Changes and Challenges in the Software Engineering Laboratory

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Background
Since 1976, the Software Engineering Laboratory (SEL) has been dedicated to understanding and improving the way in which one NASA organization, the Flight Dynamics Division (FDD), develops, maintains, and manages complex flight dynamics systems. The SEL is composed of three member organizations: NASA/GSFC, the University of Maryland, and Computer Sciences Corporation. During the past 18 years, the SEL’s overall goal has remained the same: to improve the FDD’s software products and processes in a measured manner. This requires that each development and maintenance effort be viewed, in part, as a SEL experiment which examines a specific technology or builds a model of interest for use on subsequent efforts. The SEL has undertaken many technology studies while developing operational support systems for numerous NASA spacecraft missions.

Software Improvement Approach
The SEL’s basic approach toward software process improvement is to first understand and characterize the process and product as they exist to establish a local baseline. Only then can new technologies be introduced and assessed (phase two) with regard to both process changes and product impacts. Typically, several studies/assessments are in progress at any one time, each with a duration of approximately 1-3 years. The third phase of the SEL approach (packaging) synthesizes the results of the first two phases and feeds them back into the cycle to assist software development on subsequent projects. Packages include products such as process tailoring guidelines, training courses, tools, and guidebooks. The SEL’s process improvement approach has proven very effective in the FDD, with the organization’s software product showing substantial improvements in error rates, reuse, and cycle time; and it has been recognized throughout the software engineering community. In 1994, the SEL received the IEEE Computer Society Award for Software Process Achievement and a Federal Technology Leadership Award for its application of these innovative concepts in a production environment.

SEL Operational Changes
The SEL’s development and maintenance environments differ somewhat in their characteristics. On development efforts, the languages and processors used reflect a
movement toward workstation-based systems: languages are FORTRAN (70%), Ada (15%), and C (15%) spread over 65% mainframe systems and 35% workstation systems. Maintenance efforts are dominated by FORTRAN with 85% usage, followed by Ada (10%), with the remaining systems implemented in a variety of languages, such as assembler and Pascal. Platforms of systems under maintenance are predominantly mainframes (80%), with the remaining 20% maintained on workstation-based processors.

Based in part on these environmental factors, and on recent plans for changes in this environment, several significant paradigm shifts occurred in the SEL’s operation. This has led to changes in three areas:

- Organizational goals
- Operations and development environments
- Resources

Change #1: Organizational Goals
From its inception, the SEL has focused on both increasing software reliability and reducing life cycle costs. Over the past 8 years, the SEL has achieved measured gains in both areas: reliability of delivered systems has increased threefold and current mission support costs are half that of older systems. However, with “time to deploy” pressure increasing, SEL goals now emphasize development time as well as cost. In response to this, the FDD, with the SEL’s support, is expanding development of high-reuse, generalized systems to encompass more flight dynamics application areas. The SEL is investigating a variety of joint team development processes as well as cataloguing and assessing existing maintenance processes to identify potential time-savers.

Change #2: Operations and Development Environments
The change here—the transition from mainframes to workstations—has already been discussed. In support of this trend, the SEL provides historical data on completed system rehosting activities for management planning of subsequent efforts. Data collection and measurement activities are also being revisited to determine whether these procedures must be modified. In addition, new computer-aided software engineering (CASE) tools are being investigated for use on the available workstations.

Change #3: Resources
From 1989 through 1994, resources increased by about 10% per year, enabling the SEL to undertake several NASA-wide initiatives: developing guidebooks and assessment reports on specialty topics such as measurement, NASA-wide software characteristics, domain identification, and technology transfer activities. These experience exchanges facilitated the spread of SEL concepts not only throughout NASA, but beyond, to other government organizations and industry. However, resources for 1995 have been significantly reduced, prompting a reevaluation of both internal and external efforts. The SEL has decided to
focus external outreach efforts on similar domains within NASA and to investigate new processes likely to provide direct cost benefits in the FDD production environment.

**Impact and Observations**

Given the above changes, what are the lessons?

- The first experience lesson is that new process technologies must be integrated within the existing process framework. The SEL approach of understanding, assessing, and packaging is effective at instilling large, as well as small, process changes because it yields a fundamental understanding of process and product.

- Next, the move to workstations will create a tighter link between process tools, measurement, and process analysis. This should assist SEL analysts in providing more timely feedback to development groups.

- Last, the importance of understanding software domains has been reemphasized in the SEL's work. An ability to compare and contrast domains is critical for technology transfer and tailoring guidance activities.
SOFTWARE ENGINEERING LABORATORY (SEL)

THE SEL FROM 1976 - 1994

• GOALS
  - UNDERSTAND THE SOFTWARE PROCESS IN A PRODUCTION ENVIRONMENT
  - DETERMINE IMPACT OF AVAILABLE TECHNOLOGIES
  - INFUSE IDENTIFIED/REDEFINED METHODS INTO DEVELOPMENT PROCESS

• APPROACH
  - APPLY TECHNOLOGIES AND EXTRACT DETAILED DATA IN PRODUCTION ENVIRONMENT (EXPERIMENT)
  - MEASURE IMPACT (COST, QUALITY, DEVELOPMENT TIME,...)
  - PACKAGE RESULTS (STANDARDS, PROCESSES, TRAINING,...)
SEL PROCESS IMPROVEMENT APPROACH

MAKE IMPROVEMENTS PART OF YOUR BUSINESS
- Update standards
- Refine training
- Tailor processes

ASSESSING
Determine effective improvements
- Will joint team approaches help?
- Will formal methods improve reliability?
- Will case cut cost?

ITERATE
- Update standards
- Refine training
- Tailor processes

PACKAGING

UNDERSTANDING
Know your software business
- What are my software characteristics?
- What process do I use?
- What are my goals

EXAMPLES

TIME

SEL PRODUCTION ENVIRONMENT

SOFTWARE CHARACTERISTICS: SCIENTIFIC, GROUND BASED, INTERACTIVE

<table>
<thead>
<tr>
<th>LANGUAGE</th>
<th>DEVELOPMENT</th>
<th>MAINTENANCE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>70% FORTRAN</td>
<td>85% FORTRAN</td>
</tr>
<tr>
<td></td>
<td>15% Ada</td>
<td>10% Ada</td>
</tr>
<tr>
<td></td>
<td>15% C</td>
<td>5% OTHER</td>
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</table>

<table>
<thead>
<tr>
<th>PROCESSORS</th>
<th>DEVELOPMENT</th>
<th>MAINTENANCE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>65% MAINFRAME</td>
<td>80% MAINFRAME</td>
</tr>
<tr>
<td></td>
<td>35% WORKSTATION</td>
<td>20% WORKSTATION</td>
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<table>
<thead>
<tr>
<th>DURATION</th>
<th>DEVELOPMENT</th>
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<tbody>
<tr>
<td>PER PROJECT:</td>
<td>12-30 MONTHS</td>
<td>PER RELEASE:</td>
</tr>
<tr>
<td>EFFORT</td>
<td>10-25 STAFF YEARS</td>
<td>3-12 MONTHS</td>
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<tr>
<td>SIZE</td>
<td>100K-300K SLOC</td>
<td>1-5 STAFF YEARS</td>
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<tr>
<td></td>
<td>WIDE VARIATION</td>
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1994 -- 1995 CHALLENGES

- ORGANIZATIONAL GOALS
- OPERATIONS AND DEVELOPMENT ENVIRONMENTS
- RESOURCES

CHANGE #1: ORGANIZATIONAL GOALS

PREVIOUS EMPHASIS ON RELIABILITY & COST

CURRENT EMPHASIS ON COST & TIME TO DELIVER

• SEL RESPONSE
  - EXPAND OBJECT-ORIENTED, GENERALIZED DEVELOPMENT TO OTHER APPLICATIONS
  - ASSESS JOINT DEVELOPMENT PROCESSES WITHIN CURRENT SEL METHODOLOGY
  - UNDERSTAND MAINTENANCE PROCESS/PRODUCT
  - INTEGRATE NEW PROCESS TECHNOLOGIES WITHIN EXISTING FRAMEWORK
CHANGE #2: OPERATIONS AND DEVELOPMENT ENVIRONMENTS

MAINFRAME APPLICATIONS  WORKSTATION APPLICATIONS

• SEL RESPONSE
  - PROVIDE MANAGEMENT SUPPORT FOR “REHOST VS NEW” DECISIONS
  - REVISIT MEASURES AND DATA COLLECTION MECHANISMS
  - EXPAND COMPUTER-AIDED SOFTWARE ENGINEERING (CASE) TECHNOLOGY STUDY

POTENTIAL EXISTS FOR GREATER INTEGRATION OF SEL ANALYSIS WITH DEVELOPMENT

CHANGE #3: RESOURCES

GROWING SUPPORT FOR EXTERNAL OUTREACH (RESOURCES INCREASING)  FOCUS ON INTERNAL NEEDS (RESOURCES DECREASING)

• SEL RESPONSE
  - USE OUR DETAILED PROCESS UNDERSTANDING TO SELECT TECHNOLOGIES LIKELY TO IMPACT COST
  - CONTINUE DOMAIN IDENTIFICATION EFFORTS TO FIND “LIKE” DOMAINS FOR EXPERIENCE EXCHANGES
  - PROMOTE “SEL-APPROACH” TO GSFC/NASA AREAS (PRIMARY) AND OTHER ORGANIZATIONS

DOMAIN IS A KEY DRIVER FOR SEL EXTERNAL OUTREACH EFFORTS