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POLICY ASSESSMENT FOR
THE SOFTWARE PROCESS MATURITY MODEL

Beth Springsteen, Task Leader

August 1992

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Software and Intelligent Systems Technology Office
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13. ABSTRACT (Maximum 200 words) DARPA and the DoD Software Action Plan (SWAP) Committee tasked IDA to provide an analysis of DoD-wide application of the Software Engineering Institute (SEI) software process maturity model. The results of this analysis will be used by DARPA and SWAP to formulate a DoD-wide policy associated with mandating SEI's process maturity model. This document presents the analysis, focusing on a) implementation issues associated with mandating software process assessments (SPAs) and software capability evaluations (SCEs) DoD-wide, b) the availability and adequacy of data to determine the benefits and effectiveness of process maturity, and c) a comparison of the maturity model and methods with similar techniques. Based on the analysis, we conclude that policy mandating SPAs and SCEs is desirable, but improved guidance and supporting infrastructure is needed in order to implement the policy effectively. For this reason, we recommend that an action plan be developed to identify government needs and to establish responsibilities for the improvement activities. In addition, the policy mandating SCEs and SPAs DoD-wide should be delayed about one year in order to implement the action plan.					
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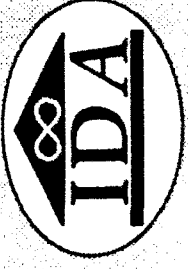
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PREFACE

The Institute for Defense Analyses (IDA) was tasked by the Defense Advanced Research Projects Agency (DARPA) and the Department of Defense (DoD) Software Action Plan (SWAP) Committee, "to provide analysis of policy issues involved in wider DoD application of the SEI software process maturity model." This work was performed under contract MDA 903 89 C 0003, DARPA Assignment A-156, Policy Assessment for the Software Process Maturity Model.

The study team, composed of members of the IDA Computer and Software Engineering Division, prepared the analysis in the form of an annotated briefing with supporting data. The briefing focused on a) implementation issues associated with mandating software process assessments and software capability evaluations DoD-wide, b) the availability and adequacy of data to determine the benefits and effectiveness of process maturity, and c) a comparison of the maturity model and methods with similar techniques.

The work was reviewed at IDA by Dr. David J. Carney, Dr. Thomas P. Frazier, Mrs. Audrey A. Hook, Dr. Richard J. Ivanetich, Mr. Clyde G. Roby, and Dr. Richard L. Wexelblat.



Policy Assessment for the Software Process Maturity Model

Beth Springsteen, Task Leader

**Bill R. Brykczynski
Dennis W. Fife
Reginald N. Meeson
John W. Norris**

Outline

The annotated briefing is organized into four parts. The first part of the briefing describes the background of the study. The second part addresses implementation issues that must be considered when mandating use of the Software Engineering Institute (SEI) process maturity model across the Department of Defense (DoD). The third part presents the quantitative and qualitative data currently available to support use of the SEI process maturity model. The fourth part includes a comparison of the SEI model and methods with similar assessment and evaluation methods. The last part includes the conclusions, the major findings, and ramifications from the IDA study.

The overview portion of the briefing will review standard definitions associated with the SEI process maturity model and a brief description of the task. This will include the objectives of the task as defined by the Software Action Plan (SWAP) Committee, the approach taken during the study, and a summary of the findings.

Outline



Overview

- Definitions
- Task Objectives
- Approach
- Summary of Findings

Assessment of Policy Implementation

Data Assessment

Model and Method Comparison

Conclusions

Definitions

- **Method**

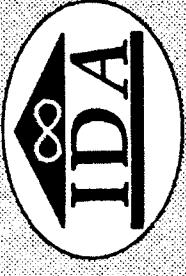
In this context, the term *method* is used to describe procedures for inquiring about a developer's software development process. There are two methods most commonly discussed, an assessment and an evaluation. An assessment is used by a development organization to identify high-priority software process issues that may benefit from process improvement efforts. SEI's Software Process Assessment (SPA), also known as a self-assessment, is an example of such a method. Assessments can be performed by a contractor or by a government agency, provided they develop software. Evaluations, on the other hand, are used by the government to identify the strengths and weaknesses of a contractor's software development process. SEI's Software Capability Evaluation (SCE) is an example of this method. Evaluations may be used by the government during source selection or to monitor contractors after they are awarded.

- **Model**

The term *model* is used to describe the framework of criteria for a type of analysis. To assist assessments and evaluations, SEI is in the process of developing a model. The SEI Capability Maturity Model (CMM) was released in draft form in August 1991 but it is presently undergoing revisions. The next release of the CMM is due in December 1992. Prior to the CMM, there was the process maturity model (PMM). This is a term used to describe the method developed and publicized by Watts Humphrey and the SEI Process Program (Humphrey 1987). Once the CMM is finalized, it will replace the PMM and will become the basis for all SPAs and SCEs.

Both the CMM and the PMM are subdivided into Key Process Areas (KPAs). KPAs are the building blocks designed to help characterize the software process. Examples of KPAs include software quality assurance, software configuration management, project management, and training.

Definitions



Method

- **Assessment Method:** used by development organizations
 - SEI Software Process Assessment (SPA)
- **Evaluation Method:** used by the government
 - SEI Software Capability Evaluation (SCE)

Model

- **Process Maturity Model (PMM):** current version of SEI process model
- **Capability Maturity Model (CMM):** draft model, unofficial
- **Key Process Areas (KPA):** building blocks to characterize the process

Task Objectives

- **Scope**

Since the CMM is currently undergoing development, the IDA study focused on the process maturity model in effect in January 1992. This model is characterized by the SEI questionnaire (Humphrey 1987), Watts Humphrey's book entitled *Managing the Software Process* (Humphrey 1989), and by the goals and practices of the KPAs presented in SEI's SCE team training course (SEI 1991).

- **Assessment of Policy Implementation**

The objective of this subtask was to identify implementation issues associated with mandating the use of SCEs and SPAs throughout the DoD. In particular, the study identified issues the DoD should be aware of prior to mandating a policy, and proposed solutions to these issues.

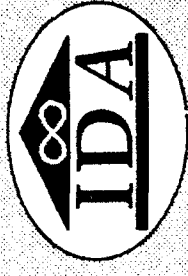
- **Data Assessment**

The data assessment subtask focused on evaluating data which may support or disprove the assumption that higher levels of maturity result in reduced risk and higher levels of productivity and quality. The objective of this subtask was not to validate the SEI process maturity model but to assess the availability and adequacy of the quantified data. In the event quantifiable data was not available, qualitative or anecdotal information was used to determine if higher levels of software process maturity are a worthwhile goal for the DoD.

- **Model and Method Comparison**

The objective of this subtask was to compare the SEI model and methods to similar techniques in order to determine its strengths and weaknesses. The purpose of this activity was not to validate the competing models and methods or to identify which one was the best, but to identify how the models and methods differ. The strengths of the competing techniques were used to determine areas for improving the SEI approach.

Task Objectives



Scope

- To assess the process maturity model in use in January 1992, not CMM

Assessment of Policy Implementation

- To provide an analysis of policy issues involved in wider Department of Defense (DoD) application of Software Engineering Institute's (SEI) software process maturity model

Data Assessment

- To assess availability and adequacy of data to determine whether higher levels of maturity are valid indicators of productivity and quality

Model and Method Comparison

- To compare the maturity model with similar techniques in order to identify its strengths and weaknesses, and to identify significant advantages offered by other models

Approach

- **Assessment of Policy Implementation**

The approach used to identify and evaluate the policy implementation issues involved the experience IDA has performing SCEs for the Strategic Defense Initiative Organization (SDIO) and the results of a workshop hosted by IDA to solicit input from the software community (IDA 1992). As a result of performing SCEs for SDIO, several implementation issues surfaced. These issues were included in the focus of the workshop.

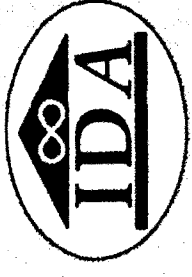
- **Data Assessment**

To assess the availability and adequacy of cost and benefit data, three approaches were taken. First, IDA developed a survey to identify contractors and government agencies that have been collecting cost and benefit data associated with using the SEI process maturity model. The survey was distributed to all SEI primary affiliates and to the attendees at the CMM Workshop hosted by SEI, April 6-7, 1992. Second, direct contacts were made with SEI and survey participants who indicated they had collected data. And third, previously published case studies and reports were reviewed for completeness and accuracy. In this case, personal contact was made with the authors of the reports in order to thoroughly understand the published data.

- **Model and Method Comparison**

The comparison portion of the study involved identifying models and methods similar to SEI's and developing criteria to compare and contrast them. The sponsor directed IDA to compare SPAs to Software Productivity Research's (SPR) assessment method entitled Checkpoint and to compare SCEs to the Air Force's Software Development/Capability Review (SDC/CR). Other assessment methods reviewed included those of Hewlett Packard, Bell Labs, and Roger Pressman. But since these latter methods offered only minor variations of the SPR and SEI method, these comparison results were not included in this document.

The focus of the model comparison was to identify what attributes are investigated by the various methods. Since SEI has the only model that is defined distinctly from the implementation methods, a model was inferred for the other methods based on their questionnaires and evaluation criteria. The method comparison focused on how the assessments and evaluations were implemented in order to identify and improve software development practices.



Approach

Assessment of Policy Implementation

- Drew on SCE experience from the Strategic Defense Initiative (SDI)
- Identified policy issues and developed strawman positions
- Organized invitational workshop to address policy issues

Data Assessment

- Developed a survey soliciting data from government & contractors
- Made direct contacts with SEI, survey participants, and others
- Evaluated published case studies and reports

Model and Method Comparison

- Identified methods similar to SPAs & SCEs
- Inferred models from methods
- Defined assessment and evaluation comparison criteria

Summary of Findings

• Assessment of Policy Implementation

SPAs and SCEs are currently being used by industry and government to promote software process improvement. Strong industry support for SPAs was indicated in a recent Ada Joint Users Group (AdaJUG 1992) position paper that concluded "Ada JUG strongly supports continuous and aggressive organizational software engineering process improvement, and endorses the use of the Software Engineering Institute (SEI) Capability Maturity Model (CMM) and Software Process Assessment (SPA) for this purpose." AdaJUG membership is primarily drawn from the DoD contractor community. In addition, SPAs are being used by large non-DoD corporations (e.g., Bell Labs, AT&T, Schlumberger, and commercial divisions of several aerospace companies) to promote software process improvement. Also, an IDA survey of 55 companies found general agreement that both SPAs and SCEs are useful for improving the software process.

Although SPAs and SCEs were found to promote software process improvement, effective DoD-wide SPA/SCE policy implementation will require improvements in several areas. First, the model upon which SPAs and SCEs are based lacks important evaluation criteria and documentation. For example, the criteria by which an organization's strengths and weaknesses in KPAs are evaluated have not been sufficiently defined. Moreover, the methods used to conduct SPAs and SCEs have not been sufficiently documented. Second, guidance should be developed to assist program offices in the myriad of details involved in conducting SCEs. Program offices need to understand how to appropriately insert SCEs into the source selection process, how to properly tailor the SCE for their programs, and how to apply the software process maturity model after contract award. In addition to program office guidance, improved training is necessary prior to wide-spread SCE implementation. For example, the SCE training course should expand its scope to include more depth in each KPA. Finally, an infrastructure to monitor and support SPAs and SCEs should be developed before widespread implementation. Currently, there is a lack of SCE data collection and monitoring. Without such data, it will be difficult to measure process maturity benefits, monitor SCE usage, and identify effective methods for improving the SCE process.

• Data Assessment

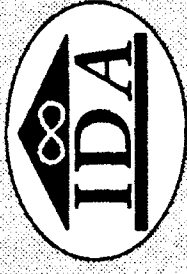
Several software process improvement case studies were analyzed to assess the availability and adequacy of data and to determine whether higher levels of maturity were valid indicators of productivity and quality. Extrapolations from various productivity and quality data bases were also examined. In addition, IDA conducted a survey to provide additional information that was applied to this aspect of the study.

Quantitative software process improvement data is very limited. Existing case studies suggest that SPA activities provide a positive return-on-investment (ROI) and improve quality. Anecdotal evidence from the IDA-conducted survey indicates that SPAs contribute toward process improvement. However, at this point, insufficient information is available to completely validate the hypothesis that higher levels of maturity are valid indicators of higher levels of productivity and quality.

• Model and Method Comparison

The SEI process maturity model was compared to the SPR assessment method and the Software Development Capability/Capacity Review (SDC/CR) evaluation method. Strengths and weaknesses of each method were identified. In summary, these methods have attributes not offered by SPAs and SCEs which may be beneficial for judging and improving a software development process.

Summary of Findings



Assessment of Policy Implementation

- SPAs and SCEs help to promote desired process improvement
- Need more complete model and method documentation
- Need more complete guidance and training
- Need infrastructure to monitor and support SPAs and SCEs

Data Assessment

- Quantitative data is very limited
- Anecdotal evidence is favorable

Model and Method Comparison

- Other models and methods have attributes not offered by SPAs and SCEs
- SPA and SCE processes could be improved

Outline

The second part of the briefing presents the implementation issues associated with using SCEs and SPAs DoD-wide. In order to identify these issues, IDA relied on the experience gained from performing SCEs for SDIO and the experience of the workshop participants. In general, IDA's experience is primarily with SCEs. Issues associated with implementing SPAs were derived from workshop participants and other users.

The findings in this section are not directed at SEI but rather at the government. They contain a list of improvements that need to be addressed to ensure that SCEs and SPAs are implemented effectively. The findings do not present any "show stoppers." But they do indicate that several areas need improvement in order to ensure that DoD policy mandating use of SCEs and SPAs could be consistently applied.

Outline



Overview



Assessment of Policy Implementation

- SCE Experience
- Workshop Summary
- Findings

Data Assessment

Model and Method Comparison

Conclusions

SCE Experience

- **Strategic Defense Initiative (SDI)**

IDA has gained considerable experience conducting SCEs for SDIO. We have taken an active role in implementing SDI's policy to use SCEs in source selection and contract monitoring. We have arranged training at the SEI for 30 people and have conducted mock evaluations to supplement this training. We have completed 7 evaluations and have an additional 15 scheduled in the near future.

- **Policy Issues Surfaced**

Several problems with SCEs arose in the course of our SDI experience. The first was the difficulty of producing qualified evaluation teams. Few military program offices have six experienced software personnel to form a complete SCE team. We took the approach of augmenting the SDI program office teams with people from other government offices, national laboratories, and IDA.

We have become concerned about the consistency of evaluations produced by different teams for several reasons. The number of proposals submitted for several SDI programs may require more than one team to conduct the necessary evaluations. To evaluate contractors fairly, evaluations conducted by different teams must be consistent. There is a wide range in individual team member software experience — from Ph.D.'s in computer science to government procurement staff with no technical training in computers or software. In addition, there have been significant changes in the SCE training curriculum over the period in which these teams were trained.

SDI is a sufficiently long-term program; once contracts are in place, we are concerned about how to encourage contractors to improve their software processes. If we select the best contractor today, how can we assure that they will continue to improve over the contract period of performance?

SDI has several special needs, including secure and trusted software. These needs are not reflected in the SCE KPAs. There is no clear guidance as to how these special areas might be addressed so that they could be considered in the source selection process. Our approach has been to add these areas as new KPAs and ask similar kinds of pointed questions about how the contractor addresses the issues.

Several contractors are submitting proposals on multiple SDI contracts. Both the SDIO and the contractors are interested in minimizing the number of evaluations conducted, because of the time and cost involved. The consistency of evaluations, discussed earlier, has a direct bearing on whether the results of an evaluation conducted for one program can be used for source selection on another program.

SCE Experience



Strategic Defense Initiative (SDI)

- Tracked SEI's process model since 1988
- Trained 30 people for SCEs (20 government, 5 IDA, 5 labs)
- Completed 7 SCEs to date (4 source selection, 3 contract monitoring)
- Scheduled 15 more SCEs
- SDIO policy required use of SCEs and SPAs

Policy Issues Surfaced

- Producing qualified teams
- Maintaining consistency between teams
- Encouraging contractors to improve
- Incorporating special SDI needs
- Minimizing repetitive SCEs

Workshop Summary

• Workshop on policy issues in DoD-wide implementation

On May 14, 1992, IDA held a one-day workshop to discuss issues related to DoD-wide implementation of SPAs and SCEs. The issues raised were in response to a draft policy statement requiring DoD component to develop plans for using SPAs to assess all internal government software developed by programs and SCEs in source selection for all software to be developed under contract. Workshop participants were selected by invitation and included both government and industry representatives. All participants had experience with either SPAs or SCEs or both.

• Purpose to raise issues of concern

The workshop was structured around five panels that met individually to discuss issues in depth. The panels then met in plenary to present results and discuss issues that overlapped. The five panel topics were selected from issues that were raised in our SDI experience and in discussions with other SPA and SCE users. These were:

Panel A: SCE team skills, training requirements, and SEL training resources

Panel B: Consistency of evaluation results with independent teams

Panel C: Achieving process improvement

Panel D: Tailoring for other review concerns

Panel E: Feasibility of a national registry of SCE results

Each of the panel topics was defined by a set of four or five questions. A strawman answer for each question was included in the workshop invitation to stimulate discussion. Each workshop participant was asked to submit a position statement addressing all of the issues.

• Workshop proceedings

A workshop proceedings was produced (IDA 1992). It contains annotated versions of the plenary panel reports, the position papers from each of the participants, and a summary comparing the position papers and panel discussions.

Workshop Summary



- Workshop on policy issues in DoD-wide implementation of software process maturity model, May 14, 1992
- Purpose to raise issues of concern on anticipated DoD-wide use of SPAs and SCEs
 - Panel A: Training
 - Panel B: Consistency
 - Panel C: Improvement
 - Panel D: Tailoring
 - Panel E: Registry
- Workshop proceedings
 - Plenary panel reports
 - Position papers of 35 participants
 - Summary of position papers

Panel A: Training

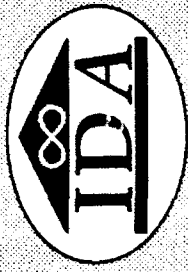
This table shows examples of the questions and answers discussed by workshop participants. Panel A discussed the skills required of SCE teams, the training they needed, and SEI's training resources.

The first question was whether more stringent screening was needed to accept candidates for SCE teams. The position statements generally concurred that more stringent screening was needed but that the entrance examination proposed by the strawman position was not a practical solution. During the panel discussion it became clear that the guidelines for selecting SCE team members were adequate, but SEI has no authority to enforce them. This new insight into the problem was included in the Panel's presentation to the afternoon plenary session.

As can be seen from the other table entries, there was general agreement among panel discussions and position papers on some issues, while differences were expressed on others.

Summaries of the other four panel discussions are included in the backup slides. For more complete information on any issue of interest, see the workshop proceedings (IDA 1992).

Panel A: Training



Question	Panel Position	Position Papers
More stringent screening needed?	No, enforce existing guidelines	More stringent, exam impractical
How to ensure qualified SCE teams?	Additional role playing	Apprenticeship, although costly
Additional training capacity needed?	Yes, expand beyond SEI	Agree
Form centralized group to perform SCEs?	No central supplier, only locator database	Agree

Findings: Model and Method Documentation

- **Lack of documented methods and criteria for implementation**

Insufficient documentation exists that describes the SCE process. There is a myriad of SCE details involving preparation for an SCE and conduct of a site visit. Documentation received during SCE training does not adequately describe these details.

During SCE training it is assumed that trainees have a comprehensive understanding of the various KPAs (e.g., configuration management, quality assurance, peer reviews). Limited guidance is provided to determine a contractor's strengths and weaknesses in a particular KPA. For example, peer reviews are one KPA. It has been found that trainees have different interpretations of what constitutes an appropriate peer review (e.g., reviews ranging from DoD-STD-2167A reviews to formal inspections). No criteria exist for judging whether or not a contractor receives an acceptable/unacceptable peer review KPA rating. Without such criteria, SCEs and SPAs are likely to produce inconsistent results.

- **Lack of experience with the maturity model**

There has been a major shift in the SEI process maturity model and a second shift is occurring. The original model, published in 1987, was primarily a questionnaire-based assessment method. The questionnaire was later de-emphasized and the model focused on a set of key process areas. At the present time, the number of KPAs is being increased and a new CMM is being developed. Today, both the questionnaire-based and KPA-based methods are being used by SPA and SCE teams. This inconsistency has led to confusion within the government and industry as to proper evaluation practices. These inconsistencies should be corrected before widespread implementation of SPAs and SCEs.

- **Model has limited scope of concern**

The process maturity model focuses on an organization's overall software engineering capability. Individual projects are examined primarily to understand how they are influenced by the organization's approach to software development. During a source selection, only existing, in-place processes are scrutinized by the SCE team. Thus, software engineering process improvements proposed by the contractor have little or no bearing on the final SCE results. There may be important differences between the software engineering processes being proposed for a specific acquisition and the processes evaluated by the SCE team.

The results of an organization's SPA do not provide project-specific process improvement suggestions. Individual project findings are combined to create an overall assessment of an organization's software process strengths and weaknesses. Thus, it becomes difficult for individual projects to identify specific improvements that should be made to benefit their project.

Several areas important to an organization's software engineering capability are not included in the SEI model. These areas include the capabilities of project personnel (e.g., staffing resources, experience, training), software engineering methods and tools (e.g., requirements, design, support, and development tools), and product and technology constraints (e.g., hardware experience, language proficiency, reuse experience). Some of these areas will be included in the forthcoming CMM, while others may be best left outside the scope of the model.

Findings: Model and Method Documentation



Need better model and method documentation for wide-spread implementation

- **Insufficient documentation of methods and criteria for implementation**
 - SCE method not adequately documented or publicly available
 - Limited guidance for determining strengths & weaknesses against KPAs
 - No criteria for rating KPAs (i.e., satisfied and unsatisfied KPAs)
 - SCEs and SPAs are likely to produce inconsistent results
- **Lack of experience with the maturity model**
 - Two major shifts in model concepts
 - Confusion of current evaluation practices
 - No SCE and SPA experience with future model (i.e., CMM)
- **Model has limited scope of concern**
 - SCE and SPA focus on organization, lacks information on projects
 - SEI model addresses process issues, omits other important areas

Findings: Guidance

- **Lack of guidance to program offices for using SCEs**

Implementing an effective SCE within a source selection process requires considerable attention to detail by the program office. Without appropriate guidance, widespread SCE implementation may yield ineffective and inconsistent results. There are many examples of areas where program office guidance is needed: SCE wording for Request For Proposals (RFPs) and Statement of Work (SOWs), the method of communicating SCE results to the Source Selection Authority, the costs associated with an SCE. In addition, guidance is needed for tailoring an SCE to program-specific needs. For example, a source selection with many offerors may require multiple SCE teams in order to evaluate all contractors within available time. What program office issues arise in dealing with multiple teams? Also, program offices will need guidance to handle issues involving software subcontractors teamed with a prime. Would the program office perform an SCE on each subcontractor? How are SCE results then combined for each offeror? Note that some of this information is contained in SEI's Draft Implementation Guide, although it is not currently available for public release.

There are no standards and no central oversight for conducting SCEs. Presently, some SCEs are being conducted using the 1987 questionnaire-based method. The length of some SCE contractor site visits have been reduced from three days to as little as one day. There are no mechanisms in place to ensure that SCE teams are capable of producing satisfactory results. Analysis should be undertaken to determine what standards and oversight are needed.

- **Lack of guidance to program offices to facilitate improvement**

As part of the source selection process, a contractor may submit a Process Improvement Plan (PIP) that describes planned activities to improve existing software engineering processes. For example, peer review training may be established, organization-wide metrics may be implemented, or cost-estimation processes may be formalized. As this time, there is little guidance available to program offices on how to review, use, and support these PIPs. Process improvement can be facilitated by positive feedback and interaction from a program office. Guidance is needed to describe when, if, and how a program office pays for process improvement, how to prioritize process improvements, how to use SCEs effectively for contract monitoring, and so forth.

Findings: Guidance



Need better guidance for wide-spread SCE implementation

- **Insufficient guidance to program offices for using SCEs**
 - **Contents of Request for Proposal and Statement of Work***
 - **Input to Source Selection Authority***
 - **Tailoring guidance for the SCE process and criteria**
 - **Guidance for using multiple SCE teams on one acquisition**
 - **Treatment of subcontractors when teamed with a prime**
 - **No standards and oversight for conducting SCEs**
- **Lack of guidance to program offices to facilitate improvement**
 - **Reviewing and utilizing process improvement plans (PIP)**
 - **Supporting contractor's process improvement**

* Contained in SEI's Draft Implementation Guide — not currently available for public release

Findings: Training

- **Insufficient training**

The current SCE training program does not sufficiently prepare trainees for performing effective and consistent evaluations. Detailed understanding of each KPA is required in order to adequately assess a contractor's strengths and weaknesses. Currently, the training course provides little information concerning the criteria for assessing each KPA. Thus, it is possible for SCE team members to have significantly different expectations while assessing a contractor's KPAs. The SCE training course should be expanded to include the criteria by which each KPA is assessed.

SCE short courses or presentations should be developed to educate both the acquisition (e.g., contracts, legal, and program management staff) and contractor communities. Wide acceptance of SCEs, and the primary goal of software process improvement, will be impeded unless these groups understand the SCE methods and their benefits. The current training capacity may be exceeded upon widespread SCE implementation. The SEI is taking several steps to expand capacity (e.g., coordinating with the Defense Systems Management College to provide training, development of a trainer course). Additional analysis should be performed to estimate the future training demand.

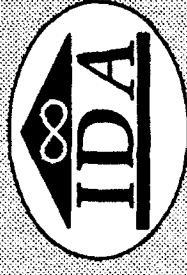
The SEI recommends that an SCE trainee possess at least seven years software development or acquisition experience. However, the applicant selection process does not ensure these criteria are met, nor does the training process ensure the training material was understood correctly. Since program offices have sent unqualified personnel to SCE training, some improvement in trainee screening is needed prior to widespread SCE implementation to ensure only well qualified people perform evaluations.

- **Shortage of qualified evaluators and trainers**

Program offices usually lack sufficient personnel to staff a full SCE team. Arrangements must often be made with people from other program offices, Commands, or federally funded research and development centers. Formal procedures for obtaining SCE team members should be developed within each of the Services and Commands.

A continuing SCE training problem will be the lack of qualified government evaluators and trainers. A detailed understanding of KPAs is required in order to participate effectively on an SCE. Good software development experience often provides the basis for this understanding. One concern is that the number of qualified government evaluators may not be sufficient for wide-spread SCE implementation. And even though SCE instructors periodically observe SCEs in operation, they often have not participated in the SCE process. Without first-hand participation, instructors do not experience the actual application of the method (e.g., necessary teamwork, consensus building, interview techniques, program office feedback).

Findings: Training



Need better training for wide-spread implementation

- **Insufficient training**
 - **KPAs are not reviewed, need more detailed training**
 - **Contracts, legal staff, and contractors are not generally trained**
 - **Capacity may be insufficient**
 - **Unqualified trainees have been selected and graduated**
- **Shortage of qualified evaluators and trainers**
 - **Staff for full SCE team not available to many program offices**
 - **Government evaluators often lack development experience**
 - **Current instructors often do not have direct SCE experience**

Findings: Infrastructure

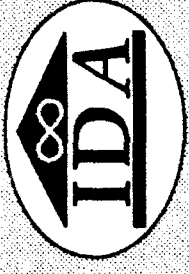
- **Lack of data collection and monitoring**

At the present time, there is little data to verify the process improvement benefits attributed to the software process maturity model. Without establishing mechanisms to provide such data, it will be difficult to assess the costs and benefits of the SPA and SCE methods. A variety of data should be collected from each SPA and SCE. From this data, the rate by which industry improves should be determinable. Mechanisms should also be in place to identify aspects of the SPA and SCE process that need improvement.

- **Insufficient means to share data and support SPAs and SCEs**

Program offices usually require additional personnel to staff an SCE team. Currently, this staffing is being done informally with little or no formal assistance. Within each Service, a means should be developed by which program offices can locate trained or experienced SCE evaluators. In addition, a reporting mechanism for lessons learned should be established to assist program offices. Support mechanisms (e.g., central help group, help lines, newsletter) for SCE and SPA teams would also help to improve the assessment and evaluation process. Currently SCE teams have no help group to refer to when implementation questions arise.

Findings: Infrastructure



Need infrastructure to monitor and support SPAs and SCEs DoD-wide

- **Inadequate data collection and monitoring**
 - **Scanty measurement data to verify process maturity benefits**
 - **Unable to monitor SCE usage (who, what, when, where)**
 - **Unable to monitor rate of industry improvement**
 - **Unable to identify effective methods for improving practices**
- **Insufficient means to share data and support SPAs and SCEs**
 - **No central registry of trained or experienced evaluators**
 - **No mechanism to report lessons learned**
 - **Limited user support mechanisms to assist SPA and SCE teams**

Priorities for Facilitating Policy Implementation

- **Short-term priorities**

There are a number of actions that should be undertaken to ensure effective widespread DoD implementation of SPAs and SCEs. Some of these actions have already been initiated, others have not.

The methods and procedures for performing SPAs and SCEs need to be documented and publicly available. The current SPA and SCE training material does not provide an adequate description of the processes. Without this documentation, a complete and consistent understanding of the evaluation and assessment process is difficult.

Criteria for evaluating and scoring KPAs must be established. Without these criteria, evaluation and assessment team members will have different, possibly significantly different, expectations for each KPA. Consistent and effective results are then unlikely.

Guidelines for program office SCE implementation should be developed. Without adequate guidance, program offices are likely to make simple mistakes that reduce the effectiveness of the SCE process. In addition, a mechanism to provide standards and oversight of the SCE process should be established. Major subversions of the SCE process are unlikely to yield effective results.

SCE and SPA training must also be improved. A key concern is providing training to properly evaluate a contractor's strengths and weaknesses in each KPA. In addition, a number of SCE short courses or presentations should be developed to educate both the acquisition (e.g., contracts, legal, and program management staff) and contractor communities.

Another short-term priority involves establishing an infrastructure to assist and monitor government usage of the SCE process. Within each Service, a means should be developed by which program offices can locate trained or experienced SCE evaluators. In addition, a reporting mechanism for lessons learned should be established to assist program offices to learn from previous experience. Support mechanisms (e.g., help lines, newsletters) for SCE and SPA teams would also help to improve the assessment and evaluation process.

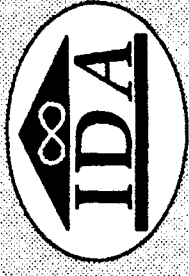
- **Long-term priorities**

A number of long-term actions should be undertaken to improve the SPA/SCE process. These actions are considered long term because they are not necessary prior to widespread SPA/SCE implementation.

Currently, there are few mechanisms in place to provide feedback from actual SCE experiences to the process maturity model and method developers. Without such feedback, the model and its methods may lack a basis in reality. For example, improved SCE feedback would have quickly identified the problems arising from the lack of KPA rating criteria. Early identification of this problem might have led to both model and training improvements.

Program office guidelines should be developed that help to encourage contractor process improvement. Process improvement can be facilitated by positive feedback and interaction from a program office. Guidance is needed to describe when, if, and how a program office pays for process improvement, how to prioritize process improvements, how to effectively use SCEs for contract monitoring, and so forth.

Priorities for Facilitating Policy Implementation



- **Short-term priorities**

- Document and publicize SCE and SPA methods
- Establish criteria for evaluating and scoring KPAs
- Establish quality standards and tailoring guides
- Improve training
- Establish infrastructure to assist and monitor government usage

- **Long-term priorities**

- Establish feedback mechanisms for model and method weaknesses
- Develop guides to encourage contractor improvement
- Collect data for future improvement of the model and methods

Outline

The third part of the briefing focuses on the findings of the data assessment. The objective of the data assessment was to determine if there is sufficient quantitative data available to support the notion that higher levels of maturity are associated with higher levels of productivity, quality, and reduced risk. The data presently available can be characterized as either a case study, data base extrapolation, or a survey. Additional details of each are provided in the attached backup slides.

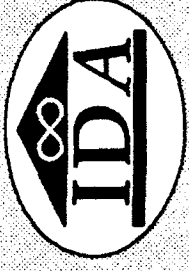
Three primary case studies describe the cost and benefits of improving process maturity: Hughes, Raytheon, and IBM Federal Systems Company (FSC). Since IBM FSC's findings are preliminary, the company requested that this data not be disseminated. It has been excluded from this annotated briefing.

The term "data base extrapolation" refers to a type of analysis that was done to estimate the impact of improving process maturity. Several cost model developers have extensive project data that has been collected over the years. The modelers adjusted the parameters in their models to emulate the characteristics of the various maturity levels based on the SEI questionnaire (i.e., SEI-87-TR-23). They extrapolated information from their data bases to characterize productivity and quality relative to a maturity level. Published findings were reviewed from Capers Jones, developer of Checkpoint, Larry Putnam, developer of SLIM, and Karl Williams, author of the Harbridge Benchmark Study.

In addition, two surveys have been performed to estimate the impact of process maturity. Lockheed's survey included interviewing representatives within Lockheed whereas IDA's survey solicited information across the software community, including DoD contractors and government developers.

The results of the benefits analysis is very dependent on the quality and accuracy of SPA and SCE ratings. Studies have been done to compare SCE results with SPA results. These studies indicate that there may be significant differences in the findings when comparing SPAs and SCEs. This section of the briefing will present the comparison data currently available and the findings of the data assessment study.

Outline



Overview

Assessment of Policy Implementation

→ Data Assessment

- Case studies (Hughes, Raytheon, IBM FSC)
- Data base extrapolations (Checkpoint, SLIM, Harbridge)
- Surveys (Lockheed, IDA)
- SCEs vs. SPAs (AF ESC, NAWC)
- Findings

Model and Method Comparison

Conclusions

Summary of Data Assessment

- **Hughes**

In the July 1991 issue of *IEEE Software*, Hughes Ground Systems Group reported the benefits and costs of moving from level 2 to level 3 (Humphrey 1991). The benefits were measured in terms of the Cost Performance Index (CPI) which is the ratio of budgeted cost to actual cost of work performed. The CPI improved from 0.94 in 1987 to 0.97 in 1990. The company attributes this to a 50% reduction in risk which equates to about \$2 million per year (Willis 1990). In addition, costs were collected in two categories. The cost of an SEI-assisted assessment was \$45,000. The cost of implementing the improvement plan was 75 staffmonths over a 2-year interval. Hughes estimated that they saved about five times as much as they spent on improvement.

In essence, the Hughes experience indicates that increasing process maturity does help to reduce risk. But there are some limits to the study. Hughes is uncertain whether all the costs were complete and if the benefits were solely attributed to the SEI process improvements. Currently, Hughes has no plans to update the study since the improvement programs in place today are much broader than those associated with SEI process maturity.

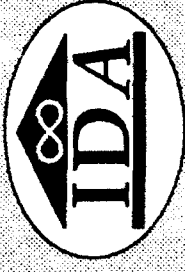
- **Raytheon**

Ray Dion of Raytheon's Equipment Division implemented a process improvement program in August 1988. To determine the benefits of this program, he analyzed how costs were distributed one and a half years before the improvement program as compared to one and a half years after the improvement program was implemented. The analysis was based on Phil Crosby's approach of categorizing costs. Costs of 6 software projects were divided into 4 categories (consisting of 45 subcategories): cost of performance, cost of non-conformance, cost of appraisal, and cost of prevention. Cost of performance includes the costs of developing the software the first time, e.g., development of requirements, design, and code. Cost of non-performance includes the cost to fix defects, e.g., re-reviews, change control board, and engineering changes. Cost of appraisal includes the cost of the first reviews and walkthroughs. And the cost of prevention includes the cost associated with improving the development process, e.g., training, tools, and fault analysis.

As a result of estimating and tracking these costs over time, the estimated data indicated that the cost of non-conformance decreased over the year and a half period the process improvement program was in effect. In general, Raytheon estimated a return of investment of 1:7.7; i.e., for every dollar spent on improvement, Raytheon estimated a savings of nearly 8 dollars (Dion 1992).

While the benefits appear very favorable, they are based on estimated data and are not directly associated with improving from one SEI maturity level to another. Also the study assumes that the quality of the software products remained constant. The study would not be as favorable if, in fact, the product quality declined as the cost of non-conformance declined.

Summary of Data Assessment



Case Studies

- Hughes
 - "Cost Performance Index (CPI) improved from 0.94 to 0.97"
 - "Increasing process maturity helps to reduce risk," "ROI is 1:5"
 - No plans to update cost/benefits, today's improvements broader
- Raytheon
 - Increased cost of prevention and reduced cost of non-conformance
 - "Process improvement is cost effective," "ROI is 1:7.7"
 - Not restricted to SEI maturity, assumed quality remained constant

Summary of Data Assessment

- **Checkpoint**

Capers Jones of SPR utilized the Checkpoint model and its associated data base of 3,000 projects to estimate the impact of stepping up SEI's maturity scale. By altering the Checkpoint parameters to correspond to the SEI questionnaire (Humphrey 1987), Jones projects that the benefits of higher levels of process maturity peak at level 3; i.e., quality will stay constant after level 3 and productivity benefits will peak at level 3 and start to decline for levels 4 and 5. Jones's analysis made a direct relationship between the Checkpoint parameters and the key process areas in the SEI process maturity model (SPR 1991). Since Checkpoint is focused at the project level, it does not account for organization issues generally captured in the higher levels of SEI's model. This analysis is an extrapolation that may be based on incomplete data.

- **PADS**

Larry Putnam of Quantitative Software Management (QSM) extrapolated from his Productivity Analysis Database System (PADS) which consists of 1,500 projects to analyze the benefits associated with SEI's maturity levels. He assessed that there was a similarity between his productivity index (PI) and the benefits that Lockheed saw in their survey (see below) (Putnam 1991). The PI is derived from the size, effort, and time used to develop the software. But since the PI does not account for any specific software development practices, it may not be appropriate to assume PI is correlated with SEI's levels.

- **Harbridge**

Karl Williams of Motorola University wrote the software portion of the Harbridge Benchmark Report and was a founding member of a Presidential Task Force on Quality and Continuous Improvement. Williams's findings indicate that advancing from one maturity to another causes quality and productivity to decrease initially (until over the learning curve) but eventually a positive return is realized (Williams 1992). The data for this study was derived indirectly from approximately 25 organizations, based on interviews and presentations. Only a few of the organizations had official SPAs or SCE; the maturity levels for the other organizations were estimated.

- **Lockheed**

Herb Krasner of Lockheed surveyed software program managers across the organization to estimate the impact of increasing process maturity. There were many Lockheed projects at the lower levels and none at the higher levels of maturity (Pore 1990). The cost drivers from Boehm's COCOMO and ratios from Cusumono's analyses of Japanese software factories were used to project the higher level results. While the survey is favorable, it is not based on quantitative data but rather on opinions of those surveyed.

- **IDA**

IDA surveyed 480 users from the SPA and SCE community. Of the respondents, 88% feel SPA are useful for identifying areas to improve the software process, and 68% of those who have been subjected to at least one SCE feel that SCEs are a useful method for the government to select and monitor contractors. In order to uncover additional cost and benefit data, IDA contacted 55 companies directly. The majority of these companies are just starting to collect software metrics. But eight companies were found to have more advanced measurement programs, making them good candidates for future validation efforts. These advanced companies had well-defined metrics, central metrics repositories, SPA results, and process improvement plans (PIP) underway. It is still too early to see the benefits of their SPAs and PIPs reflected in the measurement data. A copy of the survey form can be found in the back up slides.

Summary of Data Assessment



Data Base Extrapolations

- Checkpoint "Quality and productivity peak around level 3"
 - Retrofitted data to SEI questionnaire
- PADS: "Similar behavior between SEI's levels and Productivity Index (PI)"
 - Assumed maturity levels correlate with productivity
- Harbridge: "Improving maturity causes initial drag before benefits realized"
 - Data was derived indirectly, maturity levels were estimated

Surveys

- Lockheed: "Productivity and quality are related to maturity levels 1-3"
 - No empirical study, management does not endorse findings
- IDA: 88% of respondents feel SPAs are useful, 68% feel SCEs useful
 - Findings based on survey of SEI affiliates and CMM workshop
 - 55 companies surveyed lack definitive measurement results
 - Several companies have more advanced metrics and PIP efforts

Consistency of SCE and SPA Results

- **Background**

The Air Force Electronic Systems Command (AF ESC) and the Naval Air Weapons Center (NAWC) have performed a substantial number of SCEs for source selection. A comparison was made between the SCE results of the AF ESC and NAWC against the SPA results presented by the contractors.

- **Findings**

The AF ESC results were derived from performing SCEs during 2 source selections on 14 contractor sites. Eight of the SCEs were performed by one government team and six were performed by a second team. Several of the team members were on both teams. The SCE findings indicate that approximately 20% of the contractors were a level 3 as compared to the contractors' SPA-based claims that approximately 60% were a level 3 (Besselman 1992).

The NAWC results were based on using the SEI questionnaire (Humphrey 1987) and comparing the SCE team findings to the questionnaire responses provided by the contractors. In general, NAWC found that approximately 30% (26 of the 85) responses were different when comparing the SCE teams findings to the contractors' responses (Czaplicki 1992).

- **IDA Comments**

The findings of the Air Force and Navy studies indicate that there are differences between SCEs and SPAs. Contractor SPA results can be different from the SCE results by as much as one or two maturity levels; refer to the supporting data in part two of this document. In addition, it appears that SPAs are not consistent from one contractor to another. These differences are due to many reasons: different interpretations of the SEI rating criteria, different projects were evaluated, different levels of experience between teams, and so forth.

Since the results vary among SCEs, among SPAs and between SCEs and SPAs, it is difficult to assess the hypothesis that higher levels of maturity are beneficial in terms of productivity, quality, and risk. One contractor's level 2 maturity rating may be significantly different from another contractor's level 2. Any future validation studies must ensure common understanding and definition in order to compare process maturity results across contractors.

Consistency of SCEs and SPAs



Background:

- AF ESC compared results of 14 SCEs vs. SPAs
- NAWC compared results of 37 SCEs vs. responses to questionnaire

Findings:

AF ESC Results

SEI Level	SCE Results	SPA Results
Level 1	9	3
Level 2	2	2
Level 3	3	9

NAWC Results

No. of YES Questions	SCE Answers	SPA Answers
Average	30	56
Highest	68	85
Lowest	10	27

IDA's Comments:

- Differences exist from SPA to SPA, SPA to SCE, SCE to SCE
- Differences due to lack of defined criteria, teams, sites, projects, etc.
- Differences impact quantitative analysis and validation efforts

Findings of Data Assessment

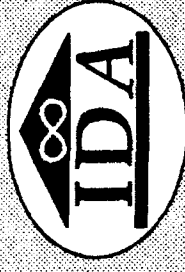
- **Quantitative data is very limited**

The data assessment portion of the study evaluated case studies, data base extrapolations, and surveys. The data appears to indicate that higher levels of maturity are beneficial in terms of productivity, quality and risk. But each of the reports had some flaws which limits the strength of the findings. In general, the studies were not able to separate out costs associated with SEI process improvement from other improvements efforts underway. The benefits of the SEI process were difficult to isolate as well. Most importantly, it is difficult to determine accurate maturity level ratings based on informal presentations, knowing that there may be inconsistencies across companies and DoD organizations for conducting and rating process maturity.

- **Anecdotal evidence is favorable**

Overwhelmingly, the IDA survey indicates that the community thinks favorably of the SPA and SCE process. There is tremendous support for software process improvement which is being supported by the use of SPAs and SCEs. While the quantitative data may not provide strong verification that process maturity is desirable, the anecdotal evidence is substantial.

Findings of Data Assessment

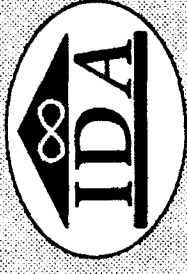


- Quantitative data is very limited
 - Limited case studies indicate positive ROI and improved quality
 - Not enough information is available to separate other factors
 - Existing data bases have no SPA or SCE data for comparison
 - Many firms are just now starting data collection efforts
 - Differences in SPA and SCE results impede data analysis and validation
- Anecdotal evidence is favorable
 - IDA's survey indicates people feel process improvement is working

Outline

The objective of the model and method comparison was to compare and contrast the SEI approach with similar techniques. The SPR method was compared to SEI's SPA since they are both used by a development organization to assess current practices and to develop improvement plans. Other methods similar to an SPA were reviewed, e.g., Bell Labs and Hewlett Packard (Miller 1991, Zimmer 1992). But because they were just variations of the SPR and SEI methods, they were not included in the briefing. In turn, SCEs were compared to the Air Force's SDC/CR. This part of the briefing will review the comparison criteria and describe the strengths and weakness of the other methods.

Outline



Overview

Assessment of Policy Implementation

Data Assessment

Model and Method Comparison



- Summary of Attributes Investigated by the Methods
- SPA comparison (Software Productivity Research, Bell Lab, HP)
- SCE comparison (SDC/CR)
- Summary of other comparison studies (Aerospace, ISO 9000)
- Findings

Conclusions

Summary of Attributes Investigated by the Methods

This table presents an image of the attributes covered by each of the assessment and evaluation methods studied (AFSC 1992, SEI 1992, SPR 1991). It is intended to show that each of the methods collects different information and covers different aspects of software development processes.

The solid black circles indicate that a method provides extensive coverage of the attribute listed to its left. The half circles are used to indicate that the attribute is addressed in varying degrees by the method. The white circles are intended to indicate areas where the method does not address the attribute in a significant way.

The second entry, labeled "Project Personnel," provides an example that uses all three ratings. The SDC/CR method collects extensive, detailed information on the contractor's staffing resources, experience of proposed project staff, and the contractor's training programs. The SPR method also collects information on personnel at the project level, but it is not as extensive as the SDC/CR data. The SPA and SCE methods focus on organization-level issues, which includes training, but they collect little or no information at the level of individual projects. This difference in focus can be seen in the next to last table entry, labeled "Organization Process Support," which shows that SPAs and SCEs cover organizational issues extensively, whereas the other methods do not.

This table represent a summary of a more detailed analysis which can be found in the back up slides.

Summary of Attributes Investigated by the Methods



Attributes (examples)	SPR	SPA/ SCE	SDC/CR
Project Tailoring (type, scope, experience, budget, schedule, size)	●	●	●
Project Personnel (staffing resources, experience, training)	●	○	●
Project Management (structure, estimation, tracking, commit)	○	●	●
Methods and Tools (requirements, design, support & dev tools)	●	○	●
Product & Technology Constraints (H/W, language, reuse, GFE)	●	○	●
Quality & Configuration Control (QA, CM, reviews)	●	●	●
Project Measurement Data (progress, quality, productivity)	●	○	○
Organization Process Support (standards, training, planning)	○	●	○
Organization Technology Support (tools, technology)	○	●	○

NOTE: findings can be broader than the attributes listed

SEI: based on goals & practices in "Evaluation Training Manual," Jan 1992
 SPR: based on Checkpoint questionnaire, Feb 1991
 SDC/CR: based on ASD Pamphlet 800-5, Oct 1991

KEY:	● Extensive
	● Included
	○ Excluded

Assessment Method: SPR

- **Strengths**

The basis for an SPR assessment is a questionnaire with approximately 400 questions (SPR 91). Most of the questions are answered by a rating on a scale from 1 (which represents best practice) to 5. Specific guidance is given on each rating for each question to calibrate the scoring. This makes scoring more objective and repeatable. The questionnaires are applied to individual projects, which provides a wealth of detailed information. In particular, this makes small but significant steps toward process improvement more easily observable. In addition to the questionnaire as a source of information, SPR assessments collect productivity and error rate data on each project.

SPR assessments identify strengths and weaknesses at both the project level and, using combined project data, at the organization level. Individual projects can be compared with other projects within the organization, with combined-project profiles of the organization, and with a composite profile of the software industry as a whole. Similarly, organizations can be compared with other organizations (if the data is available) and with the composite industry profile. The information collected enables specific process improvement actions to be taken for individual projects as well as identifying more general strategic approaches for improving the organization as a whole.

SPR assessments include a number of important attributes that are not addressed by any of SEI's key process areas. The SPR questionnaire includes questions about the physical environment provided for software developers, the experience levels of key staff members, the development methodologies used, the automated tools employed, testing techniques applied, and the degree of design and code reuse achieved. All of these issues have been determined by SPR to have a significant influence on software development productivity and on the quality of software produced.

- **Weaknesses**

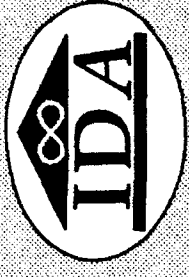
SPR's assessment questionnaire does not include open-ended questions. Users of other questionnaire-based assessment methods find that open-ended questions allow them to identify problems that are not specifically addressed by any other questions.

SPR's focus on individual projects misses several organization-level issues. For example, none of SPR's questions addresses organization-wide training needs, organization-wide standards and procedures, or responsibilities for organization-wide process improvement.

Although the SPR approach reveals comparative strengths and weaknesses, unless individual attributes are very weak, the assessments do not give specific guidance on process improvement priorities.

Finally, the SPR model is based on proprietary data collected from numerous organizations over many years. The Checkpoint questionnaire and collected data is available only as a commercial service.

Assessment Method: SPR



Strengths

- Scoring is more objective, finer level of detail, easier to measure improvement
- Quantitative cost and quality results are collected and analyzed
- Strengths and weaknesses are identified for both project & organization
- Includes attributes not present in SPA (e.g., physical environment, experience of staff, development methodologies, development tools, testing, reusability)

Weaknesses

- Since no open-ended questions, may miss problems not in questionnaire
- Since the SPR method focuses on individual projects, it lacks questions about organization-wide issues such as training, standards & procedures, and Software Engineering Process Group (SEPG)
- Results are not prioritized to facilitate improvement
- Proprietary model

Evaluation Method: SDC/CR

- **Strengths**

The SDC/CR evaluation method focuses on the software development processes and capabilities proposed for individual software acquisition programs. In particular, it scrutinizes the Software Development Plans that are submitted by contractors with their proposals.

SDC/CR evaluations are based on a set of essay questions, which each contractor must answer in detail (AFSC 1992). The responses to these questions have proven valuable in procurements where no "discussion" is allowed; that is, where the government and contractors have no opportunity to clarify or elaborate on system requirements or proposed solutions. Contractors report that, although answering the SDC/CR questions is costly, the exercise provides valuable insight into the issues that are important to the government and into their own software development practices.

The SDC/CR method includes contractor site visits, which allow contractors to explain and rationalize the software development approach they have proposed for the acquisition program.

The SDC/CR method includes attributes not addressed by SCEs. These include how the contractor views the relationship between systems engineering and software engineering, which is often critical in the development embedded software systems, and the automated tools that are to be used.

- **Weaknesses**

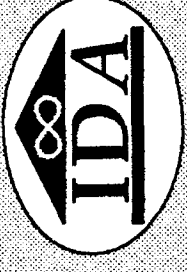
Even with the site visits, SDC/CR evaluations do not provide a traceable mechanism by which a contractor's past performance can be judged using the proposed software development methods. Currently the evaluation team refers to documentation for verification that the proposed practices have been used on previous projects. No individual interviews are performed to verify whether the documents accurately reflect the processes being used.

SDC/CR evaluations consist of 450 essay questions. It is an expensive task to provide detailed and concrete answers, an effort costing as much as \$500,000.

Criteria for scoring or rating answers to SDC/CR questions are not complete. This is a significant obstacle to using SDC/CR evaluations on a wide scale. The lack of clearly defined rating criteria also means that the set of SDC/CR questions provides little guidance for directing software development process improvements.

No guidance is provided for tailoring the SDC/CR questions to address special issues that may be of significance in a procurement. No formal training is available on SDC/CR evaluations.

Evaluation Method: SDC/CR



Strengths

- Focuses on development process and capacity being applied to specific acquisition program and reflected in Software Development Plan
- Responses to essay questions can be used when no “discussion” allowed
- Process of answering questions provides valuable insight to contractors
- On-site visit allows contractor to explain rationale for selecting the process
- Covers attributes not in SCE (e.g., systems engineering, tools)

Weaknesses

- Unable to verify whether processes were employed on past projects
- Essay questions were numerous and expensive to complete
- “Source Selection Evaluation Criteria” not complete
- Results provide little guidance for improvement
- No tailoring guidelines and no formal training

Summary of Other Studies

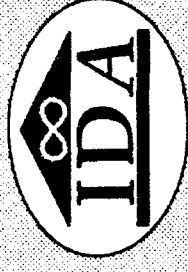
- **Aerospace**

In 1989, the Aerospace Corporation conducted a study of evaluation methods for the Air Force Space Systems Division (SSD). Its conclusions were that the SDC/CR method was the best solution for near-term use, but that for the longer term, a combination of SCE and SDC/CR methods would best serve the Air Force's needs (Haddad 1992).

- **ISO Project**

A working group of the International Standards Organization (ISO/IEC JTC-1 SC-7 WG10) conducted a study of software process assessment and capability evaluation methods. This working group includes participants from the SEI and other international corporations promoting software process improvement. The study recommended creating a new method by combining the strengths of seven different approaches studied (ISO 1992). Development of this new method is expected to start in 1993 and be completed for trial use by 1994. A stable standard is expected by 1996.

Summary of Other Studies



Aerospace

- Tasked by Air Force Space Systems Division (SSD)
- Short-term recommendation is to use SDC/CR
- Long-term recommendation is to take the best of the two approaches

ISO Project

- Study done by International Standards Organization
(ISO/IEC JTC-1 SC-7 WG 10, SPICE project)
- Study recommends combining strengths of 7 procurement and improvement models (e.g., SEI, SQPA, Bell Canada, STD, Bootstrap)
- Full-time resources allocated to develop a new standard by 1996:
 - Development work starts January 1993
 - Complete first draft January 1994
 - Trial usage of new model January 1994-1995
 - Stable standard January 1996

Findings of Model and Method Comparisons

- **Strengths of SPAs and SCEs**

SPAs and SCEs focus on organization-level support for software development processes. This allows SPAs to address organization-level problems that cannot be corrected at the project level. It also allows SCEs to evaluate the influence that the entire organization will have on a particular project. The grouping of KPAs into levels also provides a clear roadmap for process improvement at the organization level.

The use of open-ended questions enables SPAs to identify problems unique to contractor organizations that are not addressed specifically by other questions. They also enable SCEs to probe contractors on issues of importance to a particular procurement. In addition, the on-site SCE interviews provide the opportunity to verify the contractor's software development practices.

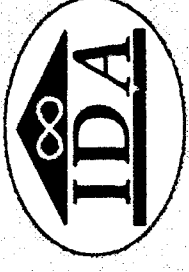
- **Strengths of SPR**

The SPR assessment method collects both qualitative and quantitative software process information from individual software development projects. Project data is combined to form a composite profile of the organization. Project data can be compared with the organization profile and with a profile of the industry as a whole. Process improvement recommendations are coupled to measures of software development productivity and product quality.

- **Strengths of SDC/CR**

The SDC/CR evaluation method focuses on the specific needs of one acquisition program at a time. Process information is collected primarily at the project level, which is more directly related to the system to be developed. Answers to the SDC/CR essay questions provide more useful information than do the simple yes/no responses to the questionnaire used in SCEs.

Findings of Model and Method Comparison

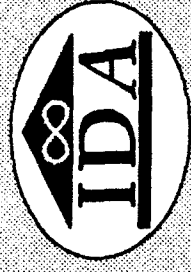


- Strengths of SPAs and SCEs
 - Focuses on organization support for software projects
 - Helps to prioritize process improvement steps
 - SPAs require buy-in from senior management
 - Open-ended questions capture additional factors
 - SCE interviews verify current practices
- Strengths of SPR
 - Detailed data is collected on processes at the project level
 - Project data is compared with company and industry norms
 - Process improvements are coupled to product measures
- Strengths of SDC/CR
 - Evaluation focuses on the specific acquisition
 - Process information is collected at organization and project levels
 - Essay questions provide more initial data than yes/no questions

Outline

The final part of the briefing presents the conclusions of the IDA study. The findings are revisited along with the recommended steps to facilitate effective implementation of the DoD policy. These steps are compared with activities currently underway at SEI. The comparison was made in order to identify activities not being addressed but which need to be performed by SEI or government agencies. In summary, the effect of the findings are presented relative to the ramifications of the DoD policy.

Outline



Overview

Assessment of Policy Implementation

Data Assessment

Model and Method Comparison

Conclusions



- **Summary of Findings**
- **SEI's Plans**
- **Policy Conclusions**

Summary of Findings

- **Assessment of Policy Implementation**

SPAs and SCEs are currently being used by industry and government to promote software process improvement. Although SPAs and SCEs were found to promote software process improvement, improvements in several areas are required to ensure effective DoD-wide SPA/SCE policy implementation. As previously described, the SEI model and methods lack important evaluation criteria and documentation. Guidance should be developed to assist program offices involved in conducting SCEs. And the SCE training course should expand its scope to include more depth in each KPA. Finally, an infrastructure to monitor and support SPAs and SCEs is necessary for wide-spread implementation. In essence, the documentation, criteria, training, and infrastructures must be established to support the DoD policy.

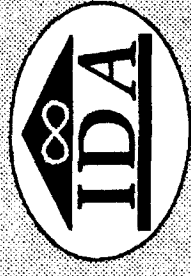
- **Data Assessment**

Even though quantitative software process improvement data is very limited, the anecdotal evidence is favorable. Existing case studies suggest that SPA activities provide a positive return-on-investment (ROI) and improve quality. Anecdotal evidence from the Lockheed and IDA surveys indicates that SPAs and SCEs are useful methods for judging and improving software processes.

- **Model and Method Comparison**

The SEI process maturity model was compared to other assessment and evaluation methods. The strengths and weaknesses of these methods should be considered when applying and improving the SEI model and methods.

Summary of Findings



Assessment of Policy Implementation

- SPAs and SCEs help to promote desired process improvement
- Need better model and method documentation
- Need better guidance and training for wide-spread implementation
- Need infrastructure to monitor and support SPAs and SCEs

Data Assessment

- Quantitative data is very limited
- Anecdotal evidence is favorable

Model and Method Comparison

- Other models and methods have attributes not offered by SPAs and SCEs
- SPA and SCE processes could be improved

Priorities vs. SEI's Plans

This chart compares the priorities presented in part two of the briefing with activities currently underway at SEI. These activities and dates were provided by SEI. When SEI had a delivery date, the date is given next to the activity. When resources or funding were not committed and the effort was not considered a short-term objective by SEI, the activity was designated as being delivered in the "future." Even though SEI has many activities underway, it is not certain that these will be sufficient to adequately address the priority items.

With this comparison, it is apparent that several of the issues identified by IDA are not currently being addressed by SEI. Plans should be made to ensure that these issues are addressed by SEI or appropriate government agencies. Many of the issues that are being addressed by SEI will not be available until the end of 1993-1994. Without proper documentation of the SCE and SCE process, rating criteria, tailoring guides or sufficient training, the government will incur some risk by mandating use of SPAs and SCEs DoD-wide at this time. This risk needs to be weighed with respect to the general indications of benefits associated with increased use of SPA's and SCE's.

Priorities vs. SEI's Plans (Calendar Year)



- Document and publicize SCE and SPA process
 - SCE product brochure (Sept 1992) SCE Method Report V1.0 (1Q 1993)
 - SCE Implementation Guide V1.1 (Nov 1992) SCE Site Visit Guide (future)
 - Installation Guide (1993) SCE Transition Strategy (1Q 1993)
- Establish criteria for evaluating and scoring KPAs
 - SCE Rating Report (Dec 1992) Intro course to CMM (future)
 - CMM Rating Method (1993)
- Establish quality standards and tailoring guides
 - SCE Position Papers (4Q 1992)
- Improve training
 - Revised SCE training V2.0 (1Q 1993) Refresher SCE training (future)
 - SCE Overview Course V1.0 (Aug 1992) Train SCE Trainer Course (future)
- Establish infrastructure to assist and monitor government usage
- Improve model and process weaknesses
 - CMM V1.1 (Dec 1992) SPA vs. SCE Report (Dec 1992)
- Develop guides to encourage improvement
 - SCE Implementation Guide V2.0 (Aug 1993)
- Collect data for future improvement of the model and methods

Policy Conclusions

- **Continue momentum and commitment for process improvement**

It is beneficial to have a DoD policy that emphasizes software process improvement using SPAs for self-improvement and SCEs for source selection. It is advantageous to use common methods across the DoD in order to standardize the messages the contracting and government software community may face.

- **Improve guidance and supporting infrastructure**

For a DoD-wide SCE and SPA program to be effective, several areas need to be improved. Without improved guidance, infrastructure, and training, many DoD agencies implementing the policy will not be prepared. Government implementors may become frustrated with the lack of direction available to support the policy. The software community may become frustrated with the lack of consistency and understanding of SPAs and SCEs.

- **Refine SEI model and application method**

There are several weaknesses in the SEI model and methodology that could benefit from improvement. The scope of the SEI model is limited as compared to similar models and the methodology lacks process information on specific projects and acquisition programs.

- **Develop action plan to address implementation priorities**

Many of the priority items identified by IDA are being addressed by SEI and many are not. Many of the items are the responsibility of the government rather than SEI. For example, each of the Services may need to develop its own tailoring guidelines for using SCEs in source selection and to establish a means of monitoring the use of SCEs. An action plan should be established to ensure that priorities are addressed in a timely manner.

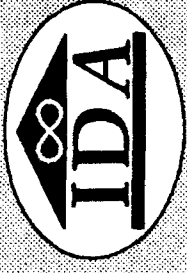
- **Reevaluate policy mandate in about one year**

Since the government is currently not prepared to perform SCEs and SPAs DoD-wide, the policy mandating the use of SPAs and SCEs should be reevaluated in about one year. This should provide sufficient time for the SEI activities to mature and to allow the government agencies time to provide the necessary support and guidelines.

- **Address process improvement during the life of a contract**

Since the primary objective of the policy is to encourage continuous process improvement, it would be advantageous to mandate a method for evaluating and reevaluating contractors during the development process. Currently the draft policy only addresses source selection which occurs at the beginning of the contract. It does not address a method for monitoring contracts after they have been awarded.

Policy Conclusions

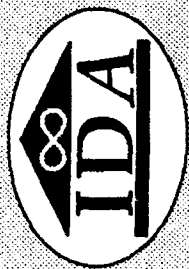


- Continue momentum and commitment for process improvement
- Improve guidance and supporting infrastructure
- Refine SEI model and application method
- Develop action plan to address implementation priorities
- Reevaluate policy mandate in about one year
- Address process improvement during the life of a contract

References

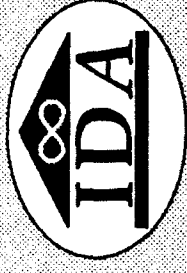
- (AdaJUG 1992) Ada Joint Users Group. 1992. *AdaJUG Position Paper on Software Engineering Process Improvement and Assessment*. February 26, 1992.
- (AFSC 1991) Air Force Systems Command. 1992. *Pamphlet 800-5. Acquisition Management: Software Development Capability Capacity Review*. Wright-Patterson AFB, OH.
- (Besselman 1992) Besselman, Joe. July 1992. A Collection of Air Force Experience with Software Capability Evaluations. *Software Engineering Institute SCE Workshop*. Pittsburgh, PA: Software Engineering Institute.
- (Czaplicki 1992) Czaplicki, Connie. July 1992. *NAWCADWAR SCE Method*. Software Engineering Institute SCE Workshop. Pittsburgh, PA: Software Engineering Institute.
- (Dion 1992) Dion, Raymond. 1992. Elements of a Process-Improvement Program. *IEEE Software* (July):83-85.
- (Haddod 1992) Haddod, R, M. Lubofsky, and B. White. June 1992. *Pre-Award Survey Method for Software Acquisition at Space Systems Division*. Aerospace report number TOR-0092(2904). El Segundo, CA: Aerospace Corporation.
- (Humphrey 1987) Humphrey, W.S., and W.L. Sweet. 1987. *A Method for Assessing the Software Engineering Capability of Contractors*. SEI Technical Report SEI-87-TR-23. Pittsburgh, PA: Software Engineering Institute.
- (Humphrey 1989) Humphrey, W.S. 1989. *Managing the Software Process*. Reading, MA: Addison-Wesley.
- (Humphrey 1991) Humphrey, W.S., T.R. Snyder, and R.R. Willis. 1991. A Software Process Improvement at Hughes Aircraft. *IEEE Software* (July): 11-22.
- (IDA 1992) Institute for Defense Analyses. May 1992. *Proceedings of the Institute for Defense Analyses Workshop on Policy Issues in Department of Defense Implementation of Software Process Maturity Model*. Alexandria, VA: Institute for Defense Analyses.
- (ISO 1992) International Standards Organization. June 11, 1992. *The Need and Requirements for a Software Process Standard*. ISO/IEC JTC 1/SC7/WG7/SG1 Issue 20. Vienna, VA: Omnicom
- (Miller 1991) Miller, Sharon and G. Tucker. 1991. Software Development Process Benchmarking. *IEEE Global Telecommunications Conference*. New York, NY: IEEE Inc.

- (Pore 1990) Pore, M. 1990. Implementing a Software Quality Improvement Program. *Second Annual Software Quality Workshop*. Sponsored by the Rochester Institute of Technology and Rome Air Development Center. Rochester, NY.
- (Putnam 1991) Putnam, Larry. 1991. *Linking the QSM Productivity Index with the SEI Maturity Level and Projecting Transitions to Various Maturity Levels*. McLean, VA: Quantitative Software Management.
- (SEI 1992) Software Engineering Institute. 1992. *Evaluation Team Training: Participant's Handbook*. Pittsburgh, PA
- (SPR 1991) Software Productivity Research. February 1991. *Checkpoint Questionnaire, Version 3.0*. Burlington, MA.
- (Williams 1992) Williams, Karl. July 1992. *Software Quality Benchmarking Report*. Schaumburg, IL: Harbridge.
- (Willis 1990) Willis, R.R. 1990. *Case History and Lessons Learned in Software Process Improvement*. NSIA Conference on Software Quality and Productivity. Williamsburg, PA.
- (Zimmer 1992) Zimmer, Barbara. 1992. *Software Quality and Productivity Analysis at HP*. Palo Alto, CA: Hewlett Packard.



Supporting Data for Policy Assessment of the SEI Process Maturity Model

Outline



Policy Assessment

- Workshop panel summaries

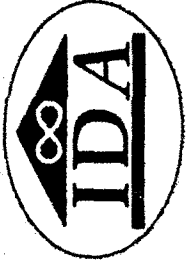
Data Assessment

- Case studies (Hughes, Raytheon, IBM)
- Data base extrapolations (Checkpoint, SLIM, Harbridge)
- Surveys (Lockheed, IDA)
- SCEs vs. SPAs (AF ESD)

Model Comparison

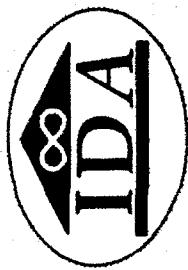
- Attributes investigated by the methods
- SPA comparison (SPR)
- SCE comparison (SDC/CR)

Panel A: Training



Question	Panel Position	Position Papers
More stringent screening needed?	No, enforce existing guidelines	More stringent, exam impractical
How to ensure qualified SCE teams?	Additional role playing	Apprenticeship, although costly
Additional training capacity needed?	Yes, expand beyond SEI	Agree
Form centralized group to perform SCEs?	No central supplier, only locator database	Agree

Panel B: Consistency



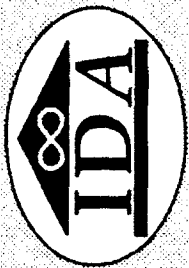
Question	Panel Position	Position Papers
How to ensure higher consistency in evaluations?	(Listed sources of inconsistency)	Inconsistency not entirely preventable
Are SCEs tailorable?	Yes, need guidelines	Agree
Does tailoring cause inconsistencies?	Possibly	Probably not
Can consensus be achieved across evaluations?	Not discussed	Need to explore, (some believe futile)
Should consistency between SCEs & SPAs be expected?	Different intent, need criteria	Agree

Panel C: Process Improvement



Question	Panel Position	Position Papers
Does CMM provide adequate road-map?	No, but not critical	Adequate
Are cost-sharing & award fees adequate incentives?	Yes	Significant reservations
Should process improvement be a contract deliverable?	No	No
What are key factors for success?	High visibility, organization commitment	Agree, add data collection and ROI

Panel D: Tailoring



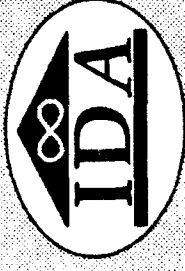
Question	Panel Position	Position Papers
Can CMM be extended or supplemented?	OK, but impacts comparability	OK, define special needs
How do you address special issues?	Add KPAs, weighting	Agree
Different model for small or specialized software?	Not convinced	Not necessary but model refinement advisable
How should kind of project affect KPA scores?	Allow different ways to satisfy KPAs	Agree

Panel E: Registry



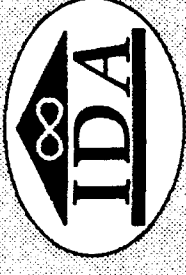
Question	Panel Position	Position Papers
What rules limit or restrict a registry of SCE results?	Research legal questions	Agree, must be accurate, unbiased
Are SCE results valid across procurements?	Yes, with several constraints	Split; consistency is a serious problem
Across application areas?	No	No
Who has access to SCE results?	Government use only	Agree (with discussion)
How to handle contractor teams?	Consider as new organization	Agree

Panel E: Registry (cont.)



Question	Panel Position	Position Papers
What is the lifetime of an SCE?	New SCE option always open	About 1 year
What should organizations know about their SCE results? Can they challenge scores?	Organizations have right to know Should have mechanism to dispute	Agree Agree

Case Study: Hughes



Background:

- Moved from SEI level 2 in 1987 to SEI level 3 in 1990
- Used Cost Performance Index (CPI) to measure benefits
CPI = Budgeted cost / Actual cost of work performed

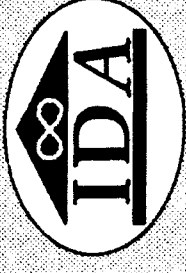
Hughes' Findings: (Humphrey 1991)

- Cost to improve from level 2 to 3 is 75mm (0.6% of staff) cost of SPA is \$45K
- CPI improved (1987 CPI = 0.94, 1990 CPI = 0.97)
- "Reduced risk by 50%, saved 5 times as much as spent on improvement"

IDA's Comments:

- Increasing process maturity helps to reduce risk
- Costs may not be complete, other improvements were underway
- Hughes has no plans to update analysis, today's improvements are broader

Case Study: Raytheon



Background:

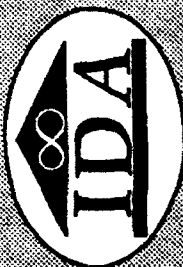
- Estimated software costs for 6 projects in 4 categories (45 subcategories)
 - Cost of Performance: cost of development
 - Cost of Non-conformance: cost to fix defects and retest
 - Cost of Appraisal: cost of reviews, inspections
 - Cost of Prevention: cost of training, tools, improvement
- Distributed costs in proportion to the staffing profiles for each project

Raytheon's Findings: (Dion 1992)

- Cost of software improvement initiative = \$1.1 M
- Reduced cost of non-conformance by \$8.2M
- Saved \$7.1M, ROI = 1:7.7

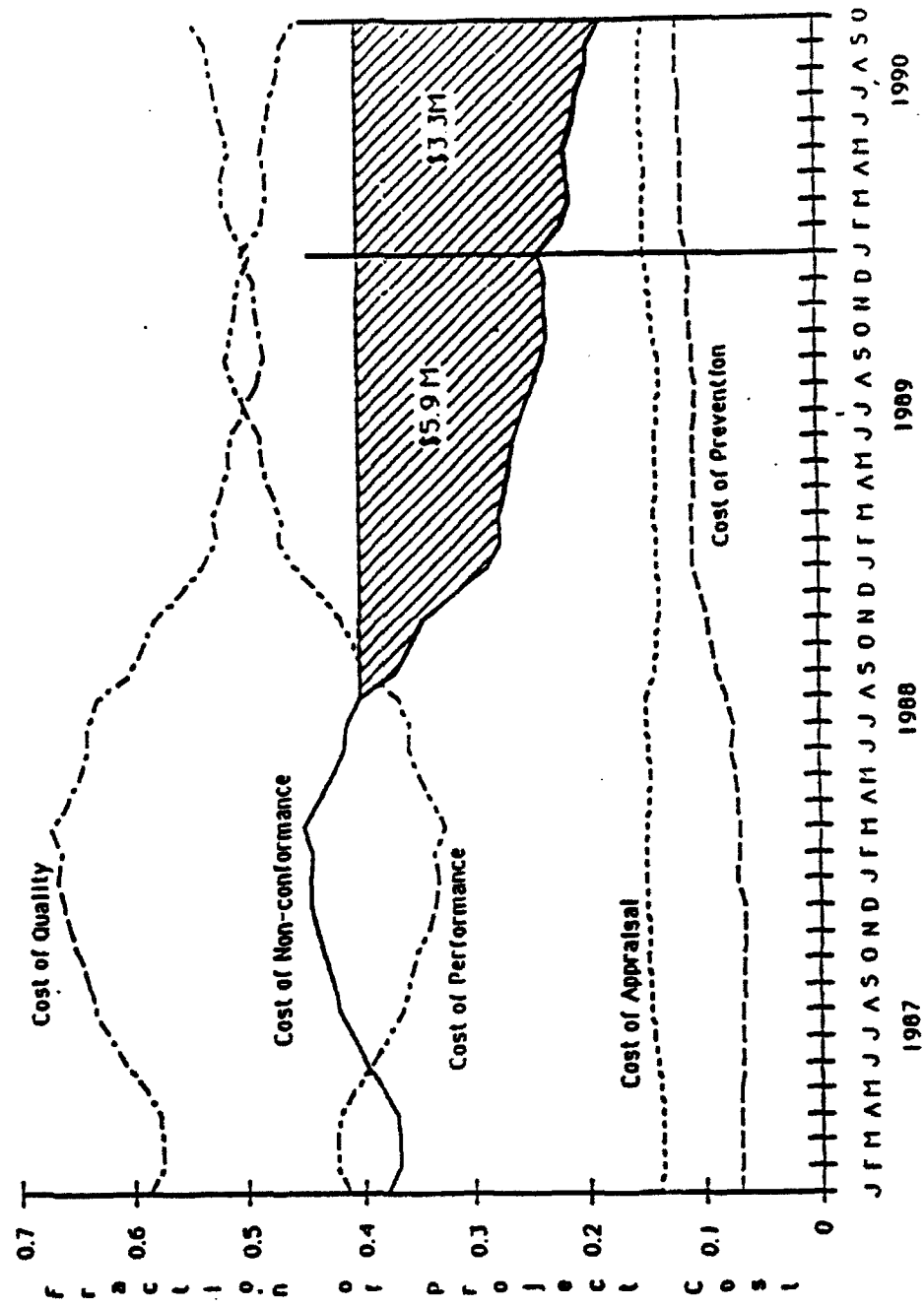
IDA's Comments:

- Software process improvement helps to reduce cost of non-conformance
- Cost/Benefit data not directly associated with the SEI maturity improvement
- No quality measurements maintained, assumes quality is constant



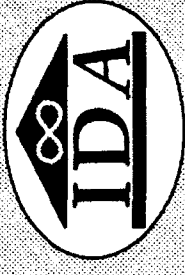
Case Study: Raytheon

SAVINGS IN REDUCED COST OF NON-CONFORMANCE



(Dion 1992)

Data Base Extrapolations: Checkpoint



Background:

- Checkpoint developed by Capers Jones includes data base consisting of over 3,000 projects
- Data base used to identify projects matching SEI criteria

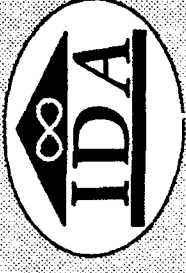
Jones' Findings:

- "Cost of carrying out level 4 & 5 activities increases relative to benefits."
- "Productivity peaked at level 3 and started to decline for levels 4 & 5."
- "Quality stayed constant after certain level of maturity."

IDA's Comments:

- Maturity level was derived by retrofitting SEI questionnaire and scoring criteria to previously collected data
- Checkpoint questionnaire does not contain SEI's organization issues

Data Base Extrapolations: SLIM



Background:

- SLIM developed by Larry Putnam contains a data base of 1,500 projects
- Assumed correspondence between Productivity Index (PI) and SEI maturity level

$0 < PI \leq 12$	= Level 1
$12 < PI \leq 15$	= Level 2
$15 < PI \leq 17$	= Level 3
$17 < PI \leq 20$	= Level 4
$20 < PI > 22$	= Level 5

$$PI = \text{size}/(\text{effort}/B)^{1/3} \times \text{time}^{4/3}$$

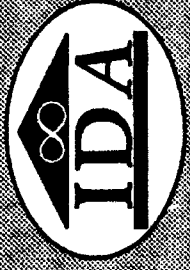
Putnam's Findings: (Putnam 1991)

- "There is similar behavior between our PI's and SEI's levels (which calls for higher levels of productivity and quality with increases in maturity levels)"

IDA's Comments:

- PI does not account for SEI's software development practices

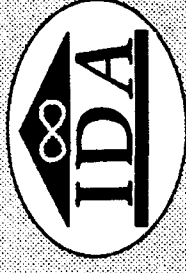
Data Base Extrapolations: SLIM



SEI Level	Krasner's Values				SLIM OUTPUT			
	Time (mo.)	Effort (MM)	Cost (\$Mil)	Defects (Def/ KSLOC)	Defects (Def/ KSLOC)	Calibrated PI	Calibrated MBI	Projected MTTD (hrs)
1	40	3645	30.3	9	11.17	12	2	4.2
2	32	1115	9.27	3	3.4	15	2	10.9
3	25	704.9	5.87	1	2.16	17	2	13.1
4	19	222	1.85	0.3	0.68	20	2	32.4
5	16	104.4	0.87	0.1	0.32	22	1	58.0

(Putnam 1991)

Data Base Extrapolations: Harbridge



Background:

- Karl Williams, author of the Harbridge House Benchmark Report, collected information on 30+ projects from 20+ organizations
- Estimated maturity level based on presentations, informal SPAs, and SEI's questionnaire

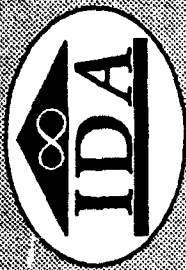
Williams' Conclusions: (Williams 1992)

- "Maturity advancement can produce quality and productivity gains"
- "Higher levels of maturity seem to correspond to higher levels of productivity and quality"
- "Advancing from one level to another causes an initial productivity drag before an improvement is realized"

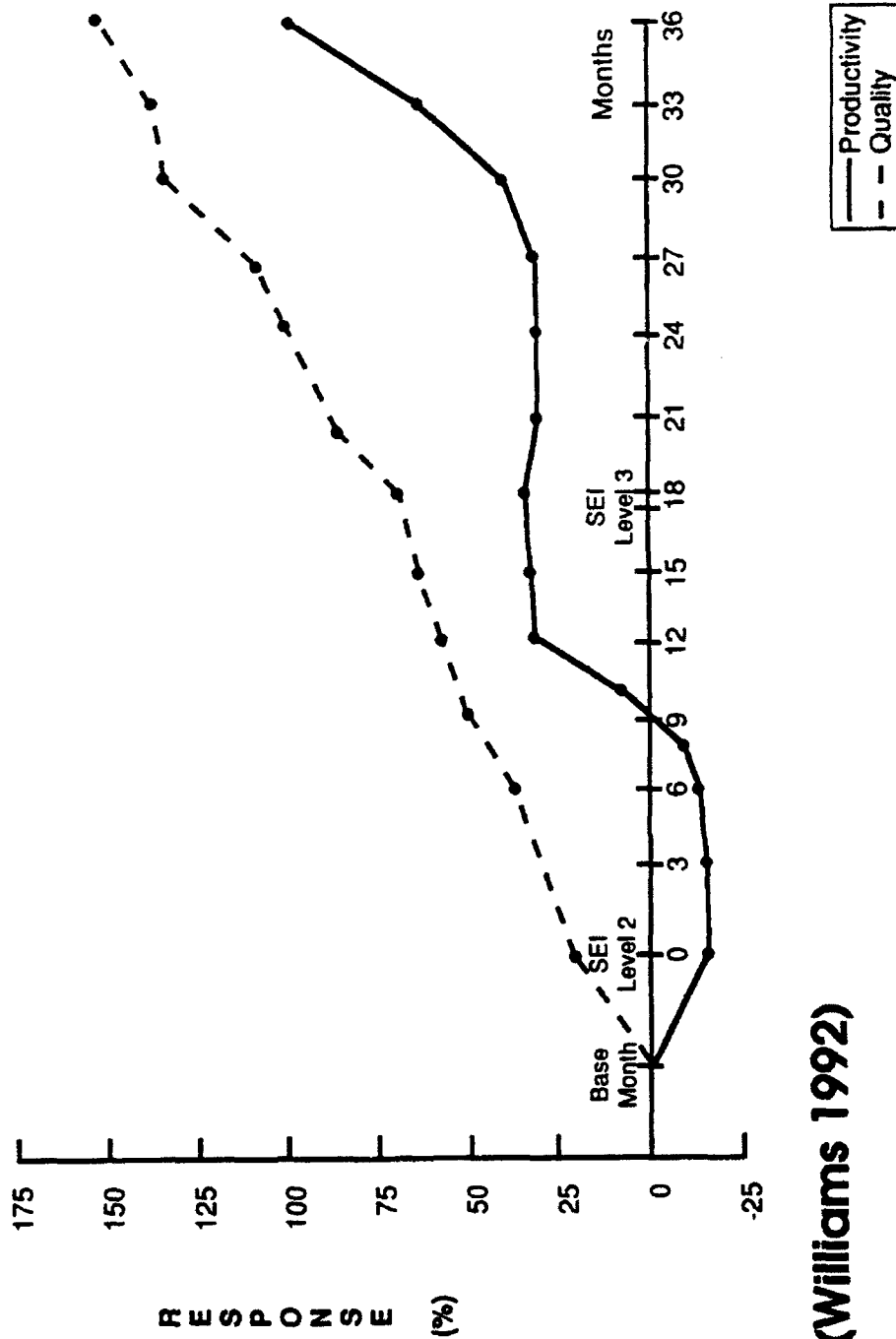
IDA's Comments:

- Since data was derived indirectly, organizations may not endorse it
- Maturity levels may be inaccurate

Data Base Extrapolations: Harbridge

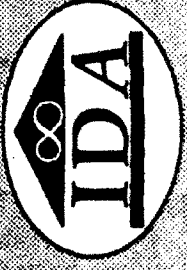


SEI LEVEL ADVANCEMENT
VS. PRODUCTIVITY AND
QUALITY
(ALL COMPANIES)

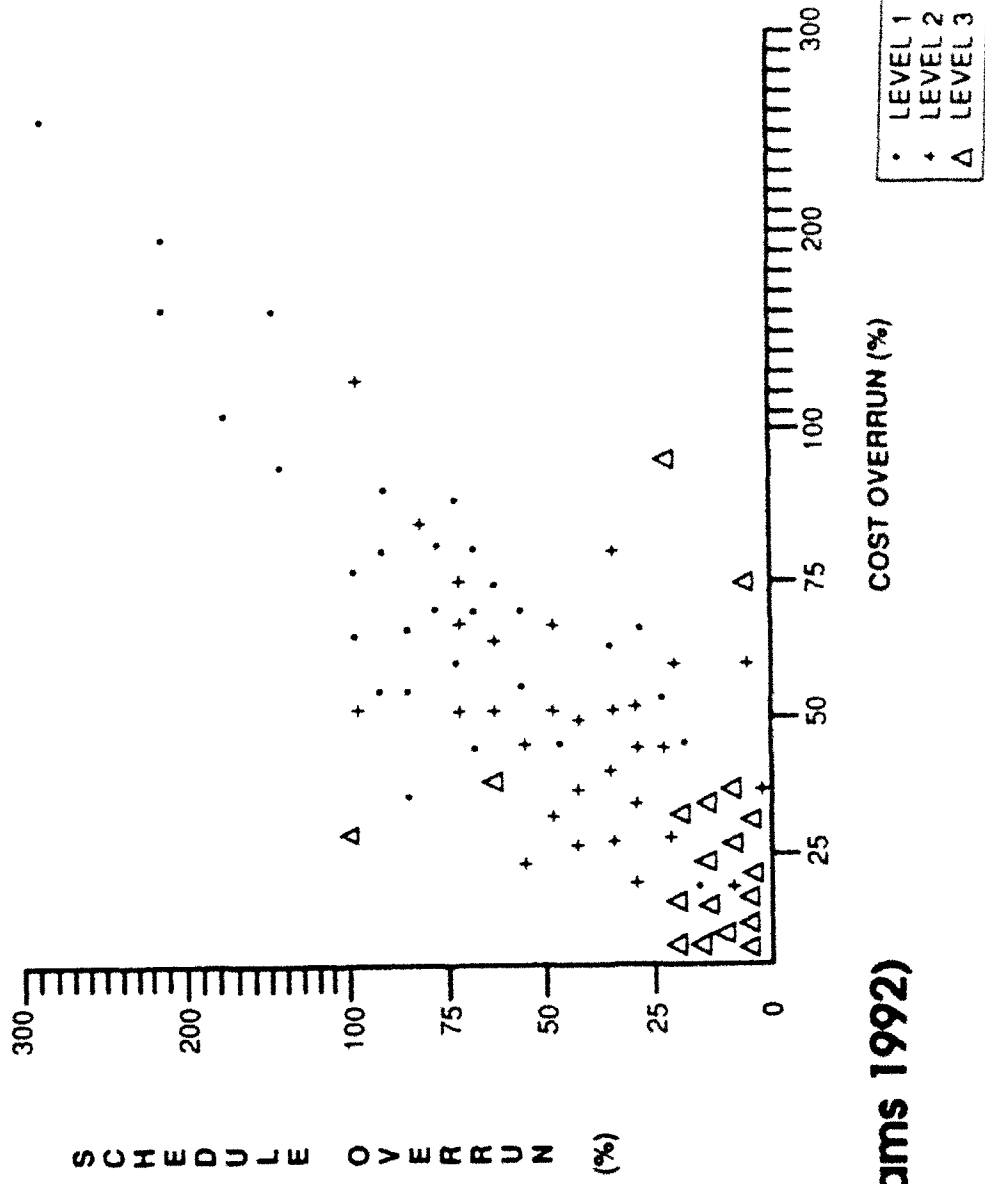


(Williams 1992)

Data Base Extrapolations: Harbridge



SCHEDULE/COST OVERRUN
BY SEI LEVEL



(Williams 1992)

Survey: Lockheed



Background:

- Surveyed PMs to estimate productivity and quality at lower maturity levels
- Used Cusumono's data and Boehm's COCOMO cost drivers to make estimates at higher maturity levels

Lockheed's Findings: (Based on typical 500 KSLOC project) (Pore 1992)

SEI Level	Defects/ KSLOC	Cost
5	.1-	\$ 1.0 M-
4	.3	\$ 2.5 M
3	1	\$ 6.5 M
2	3	\$15.0 M
1	9+	\$32.5 M

IDA's Comments:

- Results helped to motivate process improvement
- No empirical study was performed, Lockheed does not endorse the chart

Survey: IDA



Background:

- Survey sent to 480 people: SEI Primary Affiliates and CMM workshop
- 26% responded (93 contractors, 19 government, 11 consultants)
- 82% of respondents conducted at least one SPA, 85% have PIP in place

IDA's Findings:

- 88% feel SPAs are useful for improving the software process
- 68% who have been subjected to more than one SCE feel SCEs are useful
- 30-50% of respondents claimed to collect benefit and cost data

Survey: IDA (continued)



IDA's Comments:

- 55 companies surveyed do not have cost and benefit results
- Most just started collecting metrics
- Several are more advanced: Boeing, Bull World, CSC, GTE, IBM, Lockheed, Rockwell, TRW, Westinghouse
- Characteristics of the most advanced measurement programs:
 - Just establishing metrics definitions
 - Just establishing central group to maintain data repository
 - Just performed initial SPAs per site and developed PIP
 - Just too early to see improvement reflected in measurement
- Benefits of PIP difficult to isolate: CSC, IBM, Westinghouse

SEI Software Process Maturity Model Survey Form

Return to:
Beth Springsteen, IDA
1801 N. Beauregard St.
Alexandria VA 22311
FAX (703)845-6848

SPA = Software Process Assessment (performed by the development organization)
SCE = Software Capability Evaluation (performed by a government team)

General Information:

- Name: _____
- Title: _____
- Company: _____
- Address: _____
- Phone number: _____
- Number of years company has been aware of the maturity model? _____
- Number of times your company has performed SPAs? _____
- Number of times your company has been the subject of an SCE? _____
- Does your company have a software process improvement plan? _____
- Was the process improvement plan based on an SPA or SCE? _____

Cost/Benefit Information:

- Has your company measured the cost of conducting an SPA or SCE?

Describe: _____

- Has your company measured the cost associated with improving the software process?

Describe: _____

- Has your company measured the benefits associated with improving the software process?

Describe: _____

- What conclusions have been drawn from the cost/benefit data?

Describe: _____

Circle One

Yes No

Yes No

Yes No

SEI Software Process Maturity Model Survey Form (page 2)

Circle One

Opinions of the SEI Process Maturity Model:

- Is an SPA a useful method for developers to identify strengths and weaknesses of their software processes?

Describe: _____

Yes No

- Is an SCE a useful method for the government to identify strengths and weaknesses of contractors' software development process?

Describe: _____

Yes No

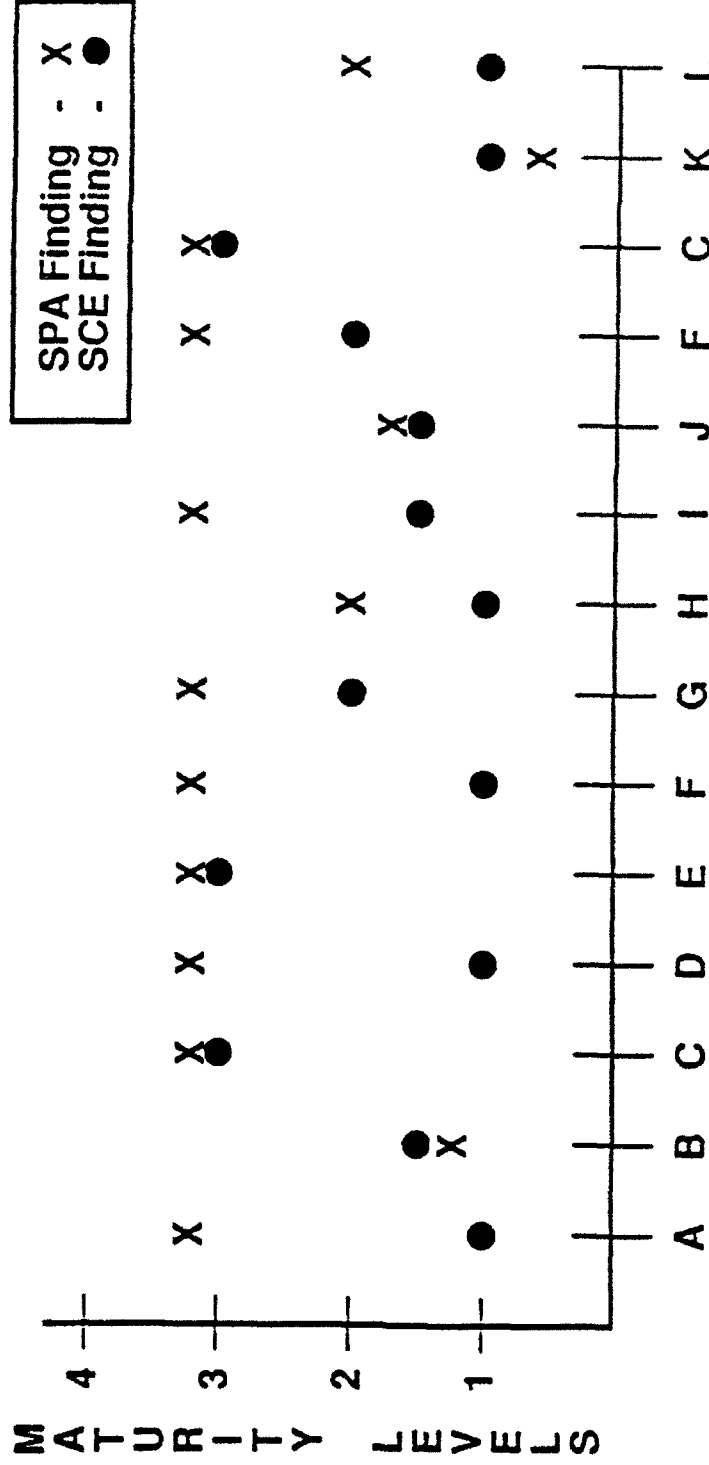
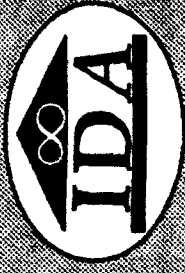
- Is the process maturity model helpful for developing Process Improvement Plans?

Describe: _____

Yes No

- Other comments and/or opinions of the process maturity model: _____

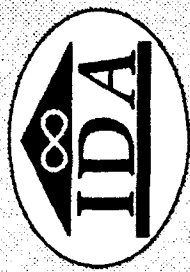
SCES vs. SPAs Findings from AF ESD



CONTRACTORS

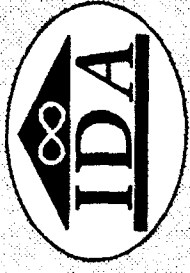
(Besselman 1992)

Attributes Investigated by the Methods



Attributes	SPR	SPA/SCE	SDC/CR
Project Tailoring:	●	●	●
Type and Scope	●	●	○
Experience (Precedented/Unprecedented)	●	○	●
Schedule, Budget, Size	●	●	●
Project Personnel:	●	○	●
Scheduled and Actual Resources	●	○	●
Experience	●	○	●
Training	●	○	●
Project Management:	○	●	●
Organization Structure & Responsibilities	●	●	●
Planning & Estimation Methods	○	●	●
Commitment Management	○	●	●
Project Tracking Methods	○	●	●
Subcontractor Control	○	●	●

Detailed Comparison (cont.)



Attributes	SPR	SPA/SCE	SDC/CR
Methods and Tools	●	○	●
System Engineering	○	○	●
Requirements, Design, and Code	●	○	●
Software Testing & Integration	●	○	●
Software Data Administration	●	○	○
IV & V	○	○	●
Software Maintenance Methods	●	○	●
Software Documentation	●	●	●
Development and Support Tools	●	○	●
Workstations Support	●	○	●

Detailed Comparison (cont.)



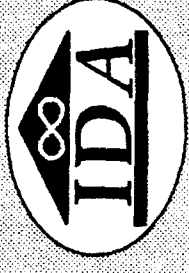
Attributes	SPR	SPA/SCE	SDC/CR
Product and Technology Constraints	●	○	●
Hardware	●	○	●
Programming Language	●	●	●
Memory and Performance Requirements	●	○	●
GFE & COTS	●	○	●
Reusable Software	●	○	●
Artificial Intelligence	○	○	●
Project Quality and Configuration Control	●	●	●
Project Quality Assurance Methods	●	●	●
Peer Reviews	●	●	●
Project CM	●	●	●

Detailed Comparison (cont.)



Attributes	SPR	SPA/SCE	SDC/CR
Project Measurement Data	●	○	○
Progress Measurements	●	○	○
Quality Measurements	●	○	○
Productivity Measurements	○	○	○
Organization Process Support	○	●	○
Process Definition	○	●	○
S/W Standards and Procedures	○	●	●
Project Planning and Tracking	○	●	○
Training Courses	○	●	○
Organization Technology Support	○	●	○
Development Tools	○	●	○
Reuse Repository and Practices	○	○	●
Technology Tracking	○	●	○

Assessment Method: SPR



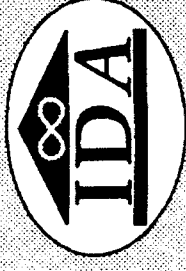
Background: (SPR 1991)

- **Software Productivity Research (SPR)** assessment method developed by Capers Jones, based on surveying over 3,000 projects
- Used to compare current practices to industry averages and corporate norms and to plan improvements
- Experience to date includes 50 companies (e.g., Bell Labs, HP, Motorola, DEC, Unisys, Wang, Sears, JC Penney, Tandem, BBN, Navy)

Model Description:

- Assessment method is questionnaire based (about 400 questions)
- Questions apply to projects, composite report reflects organization
- Qualitative questions are scored numerically from 1-5 (best-poor)
- Results in 6 categories: productivity, quality, personnel, technology, process, and environment

Assessment Method: SPR



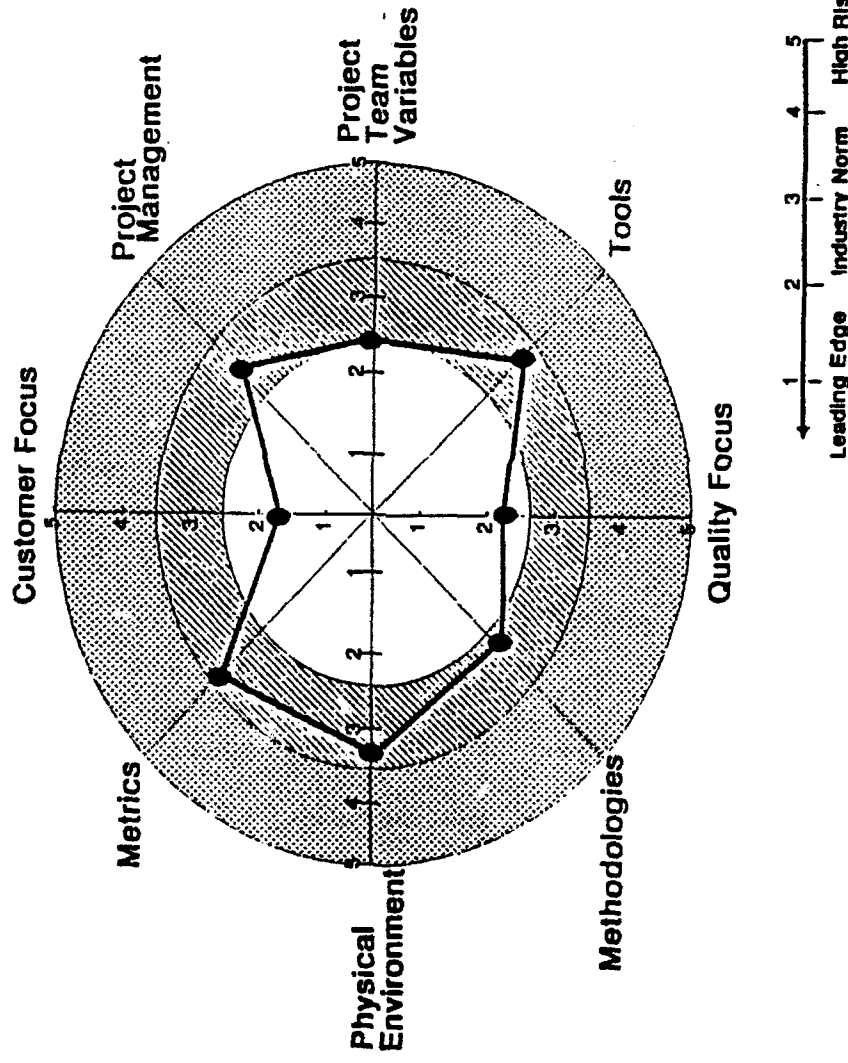
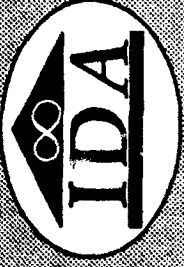
Assessment Approach:

- Lead project developers complete the questionnaire individually
- Group meeting is held to discuss each question and select appropriate response via consensus (1-day meeting)
- Checkpoint tool may be used to generate 150 different reports

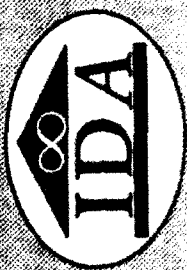
Sample Assessment Criteria:

- SEI
 - *Criteria: There is a library support system*
 - *SEI Question: Is there a mechanism for controlling changes?*
- **SPR Questions:**
 - **Release Control Methods:**
 - 1 Detailed automated release control system used
 - 2 Detailed manual system including problems, logs, staff reports
 - 3 Manual system controlled by naming convention with date and size
 - 4 Informal or ineffective system, not readily available
 - 5 No release control permission

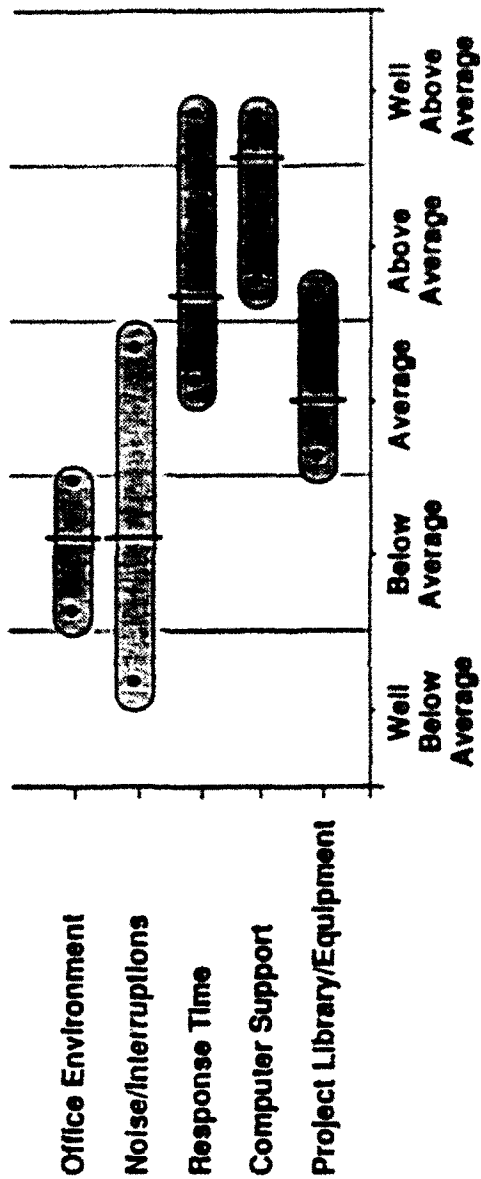
Assessment Method: SPR



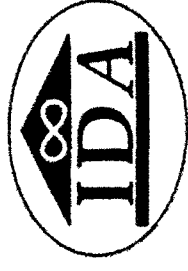
Assessment Method: SPR



Environmental Factors



Assessment Method: SPR



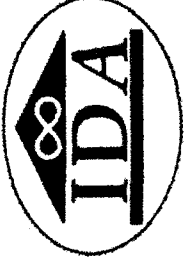
Strengths:

- Scoring is more objective, finer level of detail, easier to measure improvement
- Quantitative cost and quality results are collected and analyzed
- Strengths and weaknesses are identified for both project & organization
- Includes attributes not present in SEI's KPAs (e.g., physical environment, experience of staff, development methodologies, development tools, testing, reusability)

Weaknesses:

- Since no open-ended questions, may miss problems not in questionnaire
- Since the SPR method focuses on individual projects, it lacks questions about organization-wide issues such as training, standards & procedures, and Software Engineering Process Group (SEPG)
- Results are not prioritized to facilitate improvement

Evaluation Method: SDC/CR



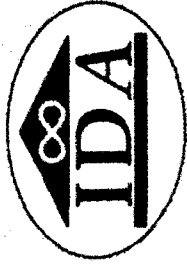
Background: (AFSC 1992)

- Software Development Capability/Capacity Review (SDC/CR) developed by Phil Babel in 1983
- Derived from reports of Independent Engineering Review Teams (IERT)
- Assesses offeror's capability and capacity to develop software as required for a particular RFP of a DoD weapon system

Model Description:

- Method includes 400+ essay questions and "standard evaluation criteria" to help evaluate responses
- Results include strengths and weaknesses for 8 categories: management approach, management tools, development process, Personnel resources, Ada, flight critical software, AI, complex H/W development

Evaluation Method: SDC/CR



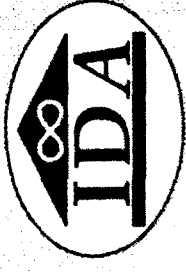
Evaluation Approach:

- Offeror provides essay responses to SDC/CR questionnaire
- 2-day in-plant review to clarify questionnaire responses
- Strengths and weaknesses are recorded for each category and provided to the Source Selection Advisory Committee (SSAC)
- Each category is ranked according to color scale for SSAC:
RED (highest risk) to BLUE (lowest risk)

Sample Evaluation Criteria:

- **SEI:**
 - *Criteria: Product capacity is tracked*
 - *Question: Are target throughput utilization estimates and actuals tracked?*
- **SDC/CR Throughput Questions: (essay response)**
 - *Describe your analysis methodology for estimating the timing requirements for target processor throughput?*
 - *How do you verify your processor timing (throughput) requirements in support of the proposal?*

Evaluation Method: SDC/CR



Strengths:

- Focuses on the development process being applied to the specific acquisition program and reflected in the Software Development Plan
- Responses to essay questions can be used when no "discussion" allowed
- Process of answering questions provides valuable insight to contractors
- On-site visit allows contractor to explain rationale for selecting the process
- Covers categories not in SEI's KPAs (e.g., systems engineering, tools)

Weaknesses:

- Unable to verify whether processes were employed on past projects
- Essay questions were numerous and expensive to complete
- "Source Selection Evaluation Criteria" not complete
- Results provide little guidance for improvement
- No tailoring guidelines and no formal training