



Scoping Framework, Preliminary Concepts for Version 4,"  
29 September 1995.

Information about the Domain Scoping Framework (including copies of the documents) may be obtained from the SRI (POC: John Cloninger, voice: 703-681-2104 email: cloningj@cc.ims.disa.mil).

## References

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- [SRI95b] Prepared by the Mitre Corporation for the DoD Software Reuse Initiative. "The DoD SRI Domain Scoping Framework Version 3.1, Volume 2: Technical Description," 29 September 1995.
- [SRI95c] Prepared by the U.S. Army Space & Strategic Defense Command, Software Engineering Division, Huntsville, Alabama for the DoD Software Reuse Initiative. "Software Reuse Business Model (SRBM) Technical Report," 31 January 1995.
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## Acronyms and Abbreviations

<b>ADAGE</b>	Avionics Domain Application Generation Environment
<b>ARC</b>	Army Reuse Center
<b>BLSM</b>	(Air Force) Base-Level System Modernization program
<b>C4I</b>	Command, Control, Communication, Computers, and Intelligence
<b>CPT</b>	Captain
<b>CARDS</b>	Comprehensive Approach to Reusable Defense Software
<b>COCOMO</b>	Constructive Cost Model
<b>COTS</b>	Commercial Off-The-Shelf
<b>DE</b>	Domain Engineering
<b>DISA</b>	Defense Information Systems Agency
<b>DISC4</b>	Director, Information Systems for Command, Control, Communications, and Computers, and Computers
<b>DMA</b>	Defense Mapping Agency
<b>DoD</b>	Department of Defense
<b>DoN</b>	Department of the Navy
<b>DSSA</b>	Domain-Specific Software Architecture
<b>FODA</b>	Feature-Oriented Domain Analysis
<b>FY</b>	Fiscal Year
<b>GOSIP</b>	Government Open Systems Interconnection Profile
<b>GOTS</b>	Government Off-The-Shelf
<b>GSFC</b>	Goddard Space Flight Center
<b>HP</b>	Hewlett-Packard
<b>ID</b>	Identifier, Identification
<b>IDA</b>	Institute for Defense Analyses
<b>NASA</b>	National Aeronautics and Space Administration
<b>NIST</b>	National Institute of Standards and Technology
<b>LTC</b>	Lieutenant Colonel
<b>PEO</b>	Program Executive Office/Officer
<b>PM</b>	Program Management/Manager
<b>PRISM</b>	Portable, Reusable, Integrated Software Modules
<b>R&amp;D</b>	Research and Development
<b>RCM</b>	Reuse Capability Model
<b>ROI</b>	Return On Investment
<b>RSM</b>	Reuse Strategy Model
<b>SBIS</b>	(Army) Sustaining Base Information Services
<b>SEI</b>	Software Engineering Institute
<b>SPC</b>	Software Productivity Consortium
<b>SRI</b>	Software Reuse Initiative
<b>STAMIS</b>	Standard Army Management Information Systems
<b>STARS</b>	Software Technology for Adaptable, Reliable Systems
<b>SW</b>	Software
<b>TAFIM</b>	Technical Architecture Framework for Information Management
<b>WISR</b>	International Workshop on Software Reuse

- Identify the organization's competitors.
- Is the organization doing any business process reengineering or has it done any recently? Has any process improvement been done recently?
- Who are the functional/domain experts in the organization? Who are experts not in the organization but accessible to it?
- Add questions F40-F42 here from the existing document.

**Factor: Mission Criticality (addition)**

Determine criticality of the prospective domain(s) and product line(s) to the organization.

**Factor: Solution Area (addition)**

Identify technical solutions (including COTS, GOTS, and R&D) that could be used in this organization (i.e., rather than developing solutions from scratch).

**Factor: Evolution (addition)**

Identify new requirements or significant changes to the architecture that could materially affect the domain or product line.

**Factor: Domain Identity (modification)**

- For questions F4-F7, identify exemplar systems to support answers. Provide only cursory responses to these questions when preparing for strategic decision-making.
- For factor question F7, change the emphasis from historical to trend information (the only reason historical information is useful is to identify trends for the future).
- Identify all systems in the domain (hard data).
- Identify external and internal system dependencies (i.e., customers and suppliers of data) (hard data?)

**Factor: Market Assessment (modification)**

- F43-47: Put in Domain Assessment above.
- F48: This is the answer to which all the other questions point. It can't be a question. The answer to F48 feeds the decision to start a product line or abandon it. Need to factor in the answers, in particular, to F43-45.
- F49: Use F43, F44 to help answer this question.
- Add a question on existing investment areas and amounts (this may be a constraint on investment in new product line).

**Factor: Resource Constraints (modification)**

- F52: the quality of the staff is always much more important than the quantity, so re-focus the question

**Framework Document Comments**

The use of the framework may vary for different organizational levels and for different purposes (e.g., a strategic look across a large organization for future product line decisions or "domains of interest" versus a tactical look across a PMO for immediate product line identification or "domains of focus"). The document should reflect these different uses. Furthermore, the answers to factor questions may be interpreted differently for

different uses, and the process of applying the framework may change. At the PEO Strategic level, the framework was viewed as having four purposes: to assess reuse potential in an organization, to assess return on investment, to define an investment strategy, and to assess risks.

In capturing data for the framework (based on questions asked and documents reviewed), some data will be "hard" (e.g., numerical data on number of systems to be built, based on appropriated funds) and some data will be "soft" (e.g., the PEO's assessment of the degree of risk in his programs). These degrees of hardness should be factored into decision-making based on the framework information.

## Workshop Conclusions

There seems to be a general agreement that the existing Domain Scoping Framework was a good starting point from which to work. Few (if any) of the attendees recommended starting over from scratch, but certain core issues arose with respect to domain scoping during the course of the workshop. It was almost universally recognized that consistent use of terminology (especially "domain" and "product line") is a desirable, if unattainable, goal. Working definitions should therefore be stated for a given context, even if not agreed upon. The assembled groups placed a higher emphasis on organizational issues than did the current framework. At least three of the working groups expressed relations between different organizational views in a matrix. It was also noted that domain scoping is more than a one-time activity; it is often iterative or cyclic. Finally, we need to sell domain scoping. We need success stories to show the benefits of domain engineering. We need failure stories from which to learn. We should maintain not only a strategic view towards the promise of reuse, but also be aware of a need to show near-term benefits as well.

## Acknowledgments

We wish to thank Don Reifer of the SRI and Linda Safford of DISA for their sponsorship of the workshop. We thank Mitre Corporation for their hospitality in hosting this event. We further thank all contributors to these proceedings, the workshop attendees, and especially the program committee for their considerable efforts in making this endeavor a success.

## Additional Information

The Domain Scoping Framework is organized into the following three documents:

- *Department of Defense Software Reuse Initiative, Domain Scoping Framework Version 3.1, Volume 1: Management Overview,* 29 September 1995.
- *Department of Defense Software Reuse Initiative, Domain Scoping Framework Version 3.1, Volume 2: Technical Description,* 29 September 1995.
- *Department of Defense Software Reuse Initiative, "Domain*

comes or recommendations of a domain analysis:

1. invest in a (defined) product line
2. invest in a “one-of” system
3. buy a system or set of systems from someone else who's already developed the system or product line (one could help create a market for a product line by doing this)
4. none of the above

The team then began asking questions to test the feasibility of getting to these results:

- Does the user organization really know who else is doing similar work?
- What core competencies or strengths does the producer organization have (versus competitor labs, such as government labs)?
- Is the producer organization one that learns (in Peter Senge's meaning)? Or does it continually improve its processes? Has it reengineered its business processes recently? If the answers to all these questions are “no,” then domain engineering or analysis may be wasted, since the producer organization may be incapable of executing its product line duties effectively.
- What degree of reorganization is needed to create and sustain a product line?
- How much organizational “turbulence” is there?

There were a number of criticisms of the framework documents (e.g., “the framework needs to be restructured,” but no specifics were identified). It became apparent to the group that they were defining “organizational assessment criteria” and began to coalesce around the following two questions:

1. Is the organization properly configured (and skilled enough) to take on the desired product line roles?

and, if not, ...

2. Is the organization willing to take advantage of a product-line approach to system development?

The answers to these two questions were considered by the group to be key to deciding whether to even perform domain engineering. Thus the model for moving forward became the following:

Assess the producer organization for “product-line readiness” (a strategic look for long-term “domains of interest” and a tactical look for more immediate organizational change and payoff in “domains of focus”).

- If “yes,” proceed with domain scoping
- If “no,” suggest existing reuse readiness models (e.g., from STARS Program)

The Red Team evolved a model of how the framework might be used differently depending on DoD viewpoint and whether it was to be applied for a strategic or tactical purpose. Table 3 captures the group's thinking. The empty cells in the Framework Usage Model matrix are used to categorize framework perspectives.

tures the group's thinking. The empty cells in the Framework Usage Model matrix are used to categorize framework perspectives.

	Strategic	Tactical
Enterprise		
Service		
PEO		
PM		

**Table 3: Framework Usage Model**

- The Red Team raised the following questions about the model:
- Would a user apply the framework factors differently at each DOD level and purpose? (No)
  - Would the factor questions be interpreted differently? (Yes)
  - Does the domain framework process change? (No)
  - Are there different factors needed? (For all parts of the model)

Using the model, the product-line investment decisions can be made:

- At the strategic level: should I invest in domain(s)? (Investment potential) What product line(s)?
- At the tactical level: How should I invest in pilot projects? Where should I invest first?

The consensus, as the team began to look at the framework's factors and their amplifying questions, was that today's framework (with its emphasis on software and components) is more tactically oriented. The team then tackled the framework factors and their individual questions. The results are listed below.

### Framework Factor Comments

All factors must contribute to decision-making, including the Profile Factors. Consider eliminating Functional System Requirements, System Characteristics, Software Characteristics, and System Deployment Factors from the framework (at least at the PEO level and above, for strategic analysis), since they don't seem to figure in the decision-making process. Individual factor additions and modifications are given below<sup>1</sup>.

#### Factor: Organizational Identity (addition)

The data captured for this factor should help assess whether an organization can anticipate success in implementing a product line (should one or more be identified). The questions identified below will help characterize the state of the organization and its ability to mature to a product-line-based organization.

- Identify organization strengths and weaknesses.

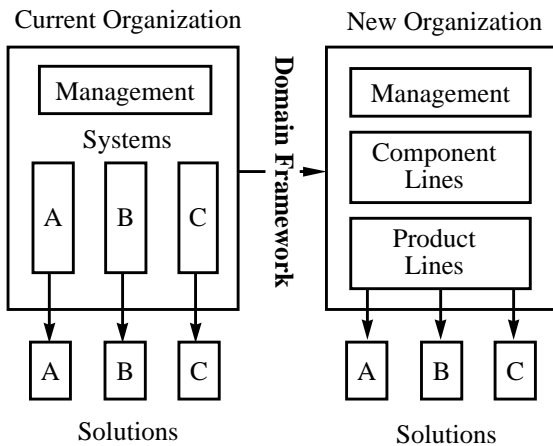
1. The factor references below (e.g., F40 - F42) use the numbering scheme in the framework's Factor Information Table [SRI95b, § 3.1.4].

to include analysis of both technical and resource constraints, such as investment capital, schedule constraints, size of available staff, level of staff expertise, interoperability, security, reliability, etc.

### Orange Team Summary (Ahn Ta, Mitre Corporation)

Members: Craig Cleaveland, LTC Tom Croak, Melvin Dickover, CPT Bill Fetzer, CPT Michael Morrissey, LTC Edward Poore, Jeff Poulin, Ed Seidewitz, Ahn Ta

The Orange Team began by refining the SRI Domain Scoping Framework context, and followed by suggesting modifications to framework’s Domain Profile Factors. The team completed its working sessions with suggested modifications to the overall framework document.



**Figure 3: Domain Frameworks as Transitioning Tool**

In refining its domain scoping context, the Orange Team started by restating the question posed by Don Reifer in his opening remarks: “If you were tasked to analyze a mission/business area for candidate domains and to identify and scope the ‘best’ domain for later analysis, what criteria (such as those in the framework) would you consider and which actions would you take?” The Orange Team decided that the Domain Framework is a tool that can be applied as part of a method for transitioning an organization’s focus from *project-oriented* to *product/component-oriented*. Domain frameworks describe and help evaluate domains. Figure 3 captures the notions inherent in this context.

The following section is a more detailed summary of the Green Team working group’s recommendations. All recommendations are directly related to factors defined in [SRI95b].

#### Factor: Domain Identity (modification)

The Green Team suggested adding the following considerations to the Domain Identity factor:

- Operational requirements
- Relation to organizational core mission requirements

- Organizational boundaries

#### Factor: Functional System Requirements (modification)

The Orange Team suggested adding the following considerations to the System Requirements factor:

- Services provided
- Services required
- Performance constraints
- Interface constraints
- Dominant functions or features to be implemented by systems in the domain.

#### Factor: Software Characteristics (modification)

The Orange Team suggested adding the following considerations to the Software Characteristics factor:

- Services provided
- Services required
- Languages
- Operating systems
- Standards
- Consider extending the framework to address the variability of the domain.
- Cause/rationale
- Range
- Delete “system deployment” factors.
- Add a “core technology” factor to help correlate and identify common function.

#### Suggested Modifications to the Framework Documents

The Orange Team’s general comments about the framework documents are: clear, consistent definitions should be given within the text where they are used; the framework discussion should be condensed; the framework should identify its audience as anyone who is considering reuse/domain engineering effort; and, the background technical discussion should be restructured as an appendix.

### Red Team Summary (Roger Duncan, Mitre Corporation)

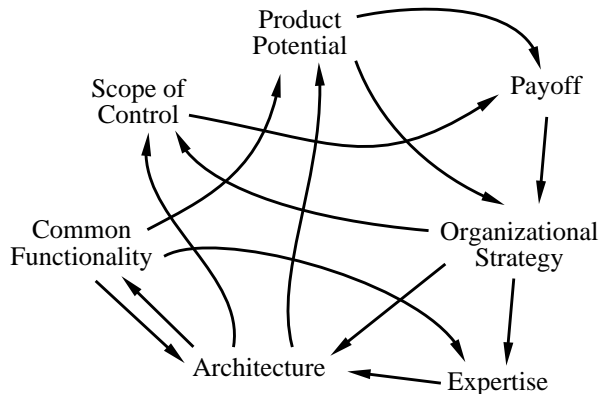
Members: Jules Bartow, Maggie Davis, Roger Duncan, Barbara Fleming, Hassan Gomaa, K.C. King, Bob Marcus, Jay Reddy, Steven Roodbeen, Mark Simos, Doug Rosson, David Weisman

The Red Team Working Group began its deliberations by focusing on definitions. The team agreed to adopt the definition of *domain* given in [SRI95b] and submitted additional definitions as well. A *functional (subject matter) expert* was defined as one who knows the problem area. A *domain expert* knows problems and their solutions in the domain. A *domain analyst* can analyze problems in the domain to get to solutions. A *domain “owner”* (the consumer) is the individual that can fund domain analysis. Finally, the *domain broker* brings the owner/user together with the problem solver.

The Red Team next tried to attack the criteria that could be used to select a product line. The group settled on four possible out-

control (does the organization have control over the scope of the planned domain engineering effort?), and Product Potential (anticipated number of domain products).

To prioritize the categories for use in domain scoping, a graphic dependency chart was created (see Figure 2 —Reuse Driver Dependencies)<sup>1</sup>. The number of inputs and output for each category was analyzed. The categories with the fewest inputs and the greatest number of outputs were deemed of highest priority.



**Figure 2: Reuse Driver Dependencies**

Common Functionality was calculated to be the most significant reuse driver (1 input and 3 outputs).

### **Green Team Summary (Jim Baldo, Mitre Corporation)**

Members: Jim Baldo, Grady Campbell, John Foreman, Ron Green, Brian Koehler, Charles Lillie, Ron Owens, Linda Safford, Mark Shelberg

The Green Team working group focused on the following areas in their review of the SRI Domain Scoping Framework: correctness of framework factors, completeness of framework factors, effort to apply framework, and integration of framework with existing SRI or DoD products. Based on this focus, the working group’s overall findings indicated that several of the framework factor attributes were at too low a level of detail. The framework needs to include an organizational factor for assessing readiness for domain and application engineering activities. The effort required to apply the framework should be less than 0.5% - 1.0% of the total effort required to perform a full domain analysis. The framework should be mapped to the SRI Reuse Business Model [SRI95c].

Although there was consensus by the working group that both volumes of the Domain Scoping Framework documents need to be revised for clarity, due to time constraints, the Green Team

1. Although dependencies were allowed in one direction only, it was determined that architecture influenced functionality during design, but functionality influenced architecture during analysis, hence the dual arrows in Figure 2.

was unable to draft a set of comments and recommendations for document revisions. The Green Team recommended using the NIST Glossary of Software Reuse Terms for definitions [NIST94]. The organization of the following section is a more detailed summary of the Green Team working group’s recommendations. All recommendations are directly related to factors defined in [SRI95b].

#### **Factor: Organizational Identity (addition)**

The Green Team initially focused on and discussed the importance of observed criteria that are critical for successfully inserting technologies associated with domain analysis. The initial criteria discussion was led by John Foreman of the ARPA STARS program and was based on experiences from the STARS demonstration projects. Therefore, the team decided that information from an organizational assessment is necessary to establish the organization’s capability to adequately perform domain analysis activities and that the factor “Organizational Identity” should be added. The working group recommended that this factor be based on and composed of the following: 1) leverage from the Software Productivity Consortium’s (SPC) RCM, STARS Reuse Strategy Model (RSM), and other experience from reuse organizational assessments; 2) determine if current organizational structure is supportive of the domain being considered; and 3) a set of recommendations that the organization could potentially use to restructure around management of the domain being considered.

#### **Factor: Technical (modification)**

The Green Team concluded that some of the current Domain Framework profile factors — Functional System Requirements, System Characteristics, and Software Characteristics — require fine-grained information and detailed analysis. These factors were considered outside the scoping boundaries and effort cost objectives for application of the framework. The working group recommended that the three profile factors be combined into a single factor called “Technical.” This factor is defined as a high-level, technical profile of the organization’s products and services: Are there existing reuse efforts? Are standards being applied consistently across the domain? What is the amount and level of training? and so on.

#### **Factor: System Deployment (elimination)**

The Green Team concluded that the Domain Framework profile factor “System Deployment” should be eliminated and merged into existing factors. “Where” a system is deployed should be included as an element of the domain identity factor. “Commitment to deploy” should be included as an element of the newly proposed “Organizational” factor. “Number of implementations” of system deployment should be included as an element of the “Market Assessment” factor.

#### **Factor: Resource Constraints (modification)**

The Green Team concluded that the “Resource Constraints” factor name should be changed to “Constraints.” The name “Resource Constraints” implies that the factor is limited or focused on engineering resource constraints. The working group recommends that the “Constraint” factor should be augmented

**Observation**

Factors influencing domain scoping were either Decision/Selection Criteria or Profile/Characteristics. Perspectives for performing domain scoping were Business, Management/Organizational, or Technical. These issues are organized in Table 1, **Domain Scoping Factor/Perspective Matrix**, and given integer designators. These designators can be used as a reference to identify factor/perspective influences on domain scoping activities and concerns.

**Recommendations**

The Blue Team made the following recommendations for improvement of the Domain Scoping Framework. The framework should be validated based on successful and failed domain engineering efforts. An interactive scoping process should be created with exit criteria defined for each stage of the process. Definitions of *domain*, *product line* should be clarified and used consistently throughout the document. Guidelines should be defined and developed for all users, with specific examples of scoped domain using the framework and its work-products. Identify users and associated roles and responsibilities. The framework needs to quantify return on investment (ROI) and reuse cost avoidance. An automated knowledge acquisition tool would help to support the process. Validate the framework across the DoD as defined by Ed Cherian (see workshop proceedings). Qualify the risks of not doing reuse. Identify the risks associated with the level of scoping. A framework implementation handbook should be developed.

**Gold Team Summary**  
(Frank Svoboda, Loral Defense Systems-East)

Members: Ted Davis, Mark Fornaro, Deborah Gary, Marilyn Gaska, Ron House, Duane Hybertson, Lorraine Martin, Nick Smith, Frank Svoboda, Jim Withey

The Gold Team working group adopted a modified brainstorming approach by initially determining its own domain scoping issues and then reconciling these with the SRI/Mitre Domain Scoping Framework. Team members voiced some objections to the definition of the word “domain” as given by the framework reference. The given definition was deemed ambiguous, subjective, and too constrained by the qualification that it apply to “software systems.” Additional criticism was levied in that the definition neither evokes any specific actions nor does it address business area issues. These criticisms noted, the Gold Team moved on to defining domain scoping contexts.

The Gold Team defined twelve potential contexts for domain scoping — settings or mini-scenarios where domain scoping would be considered beneficial:

- as the initial phase of Domain Analysis.
- to identify high reuse payoff potential.
- to understand what an organization does and to identify potential reuse across divisions.
- to develop a DoD-level taxonomy to identify organizational

structure and “buyer” (customer) markets.

- to understand what is in/not in a given domain.
- to narrow a domain to identify reuse potential.
- to identify the breadth of technology to address a need (e.g., Common Operating Environment).
- to select a domain from a larger context to find “low hanging fruit” (near-term reuse payoffs).
- to identify common functional requirements to support incremental development.
- during a downsizing cycle, to take advantage of opportunities outside of the organization to meet a mission need.
- to define what business an organization is in, including the relationship of product line growth and the corresponding asset base to be built.
- to identify the framework for modifying an organization and adjusting acquisition strategies to take advantage of reuse potential.

The Gold Team created a small taxonomy of perspectives on domain scoping. The perspectives constituted viewpoints for the various stakeholders. This taxonomy is given in the table below.

DoD	Commercial
<b>Operational (Mission)</b>	<b>Business/Marketing</b>
<b>Functional (services, strategies)</b>	<b>Organizational</b>
<b>Technical (products, systems)</b>	<b>Technical</b>

**Table 2: Domain Scoping Perspectives**

The Gold Team considered principles of economy of scope in determining how product lines and domains are to be implemented by an organization. These principles were captured in the following two statements:

1. An organization needs to maximize external product variety while minimizing internal variability of assets and development process.
2. DoD Corollary: An organization needs to maximize mission capability with least cost while meeting the warfighter’s needs.

Based on these principles, the Gold Team developed the following working hypothesis: “As domains are scoped, the perspectives given above will affect the scoping, boundary, and identification of domains. The weighting of factors varies, based on the emphasis placed on these perspectives.”

The criteria resulting were grouped into the categories given below for purposes of prioritization and reconciliation with the contexts given above. The seven categories following were judged to be the most significant: Expertise, Payoff, Organizational Strategy, Architecture, Common Functionality, Scope of

6. Define product lines within selected (pilot) domains.
7. Complete entire DoD domain definitions, based on pilot results.
8. Establish training and education programs.
9. Full-scale implementation of product line approach.

## Working Group Summaries

The working groups were instructed to identify issues associated with domain scoping, using the SRI/Mitre Domain Scoping Framework as a reference, and to derive solutions for the issues. The following definition (from [SRI95b, § 2.1]) was used for all subsequent discussion:

*Domain:* a distinct functional area that can be supported by a class of software systems with similar requirements and capabilities [NIST94].

Additionally, the following question was proposed to stimulate discussion of domain-scoping-related issues:

“If you were tasked to identify and scope a domain, what criteria (such as those in the framework) would you consider and which actions would you take?”

The working groups utilized various approaches to accomplish the indicated goals. The material given below describes the working group approaches and their results.

### Blue Team Summary

(Fred Maymir-Ducharme, Loral Defense Systems-East)

Members: Capt. Cynthia Boykin, Ed Cherian, John Cloninger, Pat Donohoe, Susan Hall, Debby LaForme, Ron Larson, Fred Maymir-Ducharme, Charles McKay, Will Tracz

The Blue Team Working Group used the existing framework document as a basis for its deliberations, but began by focusing on the existing framework and then proceeded to define new factors and criteria.

### Overall Framework Comments

Consensus on the definition of the terms “domain” and “product line” has yet to be achieved (and may never be). Definition of what constituted “the framework” was somewhat unclear. There also appears to be some confusion as to the range of applicability of domain scoping. Much of what was discussed could have been more accurately assigned to domain analysis, of which domain scoping is only the initial phase.

The framework needs to address different perspectives of domain scoping, including those of the organization (strategic management), tactical management, and technical practitioners. Organizational issues were deemed somewhat lacking in the framework. These include, but are not limited to: organizational identity, strengths/weaknesses, competitors, stability (on-going

BPR, process improvement), and domain expertise. Prior to domain scoping, an organizational assessment should be considered that considers: readiness to change and adopt new technology (concepts, methods, processes & tools); goals and priorities; mission; business requirements; domain experience; familiarity with associated (domain) legacy systems; domain engineering experience; and external forces and influences.

#### **Factor: Organizational Assessment (addition)**

This new factor encompasses readiness to change, goals, priorities, mission, domain experience, domain engineering experience, role of the organization, business requirements, familiarity with legacy systems, and external forces/influences.

#### **Factor: Technical Maturity Assessment (addition)**

Identify COTS, GOTS, bindings.

#### **Factors: Functional System Requirements, System Characteristics, Software Characteristics (modification)**

These factors should address determining sufficiency of data and influence of the given factors on strategic decisions.

#### **Factor: Domain Identity (modification)**

This factor should address existing domains, multiple perspectives of domains, whether enterprise engineering has been performed, and whether business areas have been identified.

#### **Factor: System Deployment (modification)**

Add “geography” to the existing factors.

#### **Factor: Resource Constraints (modification)**

This factor should address investment capital per application or whether the money crosses applications.

#### **Factor: System Characteristics (modification)**

Add “hardware constraints” to the existing factors.

#### **Factor: System/Software Characteristics (modification)**

Add well known examples of industry and product standards, such as TAFIM, GOSIP, etc. to the existing factors.

#### **Factor: Software Characteristics (modification)**

Add enterprise engineering, data models, and process models to the existing factors.

	Decision/ Selection Criteria	Profile/ Characteristics
<b>Business</b>	<b>1</b>	<b>2</b>
<b>Management/ Organizational</b>	<b>3</b>	<b>4</b>
<b>Technical</b>	<b>5</b>	<b>6</b>

**Table 1: Scoping Factor/Perspective Matrix**



cepts, benefits, and components. The current DoD context is a dynamic world of increasing demands and diminishing resources. Reuse of legacy systems is perceived as a high-pay-off application. The framework can support reuse, reduce/bound risks, identify opportunities, make informed decisions, and serve as a bridge between current and future business strategies. The framework itself consists of factors, usage guidelines, and application scenarios. The Domain Profile Factors [SRI95b, § 2.2.1] deal with domain identity, functional system requirements, system characteristics, software characteristics, and system deployment. The Decision Support Factors [SRI95b, § 2.2.2] concern domain and organizational assessment, market assessment, and resource constraints. Usage guidelines [SRI95b, § 3.1] describe possible uses, perspectives, and the activities involved in implementing the framework. The application scenarios [SRI95b, § 3.2] depict sample contexts and step-by-step application sequences where domain scoping may be performed.

Jim also characterized various framework issues:

- Feasibility of defining a taxonomy for scoping domains
- How to establish product lines within the DoD?
- The DoD as an enterprise
- The impact of product lines on DoD organization
- The relationship of the framework to domain analysis methods
- How to use the framework (i.e., users and audience)?
- Confusion over terminology and definitions

After the panel and Jim finished their presentations and answering individual questions, Jeff Poulin led an open discussion on issues raised by the panel.

## Day One Closing Plenary Session — Issues (Jim Withey [SEI] and Susan Hall [CACI])

The following are observations and issues resulting from the first day's discussions:

### Framework Issues

- Is software reuse a subset of the “whole process” and, if so, is it futile to tackle alone?
- Clearer definitions of “framework” and other common terms are needed.
- Framework implementation strategy is needed.
- Criteria are incomplete and may not be correct. Framework should identify general, not specific, questions to be answered.
- Scoping is an iterative (not just one-time) process.
- When is a scoping effort complete — when the money is spent or when the effort becomes more *analysis* than *scoping*?
- Domains are tactically developed, i.e., domains are often bounded by organizations instead of functional areas.
- Framework must consider the life-cycle domain model.
- Variability must be understood without modeling it and future changes must be anticipated.

- Current methods are insufficient for product line identification.
- The framework must help culture shift while helping organizations focus on their specific business areas.
- Business goals, risks, skills, and expertise drive scoping.
- How are the results from the framework used and how do they affect an organization?
- The framework needs champions for implementation, success stories for promotion, and failures to serve as a basis for improvement.
- Modeling tools and training are needed to implement the framework.

### Organization Issues

- There are no product managers, only process managers.
- Culture/paradigm shift must cover entire engineering disciplines.
- Few are motivated towards long-term goals; few are willing to pay now for future improvements.
- A middle path needs to be defined — business charter vs. technology.

### Cost Issues

- There is a mismatch between product life cycles and the “clock” of a program manager.
- The congressional budget allocation process is often at odds with strategic product line planning.
- A method is needed to amortize reuse costs: the number of years (annual funding contention) vs. the number of applications (organizational).
- Short-term as well as long-term savings need to be quantified. For example, domain analysis does not often identify near-term benefits.

## Scoping Framework Application Study (Ed Cherian)

Ed Cherian of the Office of the Secretary of Defense (OSD) led off the second day of the workshop with his presentation “Implementation of a Software Product Line Approach for Systems Acquisition/Development in the Department of Defense.” Ed discussed the advantages of a product line approach towards software development, citing the need to maintain continuity of software architecture in domain areas. The projected cost and schedule savings, and associated reductions in risks are especially significant given that the DoD controls over \$42 billion (estimated FY 94) in software-intensive systems. Ed emphasized that one of the primary advantages of a DoD product line approach was increased system interoperability. By creating a common operating environment for the warfighter, true opportunities for reuse and COTS use will be realized. Ed outlined the following subtasks required to implement a DoD-wide product line approach to software development:

1. Define terminology and obtain general consensus.
2. Establish domain scoping framework.
3. Establish overall DoD software domain taxonomy.
4. Define overall DoD software standards and protocols.
5. Initiate five pilot domain programs.

(Grady Campbell) Domain scoping in RSP involves bounding and assessing a perceived product line. Scoping must be repeated to establish strategic business objectives based on perceptions of technical capability and market need, and to reflect changing needs and capabilities. RSP advocates problem/solution experts as active participants. Domain Scoping Factors include: (for domain assessment) market potential, existing assets, commonality/variability, stability/maturity of needs and technology, and standardization, (for domain definition) assumptions of commonality, variability, exclusion, and marketability. As prerequisites to Domain Assessment, an organization must have both the charter and expertise to build products needed by a target market and a perceived need to build multiple similar products/versions for the targeted market. Designated participants must have expertise in customer's problem (market) and corresponding solutions (products). The resources needed for domain assessment are a facilitator and 3 - 5 active participants (problem/solution experts) for a duration of one week. The primary resource drivers are knowledge of market/customer needs, knowledge of organizational capability for solutions. The scoping effort may be validated by review from participating stakeholders.

(Will Tracz) Domain definition and scoping is the initial part of the ADAGE Domain Engineering Process, beginning with the required resources. Time: the duration of the effort is "until money runs out." Staffing: the level of effort required is "until money runs out." The primary resource driver of domain scoping is money. The goals of domain engineering are 1) a characterization and understanding of the problem space (the domain), 2) a characterization and understanding of the solution space (for the domain), and 3) an understanding of how requirements in the problem space map to solutions within the framework of a generic design (the DSSA). The goal of domain definition/scoping in this context is to define what can be accomplished, with an emphasis on user needs. The definition/scoping activity is broken down as follows:

- Define goals of domain analysis
- Define the domain
- Draw preliminary domain diagram
- Identify scope of domain
- Identify border of domain (input/output)
- Define domain-specific resources
- Identify domain experts
- Identify domain artifacts
- Define the domain of interest (subset of work that could be done)
- Determine model verification procedure.

The boundary of a domain is determined by its stakeholders. The problem space (functions, features, responsibilities, requirements) should be separated from the solution space (context, concepts, content). Problem domains usually remain stable, while the solution space changes; this should be taken into account during planning. Commonality of sub-domains can be exploited. Scenarios/operational flows help define/characterize domains.

(Pat Donohoe) FODA domain identification determines *organizational mission* (what are the key business or mission areas?), *system mission* (what applications does the organization build?), and *assets* (what are the materials necessary for building systems?). The purpose of scoping in FODA is to establish the bounds of the domain and the domain analysis pilot project. The domain identification steps were added to structure the decisions used to select a domain for the pilot study. During domain scoping, FODA uses a *structure diagram* to identify what's in the domain/what's not in the domain. In the terminology of the SRI Domain Scoping Framework, the FODA Structure Diagram helps to establish some of the domain profile factors relating to domain identity. The FODA *context diagram* focuses on a *target domain* and helps bound that domain, based on its interactions with external domains and entities. Domain Scoping also identifies sub-domains, peer-level domains, and super-domains, based on services or capabilities.

Scoping is an iterative process that continues through the domain modeling phase. Realistic domain scoping goals should be set, including establishing a pilot project and establishing a core competence. The SEI technology transition approach includes a planning session to discuss broad objectives, subsequent FODA training to teach the method and provide hands-on exercises, and a FODA workshop to select a target domain and develop a preliminary domain model. Assumptions about the scope are revisited, based on: the size of the domain relative to available resources; decoupling of areas that belong in other domains; and better understanding of variability (the domain may need to be rescoped based on cohesion).

(Hassan Gomaa) Domain scoping can be considered as a first-cut domain analysis: identifying domain boundaries; analyzing domain features; and performing preliminary assessment of the scope of optional features, the size of the domain kernel, and the degree of variation within the domain. The domain to be scoped must be well understood and stable. Domain expertise must be available to serve this purpose. There must be several systems of a common family to justify additional work for domain analysis. Significant common functionality must exist among the members of the family as well as significant differences. Scoping should begin with a single system or a known family. Analysis needs to emphasize the differences between systems — these differences must not be abstracted away. The systems within the domain should be described in a common notation. Although all life-cycle products are analyzed, design and implementation decisions must not appear in the analysis model. Scoping needs to anticipate future changes (a highly developed life-cycle does not separate development from maintenance).

## **SRI/Mitre Framework Overview** **(Jim Baldo, Mitre Corporation)**

Jim Baldo of Mitre led the audience on an odyssey through the Domain Scoping Framework in his presentation "SRI Domain Scoping Framework: A Guided Tour from Troy to Ithaca." Utilizing mythological analogy, Jim introduced the SRI/Mitre Domain Scoping Framework, touching on its motivation, con-

(Ed Seidewitz) Software engineers should not think of software as “trash” — something to be thrown away. (From Brad Cox) “Other engineering disciplines don’t throw away assets.” The following hypothetical question might be posed to Congress, “Should software be depreciated?” The real importance of the Domain Scoping Framework is that it must save money in the end. It is essential to get management support and understanding. We, in turn, need to show results/benefits up front. Another side issue is that of acquiring staff with appropriate domain expertise and domain definition/analysis experience. We need a better understanding of how to scope and rescope domains and what constitutes a successful product line (how to evaluate up-front costs against long-term benefits).

(Mark Shelberg) We are not alone (in performing reuse, domain analysis, domain scoping, etc.). There exists a base (an evolving network) from which to work. Domain scoping begins to normalize concepts, terminology, models, methods, and examples. There still exists a conflict between traditional products and software. A more farsighted approach requires an agency-wide commitment with the warning that an organization must either “pay now or pay later.” Up-front investment is required and, with it, an associated lag time in implementing reuse-oriented practices. Organizations need champions, tried and true domain engineering processes, past successes, and good case studies (we learn more from failures than successes). Responsibility and authority are also required, as is the willpower to follow through and sustain domain engineering. Partnership with industry would be useful. Easily accessible training and education is also desirable.

### **Domain Scoping Experts Panel Discussion** **(Chair: David Weisman, Loral Defense Systems-East)**

A brief introduction to the panel speakers and a synopsis of the main points of their presentations is given below. Each panelist has significant experience in developing, training, and/or implementing one of the major domain analysis methodologies currently in practice. The influence of these perspectives can be seen in the synopsis material. The panel included the following participants:

- Charles McKay (Dean of Natural and Applied Sciences, University of Houston at Clear Lake) has taught and extended DISA’s Domain Analysis and Design Approach (DA/DP) method.
- Mark Simos (Organon Motives) developed the Organization Domain Modeling (ODM) method which was further refined on the Unisys/Army STARS Demonstration Project.
- Grady Campbell (Software Productivity Consortium [SPC]) is the principal architect of the SPC’s Reuse-driven Software Processes (RSP) methodology.
- Will Tracz (Loral Federal Systems, Owego, NY) serves as a Principal Investigator on the ARPA Domain-Specific Soft-

ware Architecture (DSSA) Avionics Domain Application Generation Environment (ADAGE) project.

- Pat Donohoe (Software Engineering Institute) has performed training of the SEI’s Feature-Oriented Domain Analysis (FODA) method.
- Hassan Gomaa (George Mason University [GMU]) developed the Domain Modeling Method which is currently being taught at GMU.

(Charles McKay) We need to use consistent interrelated definitions of “domain” and “product line.” A domain is a “business area” and a “problem space.” A product line is a “solution space” for a subset of “domain.” As an example, the domain of motor vehicle embedded control systems has product lines of anti-lock braking systems, cruise control systems, fuel injection systems, etc. We need to expand categories of risk across business, management, and technical boundaries. We need to expand engineering perspectives across software engineering, systems engineering, hardware engineering, and human factors. We also need to expand the categories of inputs to our processes.

(Mark Simos) The workshop focus — Domain Identification and Scoping — is part of the Organization Domain Modeling (ODM) Process Model under *Planning*. Domain Scoping and Definition Products include:

- Domains of interest
- Domain Selection Criteria
- Domain Selection Report
- Domain-Specific Project Objectives
- Domain Stakeholder Model
- Intensional Domain Definition (defining features/rules)
- Extensional Domain Definition (exemplars/counter-exemplars/boundary cases)
- Domain Interconnection Model

Within domain scoping, *domains of interest* are identified and characterized in relation to organization context, systems of interest, and candidate domain engineering project stakeholders. Domain identifications are either *normative* (i.e., grouped systems and system functionality in categories familiar to stakeholders) or *innovative* (i.e., help discover novel domains — new ways to “slice the pie”). Domain scoping is tactical, not exhaustive. In stable contexts, domains of interest can be input to subsequent project selections. Domain identification/scoping is integral to later domain modeling (not separate from domain analysis methods). Domain scoping can be perceived as *intervention* in the organization (i.e., it is not a passive activity). Stakeholder analysis and explicit objectives are needed to select strategically appropriate domains. Domain relations must be mapped around the domain of focus (not initially top-down for entire organization). Scoping can be incremental and iterative. Resources must be tuned to organizational constraints. A good grasp of the method and access to domain expertise is required up front.

## DoD Program Management Issues Panel

(Chair: Don Reifer, SRI)

Don Reifer introduced the Management Issues Panel by defining goals for consideration and questions that might potentially be answered during the subsequent discussion. Given the management orientation of the panel, it was suggested that the group consider addressing the following issues:

- How to communicate management issues associated with scoping a domain and settling on product lines to a technical audience.
- Discuss challenges faced putting product lines and/or architectures in place.
- Determine how to convince program managers to perform the initial analysis.

The panelists were also asked to answer these questions in their presentations:

1. Do we need a Domain Scoping Framework? Why is the Domain Framework important to you?
2. What management issues impede its deployment?
3. If you had three wishes relative to the framework, what would you wish for?

The panel included the following participants:

- Ron House is a Navy program manager at the Naval Undersea Warfare Center.
- Lorraine Martin (Loral Defense Systems-East) is program manager for the Comprehensive Approach to Reusable Defense Software (CARDS) program. CARDS is an Air Force effort that provides reuse R&D and supports technology transition to DoD services and agencies.
- Ed Seidewitz (NASA/GSFC) was formerly the program manager for the Compass project (which utilized domain analysis and reusable software for a distributed system implementation) and is currently leading domain analysis efforts in NASA's Flight Dynamics division.
- Mark Shelberg is manager of the Defense Mapping (DMA) Agency's Interoperable Map Software (IMS) Program. DMA is currently leading an effort to build a Mapping, Charting & Geodesy generic domain architecture.
- Ron Owens (CACI) is program manager for CACI's software reuse activities, including those that support the Army Reuse Center, Air Force Reuse Center, SBIS, PEO STAMIS, DMA, and BLSM.

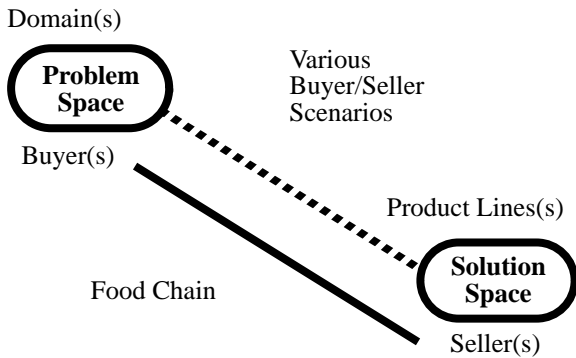
(Ron House) The Domain Scoping Framework is a mechanism to ensure that systems have a longer productive life span by supporting an expanding set of missions with fewer deployment errors and greater selection/scope of reusable components. Systems/components have a greater usage potential when products are standardized and data, interfacing, and interoperability are better understood and documented. An underlying product-

based architecture increases technology upgrade possibilities. Current acquisition strategy continues to focus on single system construction, however. Resource allocation is a top-down process driven by cost & schedule concerns. The lack of consideration for the life-cycle impacts design/development decisions. There are only limited investments in and publicized successes for activities which can lay the groundwork for improvement. We need for the DoD to establish, fund, and empower a product line identification/dissemination office that maps domains across services and to provide education services. The problem is that Congress funds stovepipe domain analysis, which implies that we must change the way we do business and fund projects. Changing the symptoms is wrong — we need to change the process.

(Lorraine Martin) The Domain Scoping Framework will be especially important for organizations that have not considered their organization as a business unit or enterprise. The framework will enable these organizations to focus on what business they are in and how current systems support that business. Product line identification may have a higher payoff than domain identification for some organizations, since investment strategies and organizational issues may be driven more by product lines than domains. At the present time, few (if any) comprehensive methods for domain and product line identification exist at the required scale. The framework needs to consider the complexity of DoD organizations. The key is not in implementing the framework, but rather in making sure that the implementation takes hold in an organization. Top-level management support can aid in achieving this goal. The DoD must adopt a strategic view towards system development that takes long-term payoff into account. We still, however, need near-term ROI to show interim progress (a tactical view is more in line with business process reengineering than with the strategic perspective of domain engineering).

(Ron Owens) The Domain Scoping Framework validates concepts already being implemented in support of the Army Reuse Center (ARC), DISC4, and Army Software Reuse Policy. The framework is a mechanism to assist in implementation and integration of the C4I Technical Architecture and the Army Software Reuse Policy. The biggest challenge in taking advantage of the Domain Scoping Framework recommendations will be in pursuing common functionality or product lines across vertical domains. Experience has shown that orientation and training will be fundamental to utilization. A crucial factor in achieving domain manager buy-in is the ability to quantify realistic estimates of short-term and long-term reuse benefits, e.g., high-level business case. One stumbling block will continue to be the inherent conflicts between organizational domains and functional domains. The DoD should establish, fund, and empower a product line identification/dissemination office that maps domains across services. Reuse advocates need to provide educational and consulting support services to DoD organizations/projects that are willing to transition (must eliminate cost/schedule constraints on participants). Product line support organizations and an acquisition/liason support office for commercial products should be developed (where appropriate).

The framework is based on a market perspective of a domain being representative of a problem space and a product line being representative of a potential solution space. A market context is established with buyers seeking solutions for a problem and consuming product lines from sellers with solutions. The framework addresses potential “food-chain” scenarios of buyers (i.e., domains) and sellers (i.e., product lines). Figure 1 illustrates the concept.



**Figure 1: DoD Product Line Market**

### Framework Space and Temporal Dimensions

The framework is applied prior to initial domain engineering activities or when the organization has determined the need to assess itself for product lines. Although the framework is not considered a domain analysis method, it could be mapped to assessment and scoping activities supported by existing methods. The framework was designed to require no longer than 0.5 - 1.0% of the time required perform a full domain analysis.

### Opening Remarks (Don Reifer, SRI)

In his opening remarks, Don Reifer (SRI) described the goals of the workshop in terms of 1) identifying the issues associated with the SRI/Mitre Domain Scoping Framework and those facing PEOs and PMs who want to apply the framework to scope domains/product lines, and 2) recommending solutions for those issues. Don posed the following challenges: we need to develop a scoping framework that is sound and usable by PEOs and PMs; we need to plan measures that address perceived/real issues (with respect to domain scoping); and we need to validate the planned measures to ensure that they make economic, technical, and management sense. The expectations and work-products of the workshop therefore include an *issues list* and an *action plan*. The issues list would capture framework-, usage-, and business-oriented concerns about the Domain Scoping Framework. The action plan would describe activities including tasks, milestones, deliverables, and measures of success) and that must be implementable within the current business climate.

Don stressed that we are not starting DE fresh, but we do need to converge our solutions into one that works to achieve architecture-based, product-line reuse. The goal of the workshop is to

neither serve as a rubber stamp of the framework, nor as a brainstorming session. The framework should serve as point of departure for what the ultimate solution should be. We want cross-fertilization from others with different viewpoints (academic/commercial/DoD, management/customer/practitioner/methodologist).

### Keynote Address (Barry Boehm, USC)

Barry Boehm of USC delivered the keynote speech, addressing the importance of domain analysis, a megaprogramming enterprise model, critical success factors, and the downward trends in the true cost of DoD software, relating these costs to reuse across related systems. Domain analysis/domain engineering (DA/DE) was deemed important because it facilitates the faster, cheaper, and better development of DoD software through software reuse, application of commercial technology, and enhanced interoperability. DA/DE is also critical to information warfare by making commercial technology universally available and creating domain assets to provide a competitive edge.

Dr. Boehm underscored some domain engineering (DE) success stories at Hewlett-Packard (HP), the ARPA Software Technology for Adaptable, Reliable Systems (STARS) program, and the Air Force Portable, Reusable, Integrated, Software Modules (PRISM) program. HP realized a factor-of-4 reduction in time-to-market at its Queensferry Telecommunications Division. The Air Force STARS Demonstration Project realized an order-of-magnitude improvement in productivity and reduction in errors. DE efforts on the Army STARS Demonstration Project at Ft. Monmouth, NJ, are projected to save the Army’s Software Engineering Directorate (SED) more than \$2 million over the next ten years, in maintenance of electronic warfare systems. PRISM has exploited commonality across command center systems for a total savings of \$26.4 million.

Dr. Boehm discussed the Megaprogramming Enterprise Model - II, which identified roles and relationships for significant players in a product-line-oriented organization. The model cites the need for an empowered Product Line Manager, Product Line Analysts, and Component Producers/Assemblers, and incorporates notions of software architecture and product line strategy as part of its implementation. Dr. Boehm cited critical domain engineering success factors, including the avoidance of stove-pipe domains, leveraging enterprise architectures, and an optimal mapping among architectures, domains, and systems. Technical factors include architecture technology, scalability of domain solutions, and process models. Business case analysis was noted as a success factor: there is a need to determine the return-on-investment (ROI) for DE (the COCOMO II Cost model was presented as a tool for this activity). Dr. Boehm concluded by highlighting an IDA study that equated Lines of Code in Service (LOCS) with machine language instructions. Using this metric, DoD software costs can be seen to decline over time.

# SRI Workshop Summary: “Domain Analysis in the DoD”

Mitre Corporation, McLean, VA  
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## Introduction

The Workshop on “Domain Analysis in the DoD,” sponsored by the Software Reuse Initiative (SRI) and Defense Information Systems Agency (DISA), was held at Mitre Corporation, in McLean, Virginia on 26 - 27 September 1995. The primary purpose of the workshop was to discuss issues related to identifying and scoping domains and product lines and to assess the usefulness of the strawman SRI Domain Scoping Framework as a proposed basis for this scoping activity. To this end, two specific objectives were identified:

- to identify the barriers facing Program Executive Offices (PEOs) and Program Managers (PMs) in incorporating domain analysis technology in their organizations and programs
- to recommend a range of solutions and/or approaches to address and overcome these barriers

Many DoD and Industry programs can benefit from the application of domain analysis technology (concepts, processes, methods, and tools). However, PEOs/PMs rarely have enough information regarding why, when, or how to use domain analysis on their programs. A more basic question is whether there are sufficient reuse benefits within an organization/domain to warrant the associated investment in domain engineering — does a product line exist that justifies reuse costs? The solution to this problem involves bringing together leading domain analysis experts and PEO/PM representatives and managers to discuss a framework, currently under development by the DoD SRI, to guide DoD managers in applying domain analysis in their organizations and programs.

The workshop brought together over fifty representatives from DoD, commercial, and academic organizations, with varied interests and perspectives on Domain Analysis, including those of methodologist, practitioner, management, and customer. The workshop approach included a Program Management panel, Domain Analysis Experts panel, a follow-up plenary discussion session, and two working group sessions. In the working groups, the attendees were divided into 5 color-coded teams: Blue, Green, Gold, Orange, and Red, and were instructed to 1) identify issues in performing domain scoping, using the SRI

Domain Scoping Framework as a “strawman”; and 2) make recommendations for improving the framework and applying its principles in real-world situations.

The teams were chosen to provide a diversified mix of viewpoints. Each team included a facilitator/rapporteur (responsible for keeping the discussion activities relevant to the task at hand) and a Framework expert (who served as the technical authority on issues relating to framework content). The general team approach involved focusing on issues and actions within the individual teams and then looking across teams for common threads in the plenary sessions. The ultimate goal was to build consensus and move ahead with implementation recommendations.

## Motivation for the Framework

(Anh Ta and Duane Hybertson, Mitre Corporation)<sup>1</sup>

The software engineering discipline has matured to the point where there is a growing acceptance that software systems within application areas (or domains) have much in common, and that this commonality can be exploited through reuse. This understanding has shifted the focus of software reuse to domain-specific approaches. Various domain analysis/engineering methods have been developed and integrated into software system development through reuse-driven processes. Experience in applying domain analysis indicates that defining and scoping a domain for analysis in many cases is not straightforward. The scope of a domain or product line is often determined more by available resources than by the scope of an existing body of knowledge [WP92]. Preliminary decisions that are made for selecting and bounding a domain can significantly affect the success of the domain analysis effort and the return on investment, yet the criteria for making these decisions are not uniform across domain analysis/engineering methods and in some cases are addressed only minimally.

The DoD is interested in a solution that can help define DoD domains in a way that will identify software commonality across existing domains and reduce arbitrary duplication. Mitre is supporting the DoD Software Reuse Initiative in developing a domain framework intended to satisfy the objectives stated above. Because of the number and variety of DoD domains, this framework is expected to have applicability beyond DoD to the software community in general. The SRI Domain Scoping Framework profiles an organization’s current products and services for identification and mapping to potential product lines. Based on these results, the framework provides information to assist organizations in making decisions about the potential value and risk of establishing product lines (e.g., domain engineering activities such as domain analysis). The framework provides a first-order, low-cost feasibility analysis for establishing product lines.

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1. This section adapted from [TH95].