Operations and usage monitoring of increment 1

### Evaluation of evidence of feasibility to proceed

- Ethnographic, operations analysis, models, simulations, prototypes
  - Top-level feasibility rationale, trade studies, business case
  - Detailed feasibility rationale, business case
  - Increment, readiness for operations: LCA feasibility rationale

### Stakeholder review and commitment

- High, but addressable
  - Acceptable
- Too high, unaddressable
  - Risk
- Negligible

Adjust scope, priorities, or discontinue
Conclusions

• Current processes not well matched to future challenges
  – Emergent, rapidly changing requirements
  – High assurance of scalable performance and qualities

• Incremental Commitment Model addresses challenges
  – Assurance via evidence-based milestone commitment reviews, stabilized incremental builds with concurrent V&V
    • Evidence shortfalls treated as risks
  – Adaptability via concurrent agile team handling change traffic and providing evidence-based rebaselining of next-increment specifications and plans
  – Use of critical success factor principles: stakeholder satisficing, incremental growth, concurrent engineering, iterative development, risk-based activities and milestones
    • Can be applied to other process models as well

• Major implications for funding, contracting, career paths
Implications for Funding, Contracting, Career Paths

- **Incremental vs. total funding**
  - Often with evidence-based competitive down-select

- **No one-size-fits all contracting**
  - Separate instruments for build-to-spec, agile rebaselining, V&V teams
    - With funding and award fees for collaboration, risk management
    - Compatible regulations, specifications, and standards
    - Compatible acquisition corps education and training
  - Generally, schedule/cost/quality as independent variable
    - Prioritized feature set as dependent variable

- **Multiple career paths**
  - For people good at build-to-spec, agile rebaselining, V&V
  - For people good at all three
    - Future program managers and chief engineers
ICM Perspectives

- ICM principles and process are not revolutionary
- They repackage current good principles and practices to make it easier to:
  - Determine what kind of process fits your project
  - Keep your process on track and adaptive to change
- And harder to:
  - Misinterpret in dangerous ways
  - Gloss over key practices
  - Neglect key stakeholders and disciplines
  - Avoid accountability for your commitments
- They provide enablers for further progress
  - Guidance for implementing VBSSE process
  - Reorienting systems engineering principles and processes
  - Reorienting system acquisition and contracting practices
General References


# List of Acronyms

<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACR</td>
<td>Architecting Commitment Review</td>
</tr>
<tr>
<td>B/L</td>
<td>Baselined</td>
</tr>
<tr>
<td>CCD</td>
<td>Core Capability Drive-Through</td>
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<tr>
<td>COTS</td>
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<tr>
<td>DCR</td>
<td>Development Commitment Review</td>
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<td>DI</td>
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<td>DOTMLPF</td>
<td>Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities</td>
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<tr>
<td>ECR</td>
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<tr>
<td>FMEA</td>
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<td>GUI</td>
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<td>ICM</td>
<td>Incremental Commitment Model</td>
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<td>IOC</td>
<td>Initial Operational Capability</td>
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<tr>
<td>IRR</td>
<td>Inception Readiness Review</td>
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## List of Acronyms (continued)

<table>
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<tr>
<th>Acronym</th>
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<tr>
<td>LCA</td>
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<td>OO&amp;D</td>
<td>Observe, Orient and Decide</td>
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<td>OODA</td>
<td>Observe, Orient, Decide, Act</td>
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<td>RACRS</td>
<td>Regional Area Crisis Response System</td>
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<td>V&amp;V</td>
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