Assessing the Software Development Process In Providing Customer Value

by

Patricia L. Rishi

S.B. Materials Science and Engineering
Massachusetts Institute of Technology

SUBMITTED TO THE DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SEPTEMBER 1996

© 1996 Patricia L. Rishi. All rights reserved.

The author hereby grants to MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part.

Signature of Author: __________________________

Department of Aeronautics and Astronautics
August 19, 1996

Certified by: __________________________

Thomas L. Magnanti
George Eastman Professor of Management Science
Thesis Supervisor

Accepted by: __________________________

Professor Edward F. Crawley
Head, Department of Aeronautics and Astronautics

OCT 15 1996
ARCHIVES
LIBRARIES
Assessing the Software Development Process In Providing Customer Value

by

Patricia L. Rishi

Submitted to the Department of Aeronautics and Astronautics
on August 19, 1996 in Partial Fulfillment of the
Requirements for the Degree of Master of Science

ABSTRACT

AT&T operations systems and personnel manage the largest communications network in the world, handling more than 200 million voice, data, and video calls on an average day. Many of these operations systems are developed by one organization, following a software development process (SDP) that governs the planning, development, and verification of systems that are then delivered to the customer for acceptance testing. This thesis describes the application of the first step of a business transformation methodology to the SDP used by this organization. The execution of all three steps of the methodology: assessment, redesign, and implementation, will culminate in a dramatically improved SDP. A team, chartered and supported by management, initiated this work as part of an ongoing effort to provide maximum value to the organization’s customers through its operations solutions and systems. The goal of the SDP assessment was to specify a target process for developing network software: by identifying and retaining components of the existing process that enable AT&T to achieve its vision, while simultaneously identifying and eliminating features of the current process that inhibit the organization from meeting this goal. The team used such tools as the affinity technique, the house of quality, Pugh charts, and fishbone diagrams to support their efforts. The team collected inputs to the assessment through three activities: baselining existing projects, interviewing customers and stakeholders, and benchmarking with external companies. By analyzing and measuring inputs from these three sources against customer needs and expectations, the team identified several performance gaps. To close the gaps, the team documented a set of recommended characteristics for the target processes. From this set, three recommendations emerged as most important: enabling greater reuse, redefining the organization’s core competencies, and closer partnering with the customer.

Thesis Supervisor: Thomas L. Magnanti
Title: George Eastman Professor of Management Science
Personal Note from the Author:

This thesis was done in partial fulfillment of the requirements for a Master of Science degree as part of the pilot offering of the System Design and Management (SDM) Program. SDM is a joint offering from the Sloan School of Management and the School of Engineering targeted to educate the future leaders of technological corporations. I am proud to have been a part of the pilot offering and I appreciate the many opportunities to help shape and direct the evolution of SDM. I have learned a great deal through my education at MIT, including many lessons in both my professional and personal lives.

I am thankful to AT&T generously supporting me to complete this degree. This thesis not only documents months of work, it also demonstrates the applicability of my learnings to the fields of telecommunications and re-engineering.
Acknowledgments

The author would like to acknowledge the many individuals who supported her in the preparation of this thesis:

- Thomas Magnanti, the thesis supervisor who holds a joint appointment from the Sloan School of Management and the School of Engineering, for his support and encouragement throughout the SDM Program and the preparation of this thesis.

- Kaveh Hushyar, Janet Morris, Debra Bond, Naser Barghouti, Ralph Caldwell, Mike Singer, and Pete Spring, from AT&T, for their teamwork, enthusiasm, and focus during the software development process assessment. Also, to AT&T for supporting the author in the SDM Program.

- Raju Rishi, the author’s husband, for his support, especially all of the times he cooked dinner because the author was busy with schoolwork.

- Bob McCarthy, classmate and good friend, for his willingness to listen and provide encouragement during the frustrating times.

- Team SDM, fellow classmates in the pilot SDM Program, for the intense experience and lots of memories.
# TABLE OF CONTENTS

1. INTRODUCTION ........................................................................................................ 14

2. OVERVIEW .................................................................................................................. 17
   2.1 ORGANIZATION ................................................................................................. 17
   2.2 RESULTS AND LEARNINGS ............................................................................. 17

3. DEFINITIONS .............................................................................................................. 19
   3.1 GENERAL TERMS .............................................................................................. 19
   3.2 THE SOFTWARE DEVELOPMENT PROCESS .................................................. 20
   3.3 VISION AND MISSION ....................................................................................... 21
      3.3.1 Business Unit ............................................................................................. 21
      3.3.2 Center .......................................................................................................... 21
   3.4 VALUE CHAIN RECONFIGURATION ................................................................. 22

4. SCOPE ......................................................................................................................... 23

5. OVERVIEW OF THE PROCESS ............................................................................... 25
   5.1 THE BUSINESS TRANSFORMATION PROCESS ............................................. 25
   5.2 THE SDP ASSESSMENT ..................................................................................... 28
      5.2.1 Capture ......................................................................................................... 29
         5.2.1.1 Baseline .................................................................................................. 30
         5.2.1.2 Benchmark ............................................................................................. 32
         5.2.1.3 Customer Values .................................................................................... 38
      5.2.2 Translate and Measure ................................................................................. 40
      5.2.3 Improve ......................................................................................................... 43
6. RESULTS

6.1 CAPTURE

6.1.1 Baselined Projects

6.1.1.1 Organizational Factors

6.1.2 Benchmark

6.1.3 Customer Values

6.2 TRANSLATE AND MEASURE

6.2.1 Baselined Projects

6.2.2 Customer Values

6.3 IMPROVE

6.3.1 Organizational Factors

7. AREAS FOR FURTHER STUDY
Executive Summary

This thesis describes the assessment of a software development process (SDP) used by one organization (which we refer to as the Center) within AT&T that provides many of the operations systems used in support of the AT&T communications network. The assessment phase was one step in a three-step business transformation approach - assessment, redesign, and implementation - that AT&T uses to streamline and improve its business processes. The goal of the SDP assessment was to specify a target process for development of network software: by identifying and retaining components of the existing process that enable AT&T to achieve its vision, while simultaneously identifying and eliminating features of the current process that inhibit the organization from meeting this goal. The assessment step consists of four major components:

- Capture (data),
- Translate (data and customer expectations into performance targets),
- Measure (relevant performance indicators and the size of the performance gaps), and
- Improve (the business processes).

This study, conducted by a team of people with diverse educational and experiential backgrounds, used data from baselining of current projects, benchmarking of other companies, and data gathered about customer expectations and values as inputs to formulating their recommendations. The team collected these inputs in a standardized form generated by employing the nominal group and affinity diagram approaches. The team identified ten projects for baselining which varied across the dimensions of geographic location, organizational reporting structure, size, source of funding, and maturity. To select the companies for benchmarking, the team applied a tailored House of Quality and Pugh charts, using such characteristics as financial performance, software development process rating (e.g., Capability Maturity Model), and delivery interval to evaluate potentially
relevant companies. This process identified ten companies, of which the team expected to obtain three actual exchanges. Each of these companies exhibited superior attributes within their industries, both in terms of their financial performance, as measured by revenue growth, market share, and return on assets, as well as their software development process, as measured through ratings such as the Software Engineering Institute’s, awards, or level of use of new technologies, such as object oriented. To elicit customer expectations, the team conducted interviews with the funding organizations and with the stakeholders, including the Center managers and the system maintenance organization. In all, the team conducted 85 interviews during the assessment phase.

The assessment phase revealed a number of findings, of which many of the specifics cannot be disclosed for proprietary reasons. However, in the areas of customer values and measurement, the team found the following:

- The top three customer values were in the areas of meeting the customer requested due date, meeting the time and cost commitment once given, and the quality of the relationship between the customer and the Center.

- The Center’s current metrics program was insufficient for correlating project attributes to project performance.

Based upon all of the findings, the team formulated three recommendations for improving the Center’s ability to fulfill its mission in supporting AT&T’s businesses:

1. The process should enable a greater amount of reuse of components and tools than is practiced today, leading to an environment that achieves a higher level of integration.
2. The organization creating and maintaining software should continuously review its desired core competencies to ensure that they support the needs of the business and allow the best use of resources.

3. The organization should strive to foster a closer relationship with its customers so that it can truly understand their needs as well as be more proactive in solving them.

This assessment represents the first phase of the AT&T business transformation process. If the performance gaps are considered large enough to require dramatic change, the Center would need to use the assessment findings as an input to the redesign phase. In that stage, the Center should focus on redesigning the software development process to meet and exceed the customers expectations and begin to formulate a strategy for implementation. Particular emphasis should be placed on defining a process that addresses the three recommendations suggested by the assessment.

The assessment and business transformation process that we have used in this thesis have potential application to the re-engineering of other software and non-software development processes within and outside of AT&T. For example, the service industry, such as financial services, could benefit from its application. The assessment procedure has shown how modern engineering and management methods as embodied in such techniques as the House of Quality and organizational analysis, can provide a systems perspective that permits an organization to elicit and combine customer needs with its own internal capabilities to better achieve its core mission and business objectives.
1. Introduction

The design and management of complex systems requires a mix of interdisciplinary knowledge from both engineering and business. In the telecommunications industry, managing complex communication networks is a complicated task. The AT&T Worldwide Intelligent Network is the world's largest communications network; it handles more than 200 million voice, data, and video calls on an average business day. For AT&T to maintain customer satisfaction, it must quickly route each call through the network on an optimal path, making a successful connection nearly 100% of the time. Each customer has different needs (e.g. reliability requirements, data processing requirements, bandwidth requirements) and, to remain competitive, the AT&T network must accommodate these differences. The provisioning of these diverse network services is complicated for several reasons. The technologies used in the network are rapidly evolving and the equipment is becoming more sophisticated and supplied by a larger number of different suppliers. The design and maintenance of data communications software requires specialized programming expertise. Moreover, differences in standards between the United States and foreign countries, such as the difference in the standard building block transmission rate, add to the complexity.

The AT&T network is managed by operations personnel and a large number of software operations systems. These systems support the provisioning (making the network service ready), maintenance, restoration (rerouting calls around broken parts of the network), and call processing in the network. This thesis assesses the software development process used by a Center that provides many of these operations systems. The goal of the assessment described in this thesis was to develop an improved process for developing network software: by identifying and retaining components of the existing process that enable AT&T to achieve its vision, while simultaneously identifying and eliminating features of the current process that inhibit the corporation from meeting
this goal. The assessment was the first step executed as part of a business transformation model described in this thesis.

The work described in this thesis was conducted by a team of people with diverse backgrounds in engineering, management, reengineering, research, software development, and systems engineering. The team was chartered by and supported by management as the first step in an ongoing effort to dramatically improve the software development process in use by one organization of AT&T so as to provide the maximum value to its customers.
2. **Overview**

2.1 **Organization**

To set the stage, we first define some terms and the scope of this thesis. The remaining thesis is divided into two main sections. Section 5 contains an overview of the methodology used in each of the steps executed as part of this work. It discusses the general business transformation model and how its methodology was applied to the software development process assessment which is the subject of this thesis. Section 6 contains the same sub-sections, in general, as Section 5; it presents the results of the application of the methodology. Finally, the appendices contain supporting material referenced from within the body of the thesis.

2.2 **Results and Learnings**

The results of this work included a set of documented recommendations for achieving the desired characteristics of a target software development process. These recommendations, while specific to the organization assessed in this thesis, emerge from the careful application of a methodology that we describe. The analysis leads to three recommendations:

1. The process should enable a greater amount of reuse of components and tools than is practiced today, leading to an environment that achieves a higher level of integration.

2. The organization creating and maintaining software should continuously review its desired core competencies to ensure that they support the needs of the business and allow the best use of resources.

3. The organization should strive to foster a closer relationship with its customers so that it can truly understand their needs as well as be more proactive in solving them.
In addition, this thesis documents the current practices of one organization of AT&T for process improvement and process re-engineering applied to software development. This methodology has been evolving over a number of years, but has not been formally documented before.

Many of the methods and heuristics taught in the System Design and Management Program courses are relevant to this applied problem setting. In particular, they allow assessments, such as this one, to be conducted in as fact-based a mode as possible, adding credibility to the results. In general, however, all of these methods and heuristics required tailoring to meet the specific needs of this work with the greatest expediency. The straightforwardness of this customization illustrates the flexibility of these methods.
3. DEFINITIONS

The following sections define terms unique to this thesis or used within a specific context in this thesis.

3.1 General Terms

Center: The organization for which the assessment, the subject of this thesis, was conducted. The Center develops software solutions for internal AT&T customers. The following organizational chart describes the various organizational levels within the Center (not complete; just for illustration):

```
  [Organizational Chart]
```

Golden Threads: a collection of tightly coupled activities that when performed together produce a result of value to the customer.

Quality Gates: designated checkpoints in the process to verify that the system development has satisfied certain predetermined criteria before the start of an activity.

SDP: Software Development Process. The subject of this assessment and thesis, as described further below.

SEI Rating: The Software Engineering Institute at Carnegie Mellon University has developed a Capability Maturity Model for software. The model categorizes software
development processes into five maturity levels. The following definitions are taken from the SEI report on their Capability Maturity Model:

Level 1: Initial. The software process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined, and success depends on individual effort.

Level 2: Repeatable. Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.

Level 3: Defined. The software process for both management and engineering activities is documented, standardized, and integrated into a standard software process for the organization. All projects use an approved, tailored version of the organization's standard software process for developing and maintaining software.

Level 4: Managed. Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled.

Level 5: Optimizing. Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

3.2 The Software Development Process

The software development process plans, designs, develops and verifies systems that are then delivered to the customer for acceptance testing. It begins with the receipt of a documented request that contains high-level detail describing the need. It ends with the delivery of a verified system release to acceptance testing. The process is comprised of five sub-processes:

1. Development Project Management which negotiates commitments, manages system development and provides status to all stakeholders;

2. Write Requirements, which defines and produces requirements documents;

3. System Architecture, an optional sub-process, which examines/assesses architectural impacts and alternatives for the system by conducting a System Architecture Review and a Security Review;
4. **Design and Implementation** which designs, codes, and conducts developer testing;

5. **System Test** which verifies that the system meets requirements specifications.

### 3.3 Vision and Mission

#### 3.3.1 Business Unit

The Business Unit, of which the Center is a part, has the following vision and mission:

**Business Unit Vision:** We provide our customers the best network services in the world.

**Business Unit Mission:** The mission of the Business Unit is to support the other individual business units in the achievement of their goals by providing premises-to-premises network services, both now and in the future:

- That are positively differentiated from our competitors in customer perceived quality, reliability, innovation timeliness and performance.
- At a cost that is lower than our competitors.
- By a professional, motivated, customer-focused winning team.

#### 3.3.2 Center

The vision and mission of the Center focuses on three aspects of the organization: people, business, and process/technology. It supports the Business Unit vision and mission. At a high level, the vision calls for people to work in customer-focused teams to leverage their telecommunications network knowledge in providing solutions to AT&T's expanded business.
3.4 Value Chain Reconfiguration

We use the term "configuration of the value chain" to describe the mix of activities involved in providing network services and the individuals who are performing each activity. This thesis examines three specific parts of the value chain:

i. Activities performed internally because of the core competencies of the Center. For these activities, the people in the Center have highly specialized knowledge that cannot be easily imitated or exported.

ii. Activities conducted in partnership with other suppliers to create value through the mutual commitment and co-specialization of the two entities. An example of this part of the value chain includes products that are bought in a base configuration and then customized for the particular needs of the Center.

iii. Instances in which the Center can simply purchase needed components (e.g., commodities) from suppliers because of their inexpensive and/or abundant nature. In this third case, there is less value in the Center performing the activity internally rather than outsourcing or purchasing it.

In discussing the value chain reconfiguration in this thesis, we refer to the adjustment of the mix of these three components. For simplicity, we refer to these three components of the value chain as build, partner, and buy.
4. **Scope**

The software development process (SDP) begins with a customer need and ends with production-level software delivery. This thesis and the SDP assessment, because of organizational boundaries and domains of control, focus on a piece of the software development process, starting with a defined customer need (documented as high level requirements) and ending after system testing of the software. The thesis does not address other important upstream and downstream pieces of the process (e.g., customer acceptance testing and feasibility assessment).

Within this assessment, based on an understanding of customer needs and expectations, the thesis focuses on reducing delivery intervals, so that the Center can meet the customer requested due dates, and reducing costs, while maintaining the prevailing high level of quality and reliability. The specific areas addressed included:

- value chain reconfiguration
- process changes
- technology
- measurements and targets
- organizational structure
- roles and responsibilities.

Some areas are outside the scope of this assessment and this thesis:

- skill sets assessment of the people of the Center
- implementation plans
- supplier selection (i.e. ranking or recommending alternative suppliers)
Note that this thesis focuses primarily on the methodology underlying the assessment, which can be applied in a variety of companies and industries with little modification. However, this thesis does not describe the specific results of the assessment, nor the recommendations made by the assessment team, since they are of a proprietary nature.
5. **OVERVIEW OF THE PROCESS**

5.1 **The Business Transformation Process**

The subject of this thesis is the assessment of one AT&T Center software development process as a first step to transforming it to better meet the Center's mission and vision. In general, assessment is the first step in the three-phase approach to business transformations: assessment, redesign, and implementation (see Figure 1):

![Diagram of Business Transformation Flow]

*Figure 1: General Business Transformation Flow*

This model has evolved into its current form within AT&T over many years. The **assessment** phase generally produces two outputs, a set of incremental improvements that can be implemented as appropriate in the current environment and a set of re-engineering opportunities for the next phase, redesign. The **redesign** phase uses the outputs of the assessment to formulate a dramatically different process flow that leverages the positive attributes gleaned in the assessment phase and minimizes any negative impacts or features. At this stage, the organization will **implement** the new
process and/or process changes that will carry the new process through to achieve the vision of the organization. The typical time to go through the entire cycle, from beginning of assessment through complete implementation, is on the order of years, while the assessment portion of the flow typically requires months to complete. The literature has suggested that in order for re-engineering to be successful, it must fundamentally change "six crucial organizational elements or depth levers: roles and responsibilities, measurements and incentives, organizational structure, information technology, shared values, and skills".

Three basic sources serve as inputs to assessment.

![Diagram](image)

**Figure 2: Inputs and Outputs of the Assessment Phase**

i. **Baselining** of the current environment as a "stake in the ground",

ii. **Benchmarking** of external and/or internal organizations to understand the possibilities for the process and as a way of generating new ideas and thinking "out-of-the-box", and

iii. Gathering customer **expectations** to establish a complete understanding of their values.
When these three elements are combined in the assessment, the outputs are a set of incremental improvements, typically implemented by process management teams, and a set of redesign opportunities, that are candidates for the next phase (design) of the business transformation.

The current assessment methodology consists of a four step approach: capture, translate, measure, and improve (see Figure 3):

![Assessment Methodology Diagram](image-url)

**Figure 3: Assessment Methodology**

- **Capture**: collects data from the three input sources cited (see Figure 2).

- **Translate**: maps the baselining and benchmarking data against the customer expectations to develop target performance goals and cascaded performance objectives.

- **Measure**: determines which functions have the highest value added, identifies critical information and their associated flows, and characterizes and sizes any existing gaps. This assessment conducted the translate and measure steps simultaneously.

- **Improve**: specifies the target environment and technology/systems as well as the specific business implementation recommendations that will close the gaps and move the organization toward its vision.
5.2 The SDP Assessment

The first step of the business transformation process is assessment. The SDP assessment, which is the subject of this thesis, applies this first step to the business of the Center. The final recommendations will address the specific areas outlined in the thesis scope (see Section 4). In general, assessments "typically result in an increased awareness of the quality and characteristics of an organization's current software process, including procedures, technologies, and the capability to use them."

In particular, the team outlined the following topics ahead of time as particular items of interest:

- Value chain reconfiguration
  - Examination and possible redefinition of the core competencies of the Center.
  - The degree to which the Center should enter into partner agreements with suppliers.
  - The degree to which the Center should utilize arms-length suppliers for commodity items.

- Process changes
  - Enablers of re-use.
  - The target amount of concurrency. (This recommendation will most likely include a target amount per software development process model. For example, the amount of concurrency recommended will likely be different for small and large development projects.)

- Measures and targets

- Technology
  - Examination of the value of using object oriented technology in the Center.
  - Possible improvements through the use of automated tools (e.g., code generators).
• Organizational models
  
  • Examination of the Center through strategic, political, and cultural lenses.
  
  • The progress of the Center toward becoming a "new" organization that is flat, flexible, global, diverse, and networked.

• Roles and responsibilities
  
  • Project management.

• The unknown
  
  • Items identified through the baselining, benchmarking or customer value interviews.

5.2.1 Capture

The purpose of the capture phase is to gather all of the relevant data from which to conduct the analysis required in the translate, measure, and improve phases. To the extent possible, the information gathered from the various sources (in this case: from internal projects - baseline, from external companies - benchmark, and from the customers and stakeholders - expectations) should be easily comparable as well as easy to synthesize and internalize. Therefore, we used the nominal group technique\textsuperscript{vi} and affinity diagrams\textsuperscript{vii} to carefully prepare the question sets to be used when interviewing each of the sources. A variety of industries use this technique as an effective means for generating ideas and then hierarchically organizing them. As these techniques recommend, the individual team members first brainstormed independently various questions which were then combined with those submitted by the other team members. The team grouped all of the questions into higher level categories, removing duplicates as they went. Finally, the team reviewed the question set to generate new questions conceived during review of the question set. The team then
used the resulting question set as an outline for the interview to guide the interviewers through the important topic areas.

5.2.1.1 Baseline

Baselining consists of collecting detailed information on existing projects so that the team can develop a thorough understanding of the current operating environment. The team looks for the "golden threads" (see the definition in Section 2), such as providing a time and cost commitment to the customer. By identifying all activities on a particular golden thread, the team can later evaluate the value and necessity of each activity. Each golden thread should produce an output of value to the customer and each activity on the golden thread should contribute to that output. The golden threads are identified through a combination of the baselining of projects, which provides insight into the various activities being performed, and through the customer values analysis, which clarifies important outputs to the customer. The baselining effort, therefore, can be used to begin to identify key activities and golden threads.

The Center has a large number of systems, and each typically has more than one release per year. Given the time constraint of the assessment, we could not possibly baseline a majority, nor even a statistically representative sample, of the system projects. Therefore, we had to carefully select the projects to be baselined, trying to generate, as closely as possible, a representative sample on which to base the activity and golden thread identification, gap assessment, and recommendations. We used the following factors for project selection:

- Divisions - selecting at least one project from each of the divisions. The divisions are represented through letters of the alphabet. We selected only one project per division.
- Co-location - selecting a mix of co-located and non-co-located teams.
- Location - selecting at least one project per geographic location in which the Center develops software. We coded the actual locations into generic ones.

- Size - selecting a mix of small (<20 people), medium (20-80 people), and large (>80 people) projects

- Funder - selecting a mix of projects with different customers (sources of funding). The funders are represented by letters of the alphabet.

- Maturity - selecting a range from new systems to those that had been in existence for many years (new = systems <2 yrs. old; mid = systems between 2 and 8 yrs. old; old = systems >8 yrs. old)

- Other - if a project had a special characteristic, e.g., achieved an extremely high amount of reuse, we selected it if it fit the other criteria

Table 1 shows resulting selections.

<table>
<thead>
<tr>
<th>Project</th>
<th>Div.</th>
<th>Co-Lo?</th>
<th>Loc.</th>
<th>Size</th>
<th>Funder</th>
<th>Maturity</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>Y</td>
<td>NJ3</td>
<td>S</td>
<td>w</td>
<td>new</td>
<td>fast cycle time</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>N</td>
<td>NJ1, GA3, GA1, CO</td>
<td>S</td>
<td>x</td>
<td>new</td>
<td>new technology (flagship)</td>
</tr>
<tr>
<td>3</td>
<td>c</td>
<td>N</td>
<td>NJ2, OH2</td>
<td>L</td>
<td>u,x</td>
<td>old</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>d</td>
<td>Y</td>
<td>KS</td>
<td>M</td>
<td>y</td>
<td>mid</td>
<td>high reuse, object oriented</td>
</tr>
<tr>
<td>5</td>
<td>e</td>
<td>N</td>
<td>NJ1, GA1</td>
<td>M</td>
<td>u,x</td>
<td>old</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>f</td>
<td>N</td>
<td>NY, NJ2</td>
<td>M</td>
<td>u,w,y</td>
<td>mid</td>
<td>outsourcing</td>
</tr>
<tr>
<td>7</td>
<td>f</td>
<td>N</td>
<td>NJ2, GA2</td>
<td>L</td>
<td>u,y</td>
<td>old</td>
<td>rearchitecting</td>
</tr>
<tr>
<td>8</td>
<td>g</td>
<td>Y</td>
<td>NJ2</td>
<td>S</td>
<td>t</td>
<td>mid</td>
<td>generalist role</td>
</tr>
<tr>
<td>9</td>
<td>h</td>
<td>N</td>
<td>NJ3, GA1, VA</td>
<td>S</td>
<td>v,x,y,s</td>
<td>old</td>
<td>rearchitecting</td>
</tr>
<tr>
<td>10</td>
<td>i</td>
<td>Y</td>
<td>OH1</td>
<td>M</td>
<td>u,z</td>
<td>new/mid</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Baselining Selections**

When baselining a system, two people conducted one and a half hour interviews. The interviewers spoke to people representing various roles, e.g., systems engineer, architect, developer, tester, etc.
After completing all the interviews related to a system, the team summarized the results. We used the collective results of the baselining to formulate the Center’s responses to the questions used for benchmarking.

5.2.1.2 Benchmark

"Benchmarking is the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders."

A critical step in the assessment which occurs during the capture phase is the benchmarking of the software development processes of external companies. Benchmarking is used as one “positive, proactive process to change operations in a structured fashion to achieve superior performance.”

Due to time and budget considerations, early in the assessment planning, we limited the extent of external benchmarking to three (3) companies. Additional data would be gathered through secondary research, which is the only really viable option when collecting information on competitors (who normally do not entertain an exchange).

In addition, we chose to use the benchmarking exchanges to gather those best practices and enablers that permitted other companies to be successful in their industry. Secondary to these, we would also use benchmarking to gather performance levels and customer values of other companies. In a general sense, the benchmarking was to be a “breadth” survey rather than a “depth” one. If the benchmarking identified particular areas where more information would help the Center better understand how to apply the learnings, then we would conduct a further “depth” benchmarking study to gather more information specific to those particular areas.
With such limited opportunity to learn from the best-in-class companies, the benchmarking team wanted to ensure that any benchmarking visits would provide the most useful, actionable information. Therefore, it placed much emphasis on the company selection process. From the beginning, the team decided that it would be best to insist on a mix of company characteristics in the company set selected for the site visits. This decision was a result of the need to balance applicability with dramatic improvements. Selecting a company very analogous to the business of the Center mitigated the risk that the information gathered would not be comparable to the activities in the Center. However, it also was likely to lead to similar approaches to similar problems, thus not providing “out-of-the-box” thinking that might lead to dramatic improvements. The intent was to select at least one company in a different industry than AT&T, but yet with an analogous business that might provide some new insights and new approaches to existing Center software development process problems. For example, the banking and financial services industry produces software that must be highly reliable and delivered in a very short interval, analogous to that of the Center. However, given resource constraints, it was possible to analyze only a reasonably small number of companies (thirty to fifty) to determine how well each met the selection criteria.

To select the companies to benchmark, we used a tailored version of the House of Quality\textsuperscript{\textsuperscript{III}},\textsuperscript{\textsuperscript{IV}} iterating twice. First, we defined a matrix with the customer requirements of the Center along the left and possible selection criteria in the columns along the top. We initially estimated weights for the customer requirements based on the collective, subjective opinions of the team, and after performing the customer/stakeholder interviews, we revisited these weights and verified that they were in the correct proportion. We weighted some of the selection criteria quantitatively and others only qualitatively to ensure a reasonable mix of company characteristics that were important for
variety. The qualitative set of characteristics included: customer composition, industry, size of company, and whether the software produced had high reliability as one of its imperatives. We mapped the selection criteria to the customer requirements using the standard procedure of indicating that the selection criteria satisfied a customer requirement to a high, medium or low degree and using the numerical equivalents of high = 9, medium = 3, low = 1. Finally, we calculated the overall score of each selection criteria using weighted averages. We made an exception for the customer requirement of “high quality/reliability/performance” because of the relevance of this requirement for the purpose of this selection matrix. Customers of the Center expect high quality always and high reliability when needed, and the Center has historically performed well in these categories as confirmed through the customer and stakeholder interviews. Therefore, we gave a reduced weighting factor to company selection criteria that would prefer companies excelling in quality/reliability/performance (and so offering only marginal value). Appendix 3 contains the resulting matrix. The qualitative characteristic columns are blank because they were not a measure of the “desirability” of a given company; we included these columns to ensure that we were pursuing a variety of industries and that any companies considered were analogous to AT&T and the Center in the areas of customer composition, size, and reliability imperative.

The characteristic which received the highest desirability rating was “level of systems integration” because it addressed all but one of the customer requirements. The next two highest rated characteristics were “SEI Rating” followed by “revenue/growth/profits/market position”. Therefore, when selecting companies to benchmark against, the team ensured that those companies excelled in these areas and expected any findings from them to lead to significant improvement. Other companies have started using measurements such as SEI rating to determine the capability of
an organization. For example, Bell Canada, in partnership with Northern Telecom and Bell Northern research, has developed a new Telecom Software Product Development Capability Assessment model, named TRILLIUMiii, that uses the SEI Capability Maturity Model as one of its foundations. Similarly, the International Organization for Standardization (ISO) and International Electrotechnical Commission’s Joint Technical Committee #1/Subcommittee 7 created a special project called SPICEiv (Software Process Improvement and Capability dEtermination) to develop an international standard on software process assessment. SPICE also cites the SEI Capability Maturity Model as one of its origins. The team chose to use SEI ratings since they are most easily accessible.

Next, we transferred the columns from the first House of Quality to be the columns of the next House of Quality. Traditionally, these columns would have become the rows of the next House. However, since we had relatively few selection criteria and were considering a relatively large set of companies, we transposed the rows and columns of the matrix. We conducted secondary research to fill in the rows of the second House, that is, both to identify candidate companies as well as gather relevant details about how the company performed in the areas of the selection criteria. In this case, a simple assignment of a high, medium, or low was not possible since there needed to be an additional translation between how a company performed in a given category and a numerical equivalent. Due to the large number of companies being considered, we made some simplifying assumptions and aggregations.

1. Lack of compelling data - Budget constraints limited the amount of time we could spend conducting secondary research of candidate companies. At the end of the research phase, if any companies did not have enough data compelling the continued pursuance of that company, then we dropped the company from consideration. An implicit assumption here
was that if a company excelled in one of the areas of interest, then secondary research should have found data to support this finding. If not, we assumed that with high probability, the company did not stand out in the areas of interest to the Center. This simplification reduced the list of candidate companies from about 48 to 20.

II. Undesirable - Although some companies on the candidate list were top performers in various criteria, we eliminated them from consideration because they were undesirable for one of the following reasons:

A. They had been benchmarked against before.
B. They were considered to have matured through learning by AT&T’s direct example.
C. They were considered to be of poor quality or reliability.
D. Previous experience in trying to arrange a benchmarking exchange demonstrated an unwillingness by the company to participate.

This simplification reduced the list of candidate companies from 20 to 16.

III. Industry aggregation - To ensure that any given relevant industry was neither underrepresented nor overrepresented, we grouped the remaining companies into industries according to the Fortune 500 classifications.

During the application of these three criteria, we added a few more companies into the pool for consideration as additional data became available. Some industries, such as financial services, dropped out completely. Those that remained fell into the following four industries:

I. Aerospace
II. Computer (Hardware)
III. Computer (Software Services)
IV. Electronics.

Originally, as described above, at this point we intended to create a second House of Quality using the columns of the first House of Quality as the rows; however, given that we still had 20 companies to select from with the intent of choosing only 3, and it would be difficult to turn qualitative characteristics into high/medium/low ratings, we felt that use of a Pugh chart\textsuperscript{iv} would add the same value and take less time. It is important to note that in order to obtain 3 benchmarking exchanges in the timeframe required, the benchmarking literature and our experience suggested that we select and approach about 8 to 10 companies.

By abstracting the selection criteria up one level, we could apply the Pugh chart concept quickly with maximum value. We abstracted all of the selection criteria determined in the original House of Quality (Appendix 3) into two main criteria:

1. Financial Rating

   The aggregate standing of the company considering all relevant inputs such as market position, return on assets, stock price trends, total profit, etc., all gathered through secondary research. Note that this category would include the third highest desirable characteristic of "revenue/growth/profit/market position" from Appendix 3.

2. Software Process Rating

   A combination of measurements of the effectiveness and success of the company's software process. This rating was based on inputs such as SEI rating, Capers-Jones rating\textsuperscript{v}, use of technology (e.g., object oriented), industry research report ratings, etc., also all gathered through secondary research. This category would include the two highest desirable characteristics from Appendix 3 - "level of systems integration" and "SEI rating."
Note that any method of selection is fallible. By grouping the rating of a company into these two domains, we felt we could avoid many pitfalls. For instance, the financial rating criteria evaluates the overall company, not just the software development sector. Therefore, we might eliminate a company with an outstanding software development process because the parent company was not a top financial performer. Due to the limited scope of the benchmarking (limited to 3 exchanges), the selection team demanded that any selected company rate a "high" in both categories. For purposes of the Pugh chart, we used "high", "medium", and "low" instead of the more common "++" to "--" scores. Therefore, we did not fully evaluate some companies if they did not score a "high" in the first category assessed.

We contacted those companies that we had assessed as "high" in both categories to set up an exchange. Appendix 4 outlines the topics covered by the exchanges.

5.2.1.3 Customer Values

Both within AT&T and outside, the definition of customer has been the subject of great debate. Within the Center, we have found it useful to make the distinction between the funding customer and the using customer. The funding customer is the individual/organization/team who is providing the actual budget dollars to develop the software. Although these customers are usually involved in supporting or managing the operational processes and do not typically use the end product, they often represent those who do. On the other hand, the using customer actually uses the end product, the system. This distinction is important in the framework of this assessment because a typical measure of customer satisfaction, a customer satisfaction survey, applied in the environment of the Center, consists of surveying the using customers on their satisfaction with the systems. These surveys result in an overall user satisfaction score, which is tracked as part of the metrics and quality programs. The Center usually measured the satisfaction of the funder, on the other hand,
indirectly in two ways. First, the Center feels that a funder who continues to bring repeat business to it is at least partially satisfied. Second, the reward system in the Center allows the systems development team to negotiate goals with the customers (funders or users, but usually funders) and then be measured against those goals at the end of the year.

The distinction between funders and users is meaningful because the voice of the customer is different for each of these customer communities, and both are important. In general, the critical drivers of the funding customer’s satisfaction include the delivery interval, cost, and quality of the systems produced, and their focus is aligned with their vision for the future. The using customer’s main concerns tend to be on the feature set, user interface, performance, and system availability and their focus is concentrated more on the short term and performing their day-to-day work. This generalization about the value set of the using customer is supported by Kekre, Krishnan, and Srinivasan who state that their “analysis suggests that though reliability is a significant factor, once an acceptable level of reliability is achieved, three other factors dominate [user satisfaction]: capability, usability, and performance”, in that order.

For this assessment, we collected “customer” input mainly from the funding customers for two reasons:

1. satisfaction of this customer set has a large and direct impact on the Center’s business.

2. the regular user satisfaction surveys are already capturing using customer satisfaction.

To fully understand the voice of the customer, we conducted one-on-one interviews with the following:

- a representative subset of the funding customers (customers),
- all managers of a given level within the Center (stakeholders), and
members of the organization that maintains the systems that the Center produces.

We interviewed the managers within the Center so that the assessment could include an evaluation of how the Center customers viewed the Center as compared to the way the internal managers perceived how the customers viewed the Center. Appendix 2 contains the questionnaire used for the customers. This information is relevant because individuals and organizations are less motivated to implement changes when they perceive that they are performing at or above customer expectations. Kanter, Stein, and Jick stress this point when they cite creating a sense of urgency as one of the “ten commandments” for executing change. Thus, if the members of the Center felt that they were performing at or above customer expectations, while the customers reported that the Center was not, an important step in implementing changes in the Center would be to first educate and inform the organization about this perception gap. In addition, interviewing this cross-section of individuals informally seeds buy-in into the overall assessment and its findings.

From the customer interviews, we were able to identify “value clusters”. These areas are of most value to the customer and should serve as the focus of our efforts. Once we understand the customer’s value clusters, we can refine our thoughts about the golden threads of activities that provide these values. Through a combination of inputs from the baselining effort and from the customer value cluster identification, we can iterate until we have succinctly captured the golden threads.

5.2.2 Translate and Measure

The Center often conducts the translate and measure phases of an assessment together. Using all of the data, both quantitative and qualitative, gathered as part of the capture phase, we next wish to
identify and measure the size of the gaps in performance as measured by the captured customer values.

To make the recommendations resulting from the execution of the Improve phase as fact-based as possible, it is necessary to translate the data captured into a concise form that records the data as objectively as possible and separates fact-based from subjective information. For this assessment, this step consisted of two items:

I. Compile the performance data available on the ten (10) baselined projects. For each project, the Center collects and reports to a central repository a standard set of metrics. Therefore, the performance data collected should be consistently measured against a standard definition. In particular, the primary metrics collected are:

A. Development Cost Ratio

   Actual cost incurred for developing a system release divided by the estimated cost. Costs include the staffing costs from Write Requirements through System Test.

B. Development Function Points per Staff Month

   The total number of function points in a given system release divided by the total actual staff months used to develop the release. Function points are counted by certified function point counters within the Center.

C. Development Interval Ratio

   The actual delivery interval in months divided by the estimated interval.

D. User Satisfaction

   A score derived from user satisfaction surveys.

E. Customer Found Modification Requests (MRs)

   The number of modification requests created by the customer after System Test.
F. Defect Density

The total number of modification requests for a given system release divided by either the thousands of lines of code or the number of function points.

A survey of the central repository found that reporting of these metrics were spotty. As an aside, it is also interesting to assess how well these existing metrics address the determined customer values. If they do not measure the customer values well, then the Center cannot really understand how well it is performing in the eyes of its customer.

II. Determine measurable project characteristics hypothesized to effect the successfullness of a projects and then measure the baselined projects against these characteristics. As with metrics, it is important to report the data collected as consistently as possible so that they can be used as a basis for recommendations and so that they are comparable relative to each other. However, since compiling the data into such a form is laborious and intensive, the team felt it was necessary to measure the baselined projects only in characteristics we believed were most important in determining a project's success in meeting customer needs.

By reviewing the attributes of the projects believed to have an effect of the project's performance, we can identify the root causes of the gaps. To frame the analysis at the appropriate level, it is usually best to concentrate on the top fifteen (15) to thirty (30) root causes. Each one should be mapped back to the gap(s) to which they are contributing. In many cases, root causes map to more than one gap. Visually, it is useful to present the mapping of the root causes to the gaps using a fishbone diagram\textsuperscript{ix}, where, if desired, the root causes could be further exploded into their constituent parts. One fishbone diagram is prepared per gap. If possible, it is useful to measure not
only the size of the gap, but how much each root causes contributes to the gap so that the Center will gain an understanding of the rank ordering of the root causes.

5.2.3 Improve

The improve phase specifies the target environment and technology/systems as well as the specific business implementation recommendations that will close the gaps and move the organization toward its vision. The analysis draws its inputs, which culminate in the improve recommendations, from the projects baselining activities, the benchmarking, and the collection of the customer values through the interviews. The input includes the key activities on the golden threads developed through baselining and customer interviews. Conducting value/function analysis on these key activities helps to understand the contribution of each toward fulfilling the customer values. Any activities providing little or no value and serving no necessary function are candidates for deletion from the process. Activities providing high value are tagged so that they remain in the process. Further reviewing them ensures that they are being executed to achieve their maximum contribution.

Using these inputs, and especially the fishbone diagrams from the Translate and Measure phase, permits us to identify solution characteristics that should remedy, partly or wholly, the root causes, and therefore help us to close the gap to which the root cause is mapped. To identify the solution characteristics, it is effective for the assessors to brainstorm ideas both individually and collectively, much like in the concept generation phase of a standard product development process. Then, using a concept scoring matrix, each assessor can rate how effective s/he thinks that the solution characteristic will be in closing the gap. Through several iterations of this scoring process, solution characteristics can be combined and/or modified to leverage the positive aspects of each and diminish the negative. This combination of concept generation and concept scoring for
selection identifies the top solution characteristics and allows for "out-of-the-box" thinking for creative problem solving.

Next, it is useful for the team, management, and the customer to develop a crisp understanding of the solution characteristics and how effective each will be in closing the gaps. With limited resources, a corporation will want to concentrate on those solutions that contribute most toward closing the gaps. As before, one well practiced method of prioritizing the solution characteristics is to prepare a tailored House of Quality matrix describing how well each solution characteristic addresses each gap. The gaps are placed across the top of the matrix as the column headings and each can be weighted appropriately. For this assessment, we determined the initial weightings of the gaps by combining the Translate and Measure practices applied to the information gathered during the customer interviews. Based on the perceived or stated importances of the customer values discussed during these interviews, the team generated these initial weightings. Then, by reviewing these weightings directly with the customer, we developed the final weightings. Using these finalized weightings, we conducted a sensitivity analysis on them to understand the effect of changes to them on the priority order of the solution characteristics. If the top two or three characteristics remained the same, then we could feel confident that they were the top few that best addressed the gaps. If they changed, then other solutions might have been preferred if the weighting factors were not precisely correct. A similar sensitivity analysis would address the rating factors ("H", "M", "L" or 9,3,1) of solution characteristics upon which the assessors could not agree. In our cases, the top three solution characteristics remained the same.

If the top few solution characteristics had changed, we would have taken several steps to better understand the robustness of the priority order:
1. Revisit the weighting factors with both the team and the customers to verify that the weightings being used are correct and are agreed upon by all parties.

2. Revisit the rating factors assigned to each solution characteristic in closing the given gap to ensure agreement by all parties.

3. Determine the size of the set of solution characteristics that remain the same during the sensitivity analysis. For example, determine that the top six (6) solution characteristics always remain the same set. Report the top few solution characteristics for the agreed upon weightings, but add notes on the additional solutions that might become the most important if the weighting are changed.
6. **RESULTS**

6.1 **Capture**

6.1.1 *Baseline Projects*

Many of the systems baselined faced the same fundamental struggle represented in the following opposing forces diagram:

![Opposing Forces Diagram]

On one hand, each customer had a unique set of needs, requiring a customized application. However, the more customization in any system, the less flexible it is to change and maintain in the future for several reasons:

1. a needed enhancement is more likely to impact many modules of a system's "code" since customization requires that functions be repeated,
2. reuse is hampered because of the customization, which translates into longer delivery intervals for subsequent changes, appearing to the customer as less flexibility, and
3. individuals who work on the system become experts on certain pieces of the system which, since customized, lead them to be less flexible in modifying or enhancing other areas of the system outside of their domain.
4. the Center cannot realize economies of scale across its activities.
In addition to developing criteria used to select the projects, the team captured a number of other factual characteristics for use during the subsequent assessment phases. If the data was not available to populate a value, the data is reported as a "?".

I. Number of interviews - the number of people interviewed for the baselining. The team interviewed fewer people for the smaller projects.

II. Number of releases since 1/95 - some systems bundle many features together and put out few releases per year, others put out releases each time a feature is complete, and some systems have a pre-planned release schedule that incorporates those features that are ready when the releases are put into production.

III. Number of interfaces with other systems - this number represents the number of systems to which the given one must interface for whatever reason. Some of the entries contain a range because the official interface list includes operational work centers, which are not really "systems". The lower number does not include these work centers, whereas the higher number does.

IV. Systems engineering and development in same division - a "y" (yes) response indicates that systems engineering and development report to the same division manager, while a "n" (no) indicates that they do not.

V. Reliability - depending on the impact a mistake in the software can have, the process used for the software development might vary. It is important to capture this characteristic for use during the translate phase of the assessment.

A. "H" (high) - the system reads and writes data directly from network elements

B. "M" (medium) - the systems reads data directly from network elements, but does not write any data
C. "L" (low) - the system neither reads nor writes data directly from network elements.

Table 2 summarizes these factors.

<table>
<thead>
<tr>
<th>Project</th>
<th>Number of Interviews</th>
<th>Number of Releases Since 1/95</th>
<th>Number of Interfaces with Other Systems</th>
<th>Systems Engineering and Development in Same Division</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>Y</td>
<td>H</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>?</td>
<td>?</td>
<td>Y</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>4</td>
<td>16-24</td>
<td>N</td>
<td>H</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>Y</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>?</td>
<td>9-13</td>
<td>N</td>
<td>H</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>5</td>
<td>6</td>
<td>Y</td>
<td>L</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>4</td>
<td>7</td>
<td>Y</td>
<td>L</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>Y</td>
<td>L</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>Y</td>
<td>M</td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>1</td>
<td>2</td>
<td>Y</td>
<td>H/M</td>
</tr>
</tbody>
</table>

Table 2: Summary of Baseline Project Characteristics

As stated in the "Translate and Measure" section (Section 5.2.2, page 40), one basis for evaluation is the metrics collected about each project as part of the standard Center metrics program. Since the data was not always available for all projects and when it was, it sometimes was available over several system releases, the team used some conventions for reporting:

I. If data was unavailable, an "N" was entered in the appropriate category

II. If data was available over several releases, then the most recently reported value was recorded, as well as an indication of the trend up to that point. The trend could be:

A. "\(\uparrow\)" - if the value was on an increasing trend and that trend is desirable  
   "\(\uparrow\)" - if the value was on an increasing trend and that trend is undesirable

B. "\(\downarrow\)" - if the value was on a decreasing trend and that trend is desirable  
   "\(\downarrow\)" - if the value was on a decreasing trend and that trend is undesirable

C. "-" - if the value was steady
D. "?" - if the value was not obeying any clear trend.

Since the exact metric values are proprietary, most of the values were either grouped into categories, e.g., greater than one, or left out completely (indicated by an "o" for "omitted").

III. In the defect density column, a "c" was included after the value if the defect density was based on lines of code and a "f" was included after the value if the defect density was based on function points.

Table 3 specifies the compiled values. See Page 41 for the definitions of the columns in the table.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 1 ↑</td>
<td>N</td>
<td>&gt; 1</td>
<td>N</td>
<td>o ↑</td>
<td>o c ↑</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&gt; 1 ↑</td>
<td>N</td>
<td>1.0 ↓</td>
<td>100</td>
<td>o ↑</td>
<td>o c</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&gt; 1 ↓</td>
<td>o ↑</td>
<td>1.0</td>
<td>52</td>
<td>o ↓</td>
<td>o f</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>&lt; 1</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>o -</td>
<td>o c</td>
<td>tracks reuse</td>
</tr>
<tr>
<td>6</td>
<td>&lt; 1 -</td>
<td>o ?</td>
<td>&gt; 1 -</td>
<td>83</td>
<td>o ↓</td>
<td>o c ↓</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.0 -</td>
<td>N</td>
<td>1.0 ↓</td>
<td>79 ↑</td>
<td>o -</td>
<td>o c ↓</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>&lt; 1</td>
<td>o</td>
<td>&gt; 1</td>
<td>N</td>
<td>o ↑</td>
<td>o f ↑</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>% collected</td>
<td>70%</td>
<td>30%</td>
<td>60%</td>
<td>40%</td>
<td>70%</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td>1.0 ↑</td>
<td>1.0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3: Baselined Projects Metrics**

The team attempted to correlate superior performance, as demonstrated in Table 3, with the attributes found during baselining of projects thought to be contributing to success. However, given the complexity of the circumstances of each system release, variations in the way the metrics were collected, and spotty reporting of the metrics, this analysis did not reveal any significant trends or
correlation of the practices/findings to performance. For example, data on how well a system release met its committed due date is available, but one cannot tell if the release contained all of the feature content promised in the commitment or whether some content was deferred to a later release. To date, the author has not seen a widely accepted industry standard on appropriate metrics to measure the effectiveness of the software built. Since the objective of some of the metrics is to measure the software’s success in providing customer value, each software development effort might be somewhat different and an organization should evaluate how well its metrics capture customer values.

6.1.1.1 Organizational Factors

By itself, an organizational structure cannot guarantee the success of an organization, nor can it ensure failure. However, the structure can act as an enabling force to make the objectives it supports easier to accomplish. To fully understand the software development environment in which the Center operated at the beginning of the assessment, one needs to appreciate the organizational influences characterized from three (3) different perspectives: strategic, political, and cultural. Within the scope of this thesis, it is not possible to document a full evaluation of every organizational factor, therefore, we discuss only general factors at play in each of the perspectives.

From a strategic perspective, the vision of the Center guides the decisions made. A primary force at play is the expansion of AT&T business into new domains, e.g., global markets, local telephony service, which cascades into an expansion of the Center’s business from its traditional services to those including support of these new markets. By leveraging its organizational learnings and core competencies, the Center can develop competitive solutions for the new internal customers who are addressing these new markets. As the more traditional funding streams are pressured to reduce their budgets each year, resources can be redeployed to address these new internal customers and
develop new partnerships strategic to the success of AT&T. As the Center's customer mix evolves over time, the software development process must be flexible enough to support the also-evolving customer values, of which time to market is predicted to remain a driving factor.

The political perspective revolves around power. One form of power in the Center, which is present in most organizations, is the power to make decisions. The potential impact of any decision can vary and in general as the impact grows, so does the desirability to have the power to make that decision. It is critical to the success of any organization, therefore, to clearly define the roles and responsibilities of all team members and to carefully manage the interface between their organization and others outside of the organization. If an organization does not understand and/or accept the decision making authority of others, then its attitude will be evident by the lack of support and adherence to the decisions handed to it. If an organization wants to be truly customer-focused, then it must candidly discuss and resolve any conflicting objectives before the relationship can mature. A few years ago, AT&T moved the high level system engineering responsibility out from the Center into a separate organization. In the time elapsed since, the two organizations have been working to clearly define the interface between them so they might work together for the good of the corporation. Some tension existed during this process as they strove to function as partners instead of as in a vendor-supplier relationship. As the relationship matures, their ability to work together effectively increases and the focus can move to delivering the product.

The Center's success or lack of success is related to its culture. One of the clearest examples of the Center's culture negatively impacting its success is the pervasiveness of "single software application thinking", which the team found during the baseline interviews and which was cited by the customers during their interviews as well. "Single software application thinking" occurs when
an individual limits the feasibility and solution space associated with a request because that
individual concentrates on the possibilities and limitations imposed by the one system (software
application) on which s/he works. This style of thinking is reinforced by a culture in which an
individual identifies themselves with a system, funding is allocated on a per system basis, and
groups are structured by the system on which they work. One of the executives interviewed as part
of this assessment described the Center as “system-centric”. In order for the Center to be
successful, the culture must change to allow individuals to think across systems and be focused on
satisfying customer needs.

The Center has had limited success in moving to the “new organizational structure” of networked,
flat, flexible, diverse, and global.\textsuperscript{11} The Center does exhibit many of the characteristics of a
networked and diverse organization. It is highly team-based and the teams are composed of
individuals from a variety of backgrounds. The Center does not, at present, exhibit all the
characteristics of a flat, flexible, and global organization.

\section*{6.1.2 Benchmark}

For the purposes of this thesis, we cannot divulge company names and information because of
proprietary restrictions.

We used the House of Quality given in Appendix 3 originally to prepare a lower level House of
Quality that contained the selection criteria mapped against the companies under consideration.
Due to the large number of companies being considered, to fit the matrix on a single page for
review, we chose the selection criteria as the columns and the companies as the rows. Appendix 5
and Appendix 6 give an outtake of this second House of Quality. The team evaluated each
company considered against the characteristics given in Appendix 3, with particular emphasis on
those characteristics that received the highest desirability ratings. Evaluating a company against each characteristic was not simple because there often was no quantitative measurement. Rather, the team collected information on the company related to that characteristic and then rated it based on the aggregate available data. Appendix 7 specifies the results of all of the secondary matrix and the scoring using the Pugh matrix concept.

6.1.3 Customer Values

After interviewing the customers and stakeholders, the team categorized the primary value clusters of the Center’s customers (funders) into the following five areas:

1. Ability to meet the customer requested due date (referred to as CRDD).
2. Once the Center has specified a time and cost commitment, meet it.
3. The quality of the relationship between the Center and the funder.
4. The usability of the system.
5. The cost of the systems development work.

As summarized in Appendix 8, based on the interviews, the first three items were clearly the most important and the last item was clearly a distant fifth. The appendix also summarizes the customer’s perceptions of how well the Center is performing in these areas. A full evaluation of these findings is done in the “Translate and Measure” section (see Section 6.2.2).

All the customers voiced a need for value cluster #1, meeting the customer requested due date. These customers want to be able to go to the Center, request a set of features needed to satisfy a business need, and inform the Center of the date by which the business needs it. The desired response of the Center to the customer would be a commitment to deliver the set of needed features, by the date given, at the specified cost. If the Center does not meet the CRDD, usually either the customer incurs additional costs or is put into a position of competitive disadvantage.
Meeting commitment, value cluster #2, is also very important to the customer. Once the Center gives a commitment, it should be that commitment 100% of the time. Meeting commitment includes meeting the date on-budget and with all of the feature content promised. Once again, of primary importance to the customer is meeting the date.

Finally, value cluster #3 is the quality of the relationship between the Center and the customer. Frequent, honest, open communication is needed to satisfy the customers. They want to be kept abreast of the status of projects and notified in advance if any of them are in jeopardy. They want the Center to partner with them to outline risk assessments and contingency plans and for the Center to be proactive in providing solutions.

6.2 Translate and Measure

6.2.1 Baselined Projects

We baselined ten projects as part of this assessment. In order to identify the root causes of the gaps and to recommend potential solutions, the team needed to capture the attributes of these projects believed to be contributing to the project’s success or failure. For consistency, we evaluated all attributes believed to be important over all of the projects. First, we identified all of the key attributes, then we specified how to measure a project against the attribute and, finally, we evaluated each project based on the measures. The attributes were organized into three areas - people, process/technology, and business - which correspond to the three components of the Center’s vision. Table 4 summarizes the attributes and their chosen measures.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivated by Business Needs</td>
<td>The level to which the majority of the interviewees understood the business needs and the value and/or consequence to the company of making and/or missing their delivery commitment.</td>
</tr>
<tr>
<td>Attribute</td>
<td>Measure</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>End to End Ownership</td>
<td>The degree to which some individual on the team was responsible from the definition of the need through delivery.</td>
</tr>
<tr>
<td>Systems Engineers Involved in High Level Requirements</td>
<td>The degree to which the systems engineer participated in the development of the high level requirements (which is their input).</td>
</tr>
<tr>
<td>Detail of System Requirements</td>
<td>The level of detail contained in the system requirements as judged by how useful team members downstream of the requirements process found the system requirements.</td>
</tr>
<tr>
<td>Dedicated User Focus Role</td>
<td>The existence of a role on the team dedicated to evaluate user interface issues and represent user needs.</td>
</tr>
<tr>
<td>Technical Interface With Customer</td>
<td>The degree to which the technical staff (non systems engineers) interacted with the customer directly during the solution definition phase.</td>
</tr>
<tr>
<td>Development Involvement Early</td>
<td>The level of involvement of the downstream developers in the front-end process, e.g., solution definition or requirements writing.</td>
</tr>
<tr>
<td>Proactivity</td>
<td>The number of examples of proactive behavior in proposing unsolicited solutions by the project to the customer.</td>
</tr>
<tr>
<td>Visits to the Operations Centers</td>
<td>The extent to which the project team members visited the operations centers in person.</td>
</tr>
<tr>
<td>Satisfaction With the High Level Requirements to Center Handoff</td>
<td>The level of satisfaction project team members expressed about the interaction and handoff between the high level systems engineers and the project team members.</td>
</tr>
<tr>
<td>Project Management</td>
<td>The extent to which a project manager existed and was empowered and effective in making decisions.</td>
</tr>
<tr>
<td>Use of jumpstarts</td>
<td>The level of usage of jumpstarts by other organizations/people when the project team needed to learn a new tool or technology.</td>
</tr>
<tr>
<td>Team Spirit</td>
<td>Team spirit as measured by the degree of elation and enthusiasm expressed by interviewees.</td>
</tr>
<tr>
<td>Willingness to Use Recommendations</td>
<td>The level of willingness to follow the guidelines/mandates regarding standards and technology tools and components.</td>
</tr>
<tr>
<td>Rotation in Roles</td>
<td>The degree of rotation of project team members into other roles.</td>
</tr>
<tr>
<td>Buy-In to Commitment</td>
<td>The level of buy-in interviewees expressed to the accuracy and feasibility of the time and cost commitment given, regardless of whether they had input or not.</td>
</tr>
<tr>
<td>Effectiveness of Post Mortems</td>
<td>The degree to which projects have post mortems and the level to which they implement the findings.</td>
</tr>
<tr>
<td>Effectiveness of Communications Within the Project</td>
<td>The degree to which team members were kept informed of changes and progress.</td>
</tr>
<tr>
<td>Object Oriented Design Practiced</td>
<td>The level of usage of object oriented analysis, design, and/or development.</td>
</tr>
<tr>
<td>Re-use Considered Up-Front</td>
<td>A measure of how early in the solution definition and development process that re-use of any kind was considered.</td>
</tr>
<tr>
<td>Level Re-Use</td>
<td>The amount of reused components in the final product.</td>
</tr>
<tr>
<td>Use of Standards and Technology Recommendations</td>
<td>The level of use of the recommendations of those evaluating and defining standard tools and components.</td>
</tr>
<tr>
<td>Attribute</td>
<td>Measure</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Systems Engineers Involvement in Testing</td>
<td>The level to which the systems engineers were involved in defining and/or executing test plans.</td>
</tr>
<tr>
<td>Testing Involvement Up-Front</td>
<td>A measure of how early in the solution definition and development process that testers were involved.</td>
</tr>
<tr>
<td>Automation of Test</td>
<td>The level of automated testing.</td>
</tr>
<tr>
<td>Concurrency in Process</td>
<td>The degree of concurrency occurring between steps in the software development process.</td>
</tr>
<tr>
<td>Document Change Control</td>
<td>The level to which changes to any documentation are controlled and changes communicated.</td>
</tr>
<tr>
<td>Use of Prototype</td>
<td>The extent to which prototypes were used on the project.</td>
</tr>
</tbody>
</table>

Table 4: Project Attributes and Definitions

Appendix 9 gives the results of this translation and measurement. From these results, the team noted high variation among projects in the Center. For example, in the row titled "dedicated user focus": three (3) projects had a low rating because they had no dedicated person focused on the user; three (3) projects had a medium rating because they had one or more people who had a user focus but did not have any single person dedicated in this role; and four (4) projects rated highly because they had a single, dedicated person in this role. Because of widespread variation and the complexity of factors affecting a project’s performance, we could not match single attributes with superior or inferior performance. Therefore, we applied our subjective assessment to this data and the opinions of the interviewees to abstract the attributes into the root causes of the gaps. The team looked for external evidence to corroborate the subjective beliefs. For example, the following scenario would help the team to rate a project in the category of "detail of system requirements". An interviewee might say, "The requirements specifications were not adequate for me to be able to design and code from. Things that were missing from the requirements included ...". The interviewer might then be shown another document written separately from the requirements, but which contained the additional information needed. This case would be an example of subjective opinion corroborated by external evidence that shows the types of information needed to design and code from the requirements specifications. As another example, the following scenario would help
the team to rate a project in the category of “use of standards and technology recommendations”. The interviewee might explain that “a standard component recommended to be used in his project did not meet the project’s needs”. The interviewer might then be shown a report written by the project that outlined the recommended component deficiencies followed by a formally written letter granting the project an exception from the standard. In this case, by comparing the dates on the report and the letter, the interviewer could determine the amount of time spent securing the exception.

While we cannot disclose the exact root causes that we identified because of their proprietary nature, the list included seventeen (17) items. We saw a correlation between the findings from this assessment and those reported in previous studies. For example, Lubars, Potts, and Richter found that two of the most significant requirements problems were “accurate problem domain knowledge” and “requirements volatility”. Other sources, such as Pressman, provide a comprehensive discussion of the many factors that cause software production to be so complex.

6.2.2 Customer Values

In order for any business to be successful, it must attract customers, provide a product or service to fulfill their needs, and maintain those customer’s satisfaction so that they will provide positive advertisement and potentially repeat business. Jones and Sasser point out that “except in a few rare instances, complete customer satisfaction is the key to securing customer loyalty and generating superior long-term financial performance.” For software development in the Center, the customer value model can be viewed as shown in Figure 4.
The customer is in the center of this ring. As long as the ring remains continuous without any breaks, the customer will be kept inside and be satisfied. However, if any piece of the ring contains a flaw, the ring will break and the customer might leave. In the Center’s software development business, the three critical pieces to the ring are solution development, system deployment, and maintenance. While the Center does not have direct control over all these factors (for example, an internal support organization maintains a system after it has been deployed), successful execution of all of these areas is needed to achieve customer satisfaction. Therefore, during solution development, the Center must consider life cycle management, including such items as:

- maintainability - adding provisions into the solution that allow support personnel to analyze and diagnose problems that arise after deployment.

- flexibility - modularizing the solution enough so that minor changes can be incorporated without a major development effort and more sizable changes can be achieved without rearchitecture.
• training & support - a user-friendly on-line help feature makes the system release easier to deploy and maintain.

Customers are concerned with the total lifecycle cost of the product, not just the initial development costs.

Specific to the solution development piece, once the capture phase is complete, gap definition and analysis can be done through the following four (4) steps:

1. Recognize the customer value clusters.

2. Measure the Center’s performance against those values.

3. Define gaps: where the Center’s performance does not achieve customers’ expectations.

4. Identify the “golden threads” of activities that impact the Center’s ability to provide value.

As reported in Section 6.1.3 “Customer Values”, after completing the first and second steps, we found the following five (5) value clusters: Meet the Customer Requested Due Date (CRDD), Meet Commitment, Quality of Relationship, Usability, and Cost.

As seen in Appendix 8, the Center was not performing up to customer expectations in any of the value clusters, as perceived by the customers. In addition, the team found a large difference in the perception of the Center’s performance between the managers of the Center and the customers. One of the most significant differences is that while meeting the customer requested due date (CRDD) is the most important customer value, it did not even come up during the Center managers’ interviews. Clearly the first step in closing this gap would be to highlight to the entire Center the importance of this customer value. There is no single cause the team could identify for
the performance perception difference. However, we felt that some of it is due to the evolving needs of the AT&T business that translate into evolving needs of the Center's customers. Due to increasing competition, delivery of solutions when needed has become a major driver for success. In the past, cost had been a dominant driver and people have developed proficiencies in measuring and reporting costs; however, cost has now taken a second seat to timeliness. Paul Allaire, chairman and CEO of Xerox, echoes this perspective citing "a fundamental change in customers' requirements and competitive forces" as drivers for process changes at Xerox.

In general, the team made the following observations based on the data given in Appendix 8:

- The areas of highest value to the customer are not recognized as such by the Center.
- Center managers perceive the performance of the Center to be generally better than the customers perceive it to be.
- The one area in which the Center managers perceive there may be a problem - cost - is not a major concern to the customers.

The team must address these items during the Improve phase.

For step #2, we could also attempt to evaluate the Center's performance based upon the metrics collected. However, not only were the metrics inconclusive (see Section 6.1.1), but they also did not relate to the customer value clusters as can be seen by mapping in Table 5, where "H" = high, "M" = medium, "L" = low, and "N" = no correlation.
Table 5: Mapping of Current Metrics to the Value Clusters

Table 5 demonstrates that the Center could improve its measurement of the customer value clusters.

Therefore, overall, all five of the value clusters represent gaps, so there are also five gaps.

Focusing on the top three value clusters, the team identified three (3) “golden threads”:

1. Estimation/Commitment
2. Delivery
3. Quality of Relationship.

Success of the enterprise can be measured by its performance along the dimensions of the golden threads. Table 6 summarizes some of the possible measurements of the three golden threads.

Table 6: Measurements of the Golden Threads

In these measurements, we make a distinction between “on-time” and “time to market”. “On-time” refers to the Center’s ability to deliver the product by the date committed. “Time to market”, on the
other hand, refers to the Center’s ability to deliver solutions by the customer requested due date, which translates into a shorter delivery interval compared to the Center’s current performance.

For the Center to be successful, it must develop a metrics program that measures the factors important to the customer (with Table 6 providing some examples of possible measurements) and find ways to improve its performance along the golden thread activities. The next section focuses on the improvements identified by the team.

6.3 Improve

In Section 5.1 on “The Business Transformation Process”, we stated that “The assessment phase generally produces two outputs, a set of incremental improvements that can be implemented as appropriate in the current environment and a set of re-engineering opportunities for the next phase, redesign.” Such recommendations arise as outputs of the Improve phase of the assessment methodology. For this assessment, the team developed a 1999 target view to address the gaps it had identified and that incorporated the derived solution characteristics to specify a complete view of the target environment. In addition, we also outlined a 1997 view to add understanding about the transition from the current environment to the 1999 target environment.

As described in the methodology discussion of Section 5.2.3 on “Improve”, we defined solution characteristics - ten (10) in total - that would close the gaps and address the differences in performance perception discussed in Section 6.2.2. We cannot describe these characteristics in this thesis due to their proprietary nature. As described in this same section, we prepared a House of Quality Matrix using a variety of weighting factors.
Appendix 10 gives one such matrix. Clearly, solution characteristic “B” is the most important since it is ranked number one and highly addresses three out of four of the gaps. As offered in the “Results and Learnings” section, three overriding target process characteristics resulted:

1. The process should enable a greater amount of reuse of components and tools than is practiced today, leading to an environment that achieves a higher level of integration. Mili, Mili, and Mili\textsuperscript{taxi} state that “Lanergan and Grasso estimated that 60% of business applications can be standardized and reused” and that “generally, potential (estimated) and actual reuse rates range from 15% to 85%.”

2. The organization creating and maintaining software should continuously review its desired core competencies to ensure that they support the needs of the business and allow the best use of resources.

3. The organization should strive to foster a closer relationship with its customers so that it can truly understand their needs as well as be more proactive in solving them.

If the Center can put a process in place that achieves these three solution characteristics, the team expects its performance in the top three customer values - meeting customer requested due date, meeting commitment, and quality of relationship - to improve drastically.

6.3.1 Organizational Factors

To succeed in achieving its vision, the Center needs to address the organizational factors discussed from the strategic, political, and cultural perspectives in Section 6.1.1.1. In particular, it should strive to achieve better boundary definition and management with the high level systems engineering organization and must purge the “single software application thinking” that seems to be prevalent today.
If the Center is to achieve "new organizational structure", it should place emphasis on becoming flat and flexible. When an organization reduces the layers of management and becomes flatter, individuals must assume more responsibility for negotiating issue resolution with their partners and customers rather than relying on management for this purpose. Careful attention should be paid to the incentive and career structures to maintain the employees' motivation. To be more flexible, individuals will need to be able to multitask in numerous different environments, adapting as the needs of the business evolve\textsuperscript{xxvii}. 
7. **Areas for Further Study**

This assessment represents the first phase of the AT&T business transformation process. If the performance gaps are considered large enough to require dramatic change, the Center would need to use the assessment findings as an input to the redesign phase. In that stage, the Center should focus on redesigning the software development process to meet and exceed the customers expectations and begin to formulate a strategy for implementation. Particular emphasis should be placed on defining a process that addresses the three recommendations suggested by the assessment.

The assessment and business transformation process that we have used in this thesis have potential application to the re-engineering of other software and non-software development processes within and outside of AT&T. For example, the service industry, such as financial services, could benefit from its application. The assessment procedure has shown how modern engineering and management methods as embodied in such techniques as the House of Quality and organizational analysis, can provide a systems perspective that permits an organization to elicit and combine customer needs with its own internal capabilities to better achieve its core mission and business objectives.
Appendix 1: Sample List of Questions for Baselining

SDP Assessment - Baselining Questionnaire

Organizational Model and Culture

- What is your division charter?
- Project Team Organization
  - Size (within Divisions, Districts, sub-teams)
  - Location of team members
  - Effectiveness of structure; changes to enable OOT?
  - Resource Allocation
  - Turnover Ratio (is this good or bad?)
- Standards/Technology
  - Who do you work with for new technology?
  - Is there a need to have new technology groups within project teams?
  - Do you interact or share within your division, Center, across AT&T?
- Rewards/Incentives
  - What types of rewards and when are they deployed (e.g., re-use, milestone celebrations)?
  - Are these satisfactory and considered good?

Roles and Responsibilities

- What is your role on the project team? How long? Do you like your job?
- Have you had experience in any other roles? Could you fill any other roles? Would you like to? What do you think of the generalist role?
- Who do you interact with (in and out of project team) to get your job done?
- Are there different testing roles (e.g. independent testing teams for system integration, unit testing)?
- Who is responsible for any interface applications?
- Are there any unique roles on your project? What and why?
- Who (management level) reviews milestone charts and receives progress/obstacles reports regularly?
- Who is responsible for the user documentation?
- Are there any critical members of the team (is it the role or the person)?
- Who is responsible for defining tools used? Examining vendor products?
- Who controls and maintains re-usable components?
• Do you interact with AT&T Laboratories research? For what purpose?

System Characterization

• Who are your customers and users? What is your system’s functionality?
• Do you perceive your customers and users to be happy?
• What is the size of your system?
• How important is reliability? What is its characteristics (e.g., 7x24)?
• What existing software platforms/components have been incorporated and what percentage do they constitute?
• How old is your system? When was release 1.0?
• What types and frequency of releases (e.g., new features, maintenance)?
• Are there any system interfaces? Do they follow standards?
• Are personal computers deployed for your system? Does any of the software reside on the PC?
• What are your system's key strengths and weaknesses?

Process

• Describe the process you follow for your work:
  — Inputs (standard format) and suppliers
  — When do you begin? Do you wait for your inputs to be complete?
  — Outputs and customers
  — Do you have formal reviews of your outputs? Are they required?
  — How do you document your work (e.g., use of templates)?
  — How and when are system interface documents written?
  — Are there entrance criteria for each phase of the project? Are they followed or just guidelines? Do you ever violate the criteria and why?
  — How many simultaneous releases are being worked? How does the process address this?
  — What level and degree of interaction does your work have with the other groups (e.g., systems engineers, designers, coders, testers, etc.)?
  — What customer interaction do you have?
  — How are changes managed and communicated once a step in the process is complete?
  — How are exceptions and expedite needs handled by the process?
  — How often is your role involved (e.g., Sy.: Eng., Architect) in a release?
  — What kinds of testing is performed in each phase of the project (e.g., Unit test, integration test, system test)?
  — What standard methodologies are used (e.g., structured design, OOA)?

• What work do you perform which does not contribute to the end product?

• Are business cases written for features? Who contributes to the business case? Are they ever updated or verified after project deployment?

Prototyping
  — Do you? If so, what? Is the customer involved?
— What benefits are achieved?
— What happens to the prototype once it is completed?

• Re-Use
— When in the process is re-use first considered?
— What emphasis is placed on identifying re-usable software components?
— How do you identify potential re-use; what criteria is used?
— Have any components been considered and rejected? Why?

• Project/Release Management
— How are releases scheduled and content decided?
— How are releases tracked and managed?
— How are time and cost estimates done?
— What factors impact the time to market of a release?
— How are resources allocated?
— What project management methods are used?
— Are regularly scheduled project meetings held? Are they effective?
— How often are projects killed prior to Q4? Are post-mortems done on struggling or killed projects? What is learned?

• How are user documentation needs satisfied?

• Process Evaluation
— Is the process you follow good? What are its shortcomings?
— How flexible is the process? Do you ignore parts of the process?
— How has ISO certification impacted your work?
— Have improvements been successful? Do you identify opportunities?
— What are the biggest obstacles inhibiting your productivity?

• How do you communicate with project members? Is this formal?

• Training
— Is the process you described documented? By who? Where?
— Is the documentation adequate?
— What is the training curriculum for new and continuing team members?
— Were you trained?

Technology

• Process Support and Documentation Tools
— Documentation tools
— Requirements generation
— Project management
— Time and cost estimation
— Automated test tools
— Automated tools (e.g., email, gantt charts, spreadsheets)

• Software Development Environment
— Programming environment
— Debuggers
— Configuration management
— Version control
— Build tools

• Object-Oriented Environment and Tools
— What tools?
— Does primary language support OO implementation?
— Characterize the degree of OO (none, low, medium, high)
— Is rate of OO increasing or decreasing on your project? Why?
— Do you have an object repository? Who built or provided it?
— Do you have any object-oriented data stores?
— What percentage of staff has had minimum of 40 hours of OO training?
— What percentage of staff has experience in applying OO?
— What difficulties or successes have you experienced in using OO?

• Re-Usable Components
  — What components would be useful but are not available?
  — Were any design algorithms re-used?

• Do you use any vendor-supplied tools or systems? How were they identified and decided to be used?

• What benefits of re-use have you seen?

• What is your experience with internally generated tools?

• Do you feel these tools are effective?

Measures and Targets

• What is the actual time and elapsed time it takes you to perform your work?

• How much time do you spend time doing things which do not directly contribute to your product (e.g., human resources, training, email)?

• Percentage of your work dedicated to new features vs. maintenance?

• What metrics do you collect? Who collects them?
  — Project progress (milestones)
  — Process effectiveness and efficiency (cost, time)
  — Customer metrics (time to market, on-time performance, defects)
  — Effectiveness of tools
  — Amount of re-use, Degree of OOT
  — Process adherence (e.g., reviews and inspections)
  — Training
  — Accuracy of time and cost estimations
  — Defects found during different stages of test
  — Post-mortem

• Who defines the metrics and sets targets?

• How do you use this information? For improvement?

• Do you share your metrics with the customer? Do they agree on the metrics?

Value Chain Reconfiguration

• What software vendor products are used? Are any applicable?
  — Customized
  — Off-the-shelf

• Do you think using other vendor products will impact our ability to meet time to market demands?

• What degree of emphasis is placed on examining vendor products?
• Is your experience favorable or dissatisfying when using such products?

**Closing**

• What are your thoughts concerning the Center's vision?
• What does integration mean to you?
• What is your wish list? Your ideas for improving?
Appendix 2: Sample List of Questions for Customer Interviews

SDP Assessment - Customer Questionnaire

Customer Challenges in 1996 and Beyond

- What are your business objectives?
- What are your customers' needs?
- What initiatives are underway?
- What are your performance goals?
- What are the critical factors for success (Customer Value Added, People Value Added, Economic Value Added)?
- What are the risk factors impeding your success?

Your Process for Satisfying IT Needs

- What is your process for satisfying your information technology needs?
- Do you prepare business cases? If so, who does?
- What information do you need from potential providers? What information do you get?

Opportunities for the Center in Meeting Your Challenges

- How can the Center assist you in attaining your objectives?
- How could the Center impede your progress?

Your Perception of Center Values

I. Which of these values are important to your business?
   A. Product/Service
      1. Quality (high reliability, usability)
      2. Ease of migration/re-use
      3. Smoothness of introduction
      4. Speed for problem resolution
      5. Release Schedule (content, frequency)
B. Time to Market
   1. Overall cycle time
   2. Schedule flexibility when required
C. On-time performance
   1. Accuracy of estimates
D. Cost
   1. Competitiveness of price
   2. Accuracy of estimate
E. Information
   1. Single point of contact
   2. Communication (status, education)

- How would you prioritize these needs? Do they vary by project? What are the future trends?

Your Perception of the Center’s Performance

- What are your perceptions of the Center’s performance on these values? How do you base your perception?
- Have your expectations changed?
- Have there been any changes for the better or the worse?
- What is your most satisfying and dissatisfying experiences?

Ideas for Breakthrough Improvement

- What are your ideas?
Appendix 3: House of Quality Mapping Customer Requirements to Benchmarking

Selection Criteria

<table>
<thead>
<tr>
<th>Customer Requirement</th>
<th>Weight</th>
<th>Revenue/Growth/Market Position</th>
<th>SEI Rating/Capers-Jones</th>
<th>Awards</th>
<th>Level of Systems Integration</th>
<th>Technology Use</th>
<th>Reduced delivery interval</th>
<th>Customer Composition</th>
<th>Industry</th>
<th>Size of Company</th>
<th>High reliability importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short cycle time</td>
<td>35%</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td>33%</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High quality/reliability/performance</td>
<td>10%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td></td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large feature set</td>
<td>5%</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accurate estimates</td>
<td>12%</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy to use</td>
<td>5%</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>4.5</td>
<td>4.8</td>
<td>2.3</td>
<td>6.7</td>
<td>2.9</td>
<td>4.1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 4: Benchmarking Questionnaire Topic Sets

The following are the topics covered by the benchmarking questionnaire used during all exchanges:

1. System Development Function Overview
2. Process
3. Systems Characterization
4. Roles and Responsibilities
5. Technology
6. Value Chain Reconfiguration
7. Organizational Model
8. Metrics
## Appendix 5: Second Matrix Used to Evaluate Companies

<table>
<thead>
<tr>
<th>CO.</th>
<th>REVENUE/GROWTH/ PROFITS</th>
<th>MARKET POSITION</th>
<th>INDUSTRY</th>
<th>CUSTOMER PROFILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company AA</td>
<td>Revenue $5B; IS budget $100M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the (segmented) aerospace industry:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Largest (total assets (latest annual)) - $22 Billion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Most Valuable company (market value at 3/22/96) - $30.6 Billion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Most Expensive Stock (Price/Earning ration at 3/22/96) - $77.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 2 1995 and 1994 ranking in relative market share (No. 1 in '91 - '93)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'91 - 50.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'92 - 49.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'93 - 46.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'94 - 32.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'95 - 30.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5 yr. % change is -40.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aerospace - Aircraft Engines and Engine Parts; Aircraft; Aircraft Parts and Auxiliary Equipment; Airports, Flying Fields and Airport Terminal Services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company BB</td>
<td>Private Company; 223 employees;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revenues - more than $70 Mil (up $30 Million in a recent year); Founded 1982; 1993 Sales: $50,400,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader in OO technology, recently merged with an information systems company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Services: developer of CASE Software Tools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.1M customers, most residential, Microsoft is one customer.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company CC</td>
<td>Revenue $32B; Income $3.4B; IS budget $1.5B; Rated #19 Fortune 500 1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 4 1995 ranking in relative market share (5 yr. % Δ is 227.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'91 - 1.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'92 - 2.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'93 - 3.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'94 - 4.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'95 - 5.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computers, Subsystems and Peripherals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company DD</td>
<td>$3.4 Billion (Total 1995)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1 Billion (Systems Management Revenue)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33,000 Employees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Recognized for data systems outsourcing expertise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Working on recognition for distributed systems capabilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Expand global presence through contracts with multi-nat'l cust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IT and business operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customers include: Commercial and Federal Sectors, Southern New England Telephone, Lucas Industries, Polaroid, Hughes Electronics, Mutual of NY.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

1 This matrix was populated for all companies evaluated. Only a sample is given here.
## Appendix 6: Second Matrix Used to Evaluate Companies for Benchmarking - Page 2

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>SEI RATING/ CAPER-JONES</th>
<th>AWARDS</th>
<th>DEVELOP SOFTWARE?</th>
<th>RELIABILITY IMPERATIVE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company EE</td>
<td>Level 5 (Space Shuttle Program)</td>
<td>MIS Dept - Society of Info Mgt (91); 1992 MBNQA - DEFENSE SYSTEMS &amp; ELECTRONICS GROUP</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Company FF</td>
<td>DSEG Test Engineering Dept internally appraised at SEI Level 2 and is currently working towards Level 3. (1995)</td>
<td>NASA 1995 Contractors Excellence Award for Quality and Productivity</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Company GG</td>
<td>SEI Level 2 and is currently working towards Level 3. (1995)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>LEVEL OF SYSTEMS INTEGRATION</th>
<th>TECHNOLOGY USE</th>
<th>REDUCED DELIVERY INTERVAL</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company HH</td>
<td>Defect rate 0.5-0.7 / KNCL; Spiral approach used for overall process</td>
<td>Leaders in OO</td>
<td></td>
<td>Supplier to AT&amp;T; Recommended by C. Jones as Best-In-Class</td>
</tr>
</tbody>
</table>
| Company II | • Data center outsourcing - long standing competency  
• Developed strong capabilities to assist customers in managing their networks and distributed systems | Has a Technology Management Group (TMG), 1 of 5 major operating units, that manages its commercial IT outsourcing. Focuses on process and management as it does on technology. |                           |                          |
| Company JJ | Automate entire product development process | Open hardware; CAD/CAM |                           | Evidence - helped customers to reduce       | Known for precision |

---

2 This matrix was populated for all companies evaluated. Only a sample is given here.
### Appendix 7: Pugh Chart Used For Benchmarking Company Selection

<table>
<thead>
<tr>
<th>Industry</th>
<th>Company Name</th>
<th>Financial Rating</th>
<th>Software Process Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace</td>
<td>Company A</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Company B</td>
<td>M</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Company C</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company D</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Company E</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Computer (Hardware)</td>
<td>Company F</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Company G</td>
<td>L</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Company H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company I</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company J</td>
<td>L</td>
<td>?</td>
</tr>
<tr>
<td>Computer (Software</td>
<td>Company K</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Services)</td>
<td>Company L</td>
<td>L</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Company M</td>
<td>M</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Company N</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company O</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company P</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company Q</td>
<td>H</td>
<td>?</td>
</tr>
<tr>
<td>Electronics</td>
<td>Company R</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company S</td>
<td>M</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Company T</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company U</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Company V</td>
<td>H</td>
<td>M</td>
</tr>
</tbody>
</table>
## Appendix 8: Customer Values

### Importance Rankings

<table>
<thead>
<tr>
<th>Customer</th>
<th>CRDD</th>
<th>Meeting Commitment</th>
<th>Quality of Relationship</th>
<th>Usability</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process 1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Process 2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Process 3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Process 4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Center Executive</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center Managers</td>
<td>1</td>
<td>4</td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

### Perceptions of Performance

<table>
<thead>
<tr>
<th>Customer</th>
<th>CRDD</th>
<th>Meeting Commitment</th>
<th>Quality of Relationship</th>
<th>Usability</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process 1</td>
<td>9-12 months</td>
<td>Poor</td>
<td>Crisis management</td>
<td>n/a</td>
<td>Not a concern</td>
</tr>
<tr>
<td>Process 2</td>
<td>2 years</td>
<td>Poor</td>
<td>Not proactive; barriers exist</td>
<td>Not discussed</td>
<td>Not a concern</td>
</tr>
<tr>
<td>Process 3</td>
<td>Impeded progress</td>
<td>Never</td>
<td>Need more partnered learnings</td>
<td>Poor - need to make job simpler</td>
<td>Probably too high</td>
</tr>
<tr>
<td>Process 4</td>
<td>Not considered</td>
<td>Poor - hierarchical structure impedes progress</td>
<td>Not acting like partners</td>
<td>Center doesn't understand the environment</td>
<td>Inflated 40%</td>
</tr>
<tr>
<td>Center Executive</td>
<td>Too long</td>
<td>Not discussed</td>
<td>Not discussed</td>
<td>Low - includes availability</td>
<td>Future concern</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center Managers</td>
<td>Did not come up in discussions</td>
<td>70%</td>
<td>Generally good</td>
<td>Generally good</td>
<td>May be too high</td>
</tr>
</tbody>
</table>
### Appendix 9: Mapping of Baselined Projects to Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
<th>Project 4</th>
<th>Project 5</th>
<th>Project 6</th>
<th>Project 7</th>
<th>Project 8</th>
<th>Project 9</th>
<th>Project 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivated by Business Needs</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>End to end ownership</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Systems Engineers Involved in High Level Req'ts</td>
<td>●</td>
<td>n/a</td>
<td>n/a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Detail of System Requirements</td>
<td>n/a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Dedicated User Focus Role</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Technical Interface with customer</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Development involved Early</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Proactivity</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

### LEGEND

<table>
<thead>
<tr>
<th>Level Of Achievement</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (most desired)</td>
<td>●</td>
</tr>
<tr>
<td>Medium (partially achieved)</td>
<td>●</td>
</tr>
<tr>
<td>Low (minimally achieved)</td>
<td>●</td>
</tr>
<tr>
<td>Unknown</td>
<td>Blank</td>
</tr>
</tbody>
</table>
Appendix 10: Prioritization of Solution Characteristics

<table>
<thead>
<tr>
<th>Solution Characteristics</th>
<th>CRDD</th>
<th>Commitment</th>
<th>Gaps Relationship</th>
<th>Usability</th>
<th>Cost</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>25</td>
<td>.25</td>
<td>.20</td>
<td>.20</td>
<td>.10</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>J</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

- High Impact on Closing Gap
- Medium Impact on Closing Gap
- Low Impact on Closing Gap
REFERENCES

i Datapro Management of International Telecommunications, "Basic Concepts of Communications", MIT20-600-119.


vi Brassard, M., Beyond the Seven Old Tools. 1986

vii Ibid.


x Benchmarking: Focus on World Class Practices, AT&T Select Code 500-454.


xxi Ancona, D., Kochan, T., Van Maanen, J., Scully, M., Westney, E., Course notes from the MIT Sloan School of Management Organizational Processes course.


Ibid.