SOFTWARE ENGINEERING LABORATORY

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EVALUATION OF MANAGEMENT MEASURES OF SOFTWARE DEVELOPMENT

VOLUME 1: ANALYSIS SUMMARY

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Goddard Space Flight Center

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EVALUATION OF MANAGEMENT MEASURES OF SOFTWARE DEVELOPMENT

VOLUME 1: ANALYSIS SUMMARY

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FOREWORD

The Software Engineering Laboratory (SEL) is an organization sponsored by the National Aeronautics and Space Administration, Goddard Space Flight Center (NASA/GSFC) and created for the purpose of investigating the effectiveness of software engineering technologies when applied to the development of applications software. The SEL was created in 1977 and has three primary organizational members:

NASA/GSFC (Systems Development and Analysis Branch)
The University of Maryland (Computer Sciences Department)
Computer Sciences Corporation (Flight Systems Operation)

The goals of the SEL are (1) to understand the software development process in the GSFC environment; (2) to measure the effect of various methodologies, tools, and models on this process; and (3) to identify and then to apply successful development practices. The activities, findings, and recommendations of the SEL are recorded in the Software Engineering Laboratory Series, a continuing series of reports that includes this document. A version of this document was also issued as Computer Sciences Corporation document CSC/TM-82/6063.

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ABSTRACT

This document reports the results of an evaluation of a large set of software development measures relevant to the Goddard Space Flight Center (GSFC) environment. Volume 1 explains the conceptual model, the data classification scheme, and the analytic procedures. This volume summarizes the analytic results and recommends specific software measures for collection and monitoring. Volume 1 also reproduces in full the results of the computer analyses. Volume 2 presents a detailed description of the data analyzed including definitions of measures, lists of values, and summary statistics.

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SECTION 1 - INTRODUCTION

This two-volume report presents the results of an analysis of a large set of management measures of the software development process. The purposes of the analysis are to characterize the current software development process in one environment by identifying important qualities and corresponding measures and to evaluate the effectiveness of specific tools and techniques in this environment. The measures studied are counts, ratios, and management-supplied ratings of various elements of the software development process. The measures are high level in that each describes some aspect of an entire software project (or a large part of it) rather than individual components of the project.

The data analyzed have been collected by the Goddard Space Flight Center (GSFC) Software Engineering Laboratory (SEL) from 25 actual medium-scale, scientific software projects developed for flight dynamics applications. Values have been determined for over 600 measures for each of the projects studied. Several different statistical procedures have been employed to investigate these measures.

This document describes the following aspects of this research effort:

- Motivation, rationale, and objectives
- Source, nature, and derivation of the measures
- Analytic procedures employed
- Results of the analysis
- Identification of specific measures useful to the management of software development activities

The data, procedures, and results are summarized in the text. Appendix A of this volume reproduces the results of computer-generated factor analyses of the data. Appendix A of Volume 2 contains a detailed description of the data including identification of measures, lists of values, and summary statistics. Sources cited in the references provide additional useful material.

1.1 CONCEPT OF MEASURES

The need to measure the quantity and quality of developed software is self-evident. Measures of productivity, reliability, size, and complexity, for example, are vital to software planning and management. What is not so evident, however, is which are the most important quantities and qualities and what are the best measures of them. One approach that the SEL has taken to resolve these questions has been to gather as many measures as possible and to systematically evaluate their utility. This report documents that approach.

Measures should be distinguished from qualities. As the term is used here, a measure is a count or a numerical rating of the occurrence of some property. Examples of measures include lines of code, number of computer runs, person-hours expended, and degree of use of top-down design methodology. A quality is a high-level characteristic to which one or more measures may be related. For example, the measures of errors per line of code and mean time to failure are related to the quality of reliability. However, neither measure alone adequately quantifies reliability.

Measures appeal both to the researcher and the manager as potential means of defining, explaining, and predicting software development qualities, especially productivity and reliability. These goals can be realized most efficiently by developing a single effective measure for each quality of interest. That is one of the purposes of this analysis.

Measures may be classified into four groups as illustrated by the software development model presented in Figure 1-1.

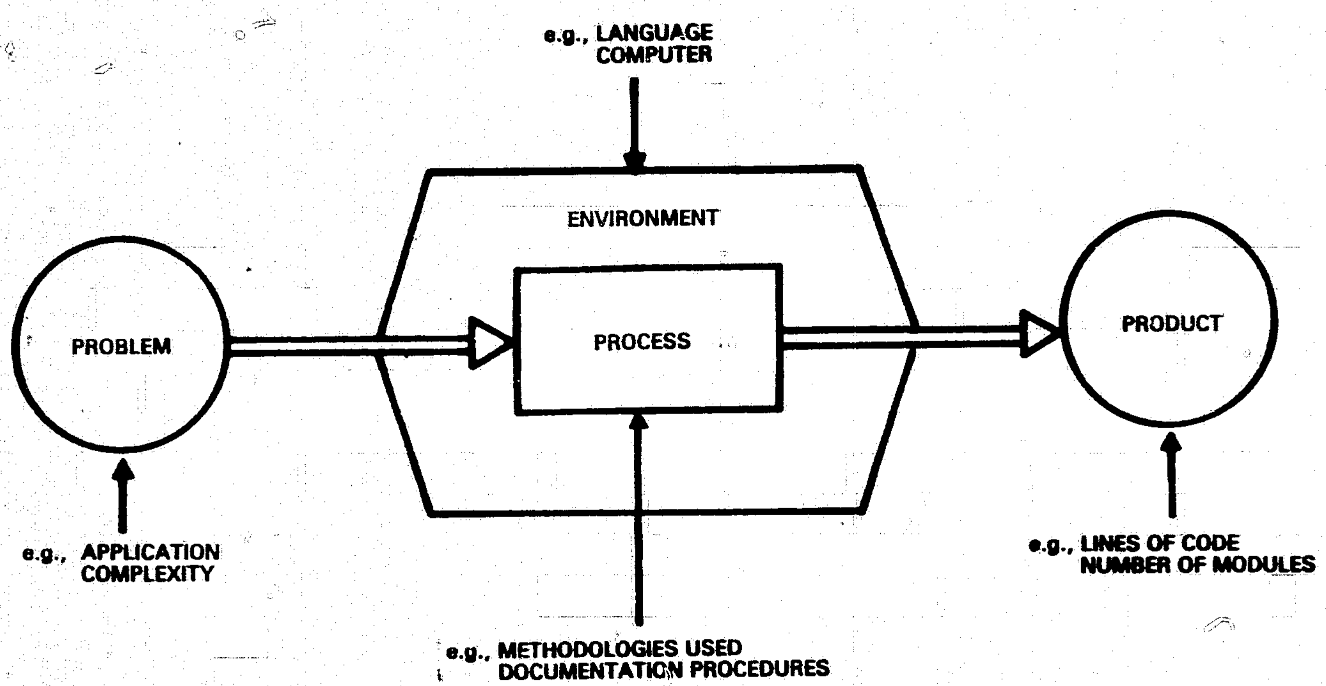


Figure 1-1. Software Development Model

It shows these components: a problem, a solution-generating process, the environment in which that process takes place, and the solution (or software product). Measures can be used to characterize the components of this model and to show their interrelationships. For example, resource utilization measures record the rate at which resources in the environment (especially personnel and computer resources) are used by the software development process. Figure 1-1 also shows other examples of appropriate measures for each component.

Measures may be further characterized as subjective or objective. The exercise of human judgment in assigning a value for a measure makes that measure subjective. The most widely accepted and widely used measures of software development are objective measures of the software product. However, currently available objective measures do not take into account the effects of development constraints and practices on the quality of the software product.

Evaluation of software quality is, at present, a matter of the subjective interpretation of results relative to requirements. Few objective measures of software quality are available. Thus, the SEL has developed a set of subjective (or interpreted) measures that complement the more commonly employed objective measures of software development. The analysis described in this report attempts to validate those measures. Section 2 discusses the specific measures investigated by the SEL; these measures describe all facets of flight dynamics software development.

1.2 OBJECTIVES OF THE ANALYSIS

One objective, then, of this analysis is to identify the significant software development attributes (qualities) and their corresponding measures from among those measures collected by the SEL. The other objective is to define their applicability to software development management. The definition of effective software development measures enables planners and managers to

- Recognize the characteristics of problem software early in development
- Identify the most effective development and management tools and techniques
- Estimate the costs and output of software development efforts

Section 5 recommends some specific measures to be used in these applications.

1.3 RELATED RESEARCH

A number of objective measures of software development attributes are widely accepted in the software engineering community. Lines of code and staff-hours are examples. However, few measures have been refined to the point of becoming useful management tools. Basili presents a survey of such efforts in Reference 1.

Subjective measures of software quality were among the first to be developed and actually applied to software management. The concepts of module strength and coupling (Reference 2) are examples of early work in this area. Unfortunately, these qualities have proved difficult to quantify, although a rating scheme has been developed based on the types of cohesion and dependencies that program modules may exhibit. Taking another approach, McCall (Reference 3) has developed a comprehensive system of software qualities and appropriate measures that others are still refining and extending (Reference 4). These investigations include both subjective and objective measures.

The approach to software measurement adopted for the analysis here is different from that generally followed. The usual procedure is to specify high-level "qualities" and then to seek numerical criteria or measures of those qualities. However, the approach followed here is to identify the qualities being measured by the data collected rather than to attempt to associate measures with previously specified qualities.

A subset of this data has been analyzed previously using this approach. The results of that analysis were reported at the Sixth Annual Software Engineering Workshop in 1981 (Reference 5). This analysis extends the scope of that work.

SECTION 2 - DATA DESCRIPTION

This section describes the sources, nature, and derivation of measures used in the analysis. Specifically, the topics discussed are

- Source of the data studied
- Classes of measures included
- Methods of measurement used

A brief description of each individual measure, lists of the actual data, and summary statistics are included in Appendix A of Volume 2.

2.1 SOURCE OF DATA

The SEL, a cooperative effort of the Goddard Space Flight Center, Computer Sciences Corporation (CSC), and the University of Maryland, assembled the data set used in this analysis. The SEL collects and analyzes data from software development projects that support flight dynamics activities. The principal objective of the SEL is to identify and apply software development tools and techniques that improve the quality of the software development process. Reference 6 describes the organization, operation, and accomplishments of the SEL in more detail.

The SEL has monitored the development of 43 software projects during the past 5 years. This document analyzes a selected subset of 25 projects. The selection criteria were intended to strengthen the rigor of the analysis. The projects selected were developed in the same programming language (FORTRAN) and used the same set of computers for similar and/or related applications.

The specific type of application software studied supports ground-based spacecraft attitude determination and control. The subsystems included in a typical attitude system are telemetry processing, sensor calibration, attitude computation, and maneuver planning. Table 2-1 shows some of the characteristics of the software studied.

Table 2-1. Summary of 11 Mission Projects Studied

Measure	Median	Interquartile Range[1]
Developed Lines of Code (Thousands)	49	18
Lines Developed Per Staff-Month	601	189
Total Effort (Staff-Months)	96	38
Average Staffing Level	5	1
Duration (Months)	15	3
Percentage of Effort		
Programmer	68	
Manager	20	
Other	12	

[1]Value is one-half of the difference between the third quartile and the first quartile.

The 25 software development efforts selected for study have been combined in two different ways for purposes of comparison. They are grouped into 11 mission projects composed of related efforts. The projects combined in this manner were undertaken in support of the same mission. Separately, 20 independent software systems are identified among the group of 25. These are subdivided into a class of 11 large systems (more than 30,000 lines of code) and a class of 9 small systems (fewer than 30,000 lines of code). Thus, four data groups are defined for the analysis. Appendix A of Volume 2 includes summaries of these groups.

2.2 CLASSES OF MEASURES

More than 600 measures have been assembled for this analysis. Some were suggested by other researchers. The measures are organized into seven topical classes:

1. Software engineering practices--tools, techniques, and practices employed by the software development team
2. Development team ability--quality and performance of the development team
3. Difficulty of project--problems encountered with complexity, staffing, and support
4. Process and product characteristics--evaluations of process performance and product quality
5. Development team background--previous experience of the development team
6. Models--measures used in some popular resource/size estimation models
7. Additional detail--other objective measures of the software product and resources

Table 2-2 shows the further division of the classes into subclasses (categories). Some additional measures have been constructed by forming weighted sums of other measures.

The measures included in these classes fully describe the process and product components in the software development model as experienced by the SEL (see Figure 1-1). Section 2.1 points out that the projects studied were chosen so that the other components of the model, the software problem (application) and the development environment (computer), would be as similar as possible. Thus, consideration of these components (problem and environment) can be minimized in the analysis.

Table 2-2. Classes of Measures

Name of Class	Symbol	No. of Measures	Sums[1] of Measures
Software Engineering Practices	SE	0	1
Practices and Techniques	MT	30	4
Tools	TS	15	1
Documentation	DC	15	1
Development Team Ability	AB	0	12
Experience With Application	AP	15	4
Effectiveness of Management	MG	35	13
Performance of Team	PF	40	0
Difficulty of Project	DF	0	1
Complexity of Problem	CP	15	5
Internal Influences on Project	IN	15	4
External Influences on Project	EX	20	7
Process and Product Characteristics			
Resources Available	RA	20	5
Software Product	PR	20	4
Product/Process Performance	PP	15	3
Development Team Background			
Team Rank	RK	40	0
Years of Professional Experience	YP	40	0
Years of Applicable Experience	YA	40	0
Years of Environment Experience	YE	40	0
Resource Model Parameters			
Walston-Felix	WF	80	2
PRICE S3	PS	20	1
COCOMO	CO	15	0
Additional Detail			
Miscellaneous	MS	40	0
Code Breakdown	SW	80	0
Estimated Statistics	ES	19	0

[1]Weighted sums of other measures.

2.3 METHODS OF MEASUREMENT

Measurement is the process of assigning a number or a state to represent a quantity or quality. Two general methods of measurement exist: objective and subjective. This analysis includes both types of measures.

Objective measures are often the result of counting processes; these are measures of tangible physical quantities and qualities. Examples include lines of code, staff-hours, and computer language used. Some of the objective measures collected by the SEL have been restated as relative scores determined from defined ranges of values.

Subjective measures result from classification or rating processes involving the exercise of human judgment. However, the evaluator also uses objective measures as guidelines in assigning values for some of the subjective quality measures developed by the SEL. The values of the subjective measures employed in this analysis are expressed as relative scores on a scale from 0 to 50. Table 2-3 shows the interpretation of these scores.

Table 2-3. Interpretation of Subjective Measures

Score	Approximate Percentage	Interpretation
0	0	Never, none
10	20	Rarely, very poor
20	40	Occasionally, poor
30	60	Frequently, good
40	80	Usually, very good
50	100	Always, excellent

Table 2-4 shows an example of how data composed of this type of measure might look. This technique is used extensively to rate the degree of use of various methodologies, tools, and management practices. The values for these measures are determined for each project after its completion or after completion of a major phase of development. This determination occurs during a detailed review by management personnel involved in the development effort.

Table 2-4. Example[1] of Subjective Measures

Project	MEASURE1	MEASURE2	MEASURE3	MEASURE4
1	0	30	20	50
2	10	10	40	20
3	50	20	30	0
4	20	40	10	30
5	10	50	50	20
6	30	20	10	40
7	30	0	20	10
8	50	40	20	0
9	10	50	0	30
10	20	0	30	40

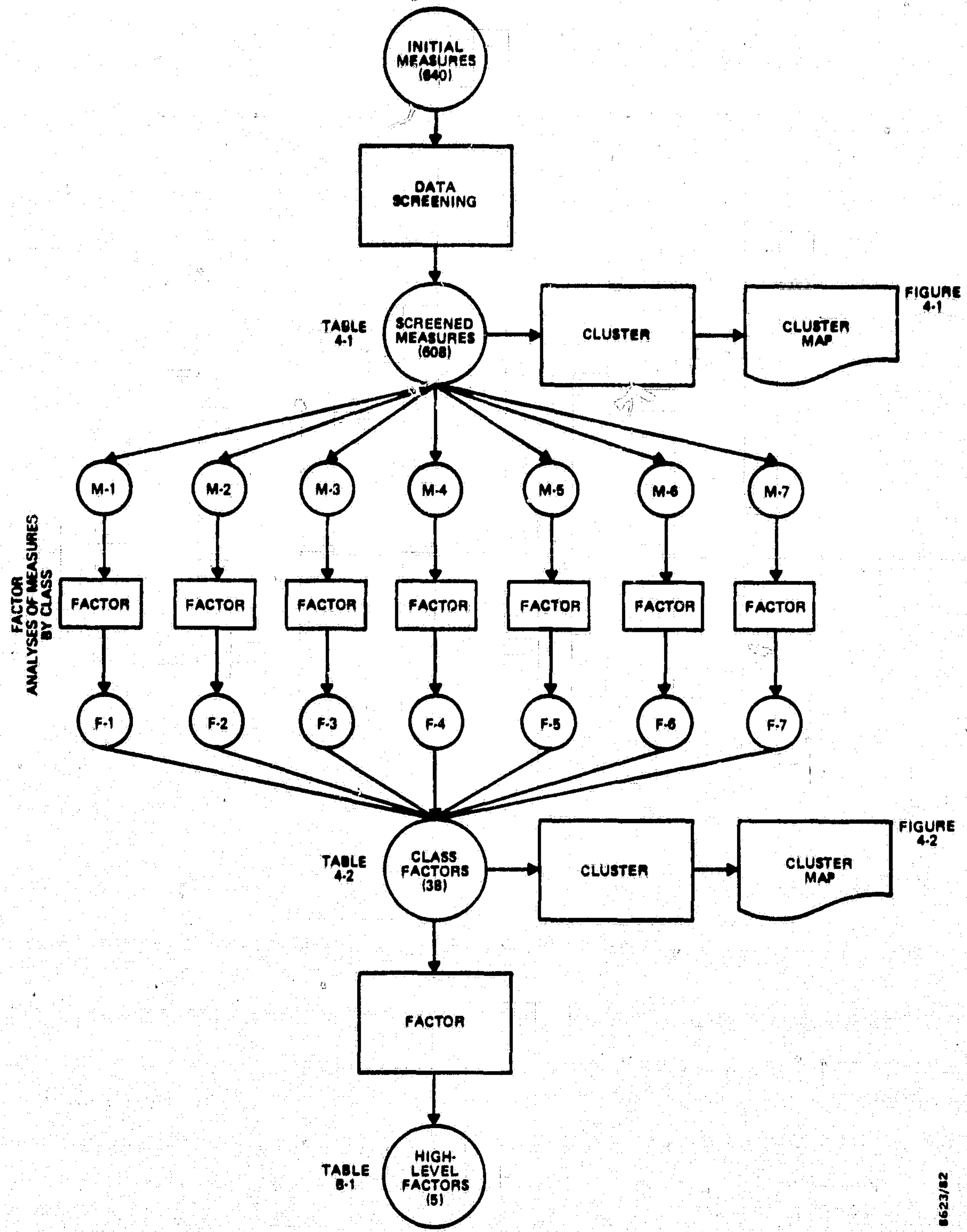
[1]Illustrative values for hypothetical measures.

SECTION 3 - ANALYTIC PROCEDURE

The measures described in Section 2 are not necessarily unique or independent. Some may, in fact, measure the same or related qualities. This analytic procedure attempts to identify the most basic set of qualities (or properties) being measured by the entire set. A basic quality is one that is independent of all other such qualities. This subset, then, identifies the basic quality characteristics describing the projects from which the data have been obtained. Studying the relationships among these basic qualities provides useful insight into how the software development process can be improved.

The procedure to be proposed is large scale. That is, the procedure is appropriate when large numbers of measures (or variables) are to be evaluated. The researcher interested in studying the relationships of only a few specific measures can probably get better results from regression- and hypothesis-testing techniques. Nevertheless, this procedure can also be useful as a screening tool for detecting confounding effects in the data before selecting other statistical techniques.

The analytic procedure followed in this experiment has several steps, as illustrated in Figure 3-1. These steps are the application of a test of normality to screen the candidate measures (data), followed by factor analyses of those not rejected by the test. Analyses are performed independently for each class of measures defined in Section 2.2; then, the results are combined. Graphic illustrations of the similarities established among the projects studied are produced by cluster analysis. Comparing the pattern of similarity based on the original set of measures with the pattern of similarity based on the basic qualities identified by the factor analysis steps confirms the interpretation and



NOTE: M-n IS THE CLASS OF MEASURES DEFINED IN SECTION n OF APPENDIX A OF VOLUME 2.
F-n IS THE GROUP OF FACTORS IDENTIFIED IN TABLE n OF APPENDIX A OF VOLUME 1.

Figure 3-1. Analytic Procedure

application of these quality measures in real-world situations. Figure 3-1 also identifies tables and figures that illustrate the data at various positions in the analytic procedure.

The final result of this procedure is a descriptive, rather than a predictive, model of the data. The procedure identifies the descriptive factors common to the set of measures. Thus, the original measures are organized into a number of groups (each corresponding to a factor) smaller than the number of measures input to the procedure. These factors correspond to the basic qualities sought for in the data.

The statistical bases of the steps in this procedure are discussed in more detail in the following sections. The statistical software used throughout the analysis is the Statistical Analysis System (Reference 7).

3.1 TEST OF NORMALITY

The test of normality analyzes the probability distribution of the values of a measure. The factor analysis procedure is based on the assumption that the values of the measures input to it are normally distributed. In practice, any approximately symmetrical distribution may be processed without seriously perturbing the results (Reference 8). However, asymmetric (or skewed) data distributions can produce misleading results. They are detected by the test used in this analysis.

Figure 3-2 shows both the normal distribution and a skewed distribution. Because the values of the subjective measures are relative scores, skewed distributions result for degree-of-use measures when there are few examples of use in the data. Consequently, most projects have scores of zero for these measures, producing dramatically skewed distributions. A "t" statistic and the 0.01 significance level are

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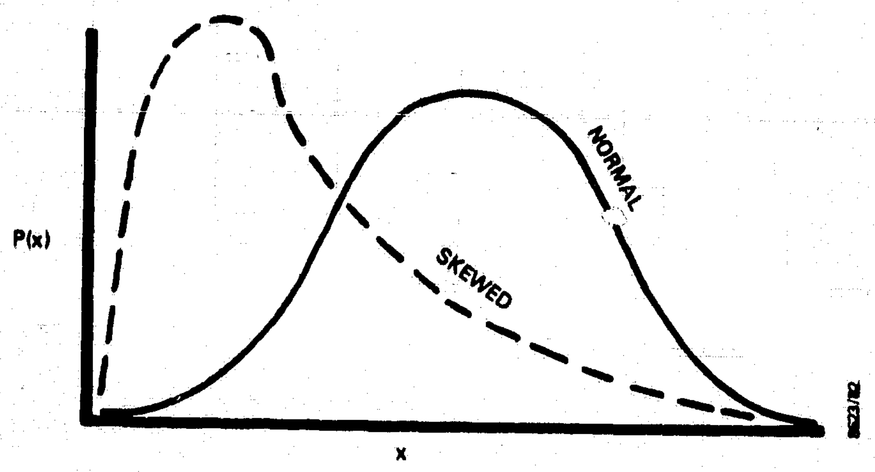


Figure 3-2. Concept of Normality

used to test the hypothesis (for each measure) that the mean of the distribution is zero.

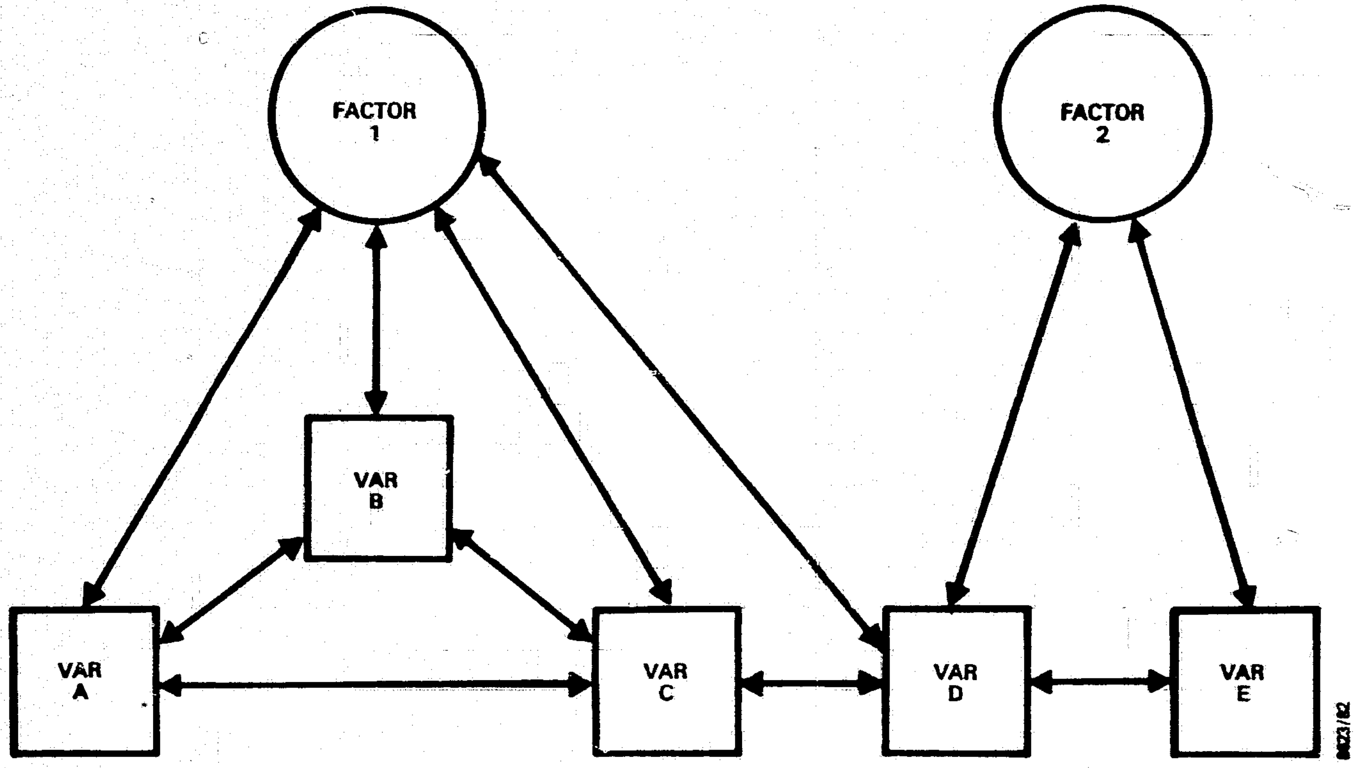
Accepting this hypothesis is equivalent to concluding that the distribution is skewed because zero is a limit of the range of values. That is, no values less than zero are possible for these measures. Section 4.1 reports the results of the test of normality.

3.2 FACTOR ANALYSIS

The goal of factor analysis is to discover the underlying structure of the data. Factor analysis hypothesizes the existence of a set of statistically independent "factors" that cannot be directly measured by the experimenter. Measures (or variables) are the quantities that are observed in practice. However, the apparent correlations among measures can be interpreted to be caused by their joint correlation with common factors (see Figure 3-3). That is, two or more measures correlated with the same factor are correlated with each other. The desirable result of a factor analysis is the extraction of a smaller set of factors whose relationships are known (they are independent) from the larger set of measures whose relationships are more complex.

Consider this example of the factor concept. The number of errors in a piece of software and its mean time to failure are measures related to reliability and are correlated with each other. However, neither measure by itself is a full description of reliability. Such things as the location of the error and the severity of the failure must also be considered. Therefore, the reliability quality factor is not directly measurable, although a number of measurable variables are correlated with it.

A successful factor analysis explains such groups of related measures. Thus, each factor defined corresponds to a distinct basic quality being measured by the original set of



NOTES: VARIABLES MAY BE CORRELATED.
FACTORS ARE INDEPENDENT.

↔ INDICATES THAT CORRELATION IS PRESENT.

Figure 3-3. Concept of Factor Analysis

measures. These qualities are the sources of variation (or differentiation) in the measures among the projects studied; therefore, these qualities form the basis for comparisons among the projects.

The output of the factor analysis procedure includes three types of information that are essential to interpreting its results. These information types are

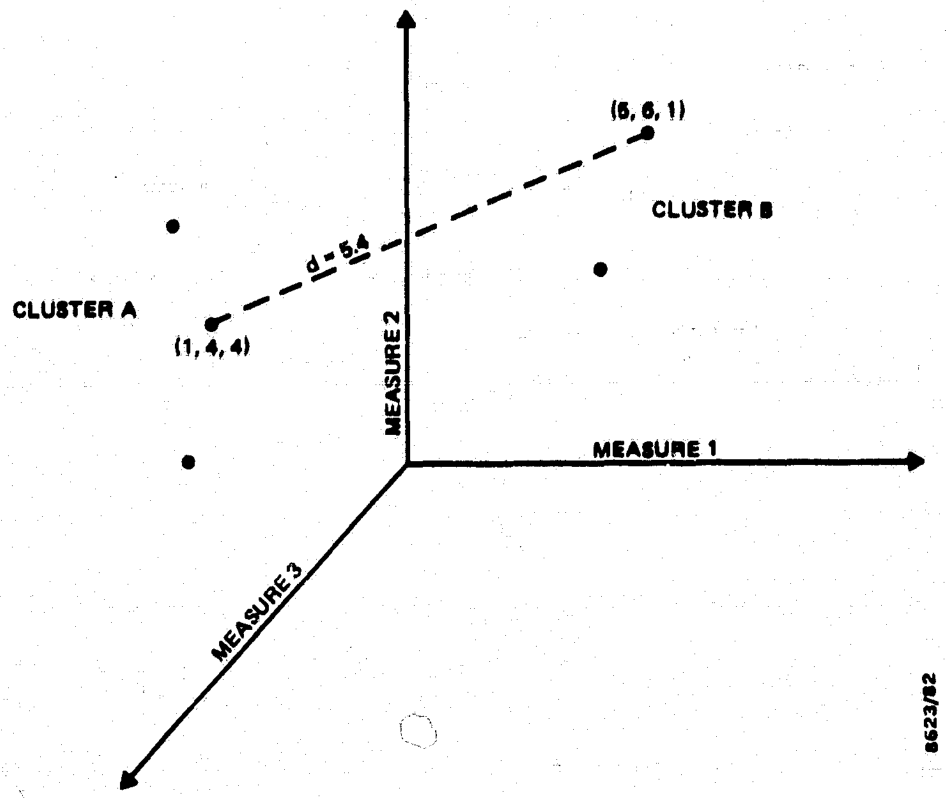
- Factor loading--percentage of the variance in the data accounted for by each factor; shows the relative importance of factors
- Factor pattern--correlations of all measures with all factors; shows the underlying structure of the data
- Communality--percentage of each measure's variance accounted for by all factors; shows how well each measure is explained by the factor model

Sections 4.2 and 4.3 report the results of the factor analyses of the SEL measures. The principles of factor analysis are explained in more detail by Harman (Reference 9).

3.3 CLUSTER ANALYSIS

The technique of cluster analysis (or numerical taxonomy) is an objective method of defining and displaying groups, or clusters, of objects (projects, in this case) that are similar with respect to a specified set of measures. The degree of similarity is determined by calculating a Euclidean distance measure from the measures input to the procedure.

A simple example clarifies this concept. Consider a set of three measures applied to each of several projects. Each project can be represented as a point in three-dimensional space where each of the three measures forms an axis (or dimension) as illustrated in Figure 3-4.



LEGEND: • REPRESENTS PLOTTED LOCATION OF THE PROJECT
d REPRESENTS THE DISTANCE BETWEEN TWO POINTS (PROJECTS)

Figure 3-4. Concept of Cluster Analysis

The Euclidean formula for the distance between two points in a three-dimensional space is as follows:

$$D = \sqrt{(x' - x'')^2 + (y' - y'')^2 + (z' - z'')^2}$$

where D = distance

x', y', z' = coordinates of point 1

x'', y'', z'' = coordinates of point 2

This formula can be easily extended to the general case of n measures or dimensions. Thus, the distances between all pairs of points can be determined and any clusters can then be identified. The results are presented in a display, or map, showing the similarities of the projects. Section 4.3 summarizes the results of the cluster analyses of SEL data. Reference 10 explains the principles of cluster analysis in more detail.

SECTION 4 - EVALUATION OF MEASURES

This section presents the results of applying the analytic procedure (described in Section 3) to the SEL data (described in Section 2). Data screening, the factor analyses of classes of measures, and the summary analysis of factors are discussed. Figure 3-1 shows the sequence of these steps and identifies the data sets used by each. The four major data sets are the initial measures, screened measures, combined (class) factors; and high-level factors.

4.1 DATA SCREENING

A test of normality (see Section 3.1) was employed to screen the data (initial measures) before other analyses. The test rejected 32 measures. These are measures for which all projects were assigned the same value or measures for which there were too few different values. Table 4-1 lists the rejected measures. As indicated in the table, several of the measures proposed by Walston and Felix (Reference 11) or used in the PRICE S3 model (Reference 12) are not useful for characterizing the software studied by the SEL because they are constant from project to project. Of the 640 measures, 608 were retained; these comprise the screened measures data set.

Table 4-1. Measures Excluded From Analysis (1 of 3)

Measure Code	Rejection Criterion[a]	Measure Description
MT08	0.327	Use of Hierarchical Input Processing Output (HIPO) charts for design
MT27	0.046	Presence of an independent verification and integration team

[a]Any value greater than 0.01 results in rejection.

Table 4-1. Measures Excluded From Analysis (2 of 3)

Measure Code	Rejection Criterion[a]	Measure Description
MT28	0.079	Degree to which development team cooperated with and responded to findings of the independent verification and integration team
TS04	0.047	Use of an online requirements language tool for analysis and assessment of changes
TS12	0.088	Use of an online configuration analysis tool for tracking development activity
DC06	0.083	Use of unit development folders for recording, in a central repository, development plans, status, and products
AP01	0.185	Contribution from expert 1
AP02	b	Contribution from expert 2
IN03	0.161	Need for weekend overtime conditions
IN04	0.013	Staffing problems during design
IN12	0.073	Project leader turnover, i.e., replacement
EX08	0.062	Development of front-end processors by an external group
EX09	0.016	Ontime delivery of software by an external group
RA08	0.020	Availability of the primary development computer
RA09	0.187	Availability of a tertiary development computer
RA12	0.022	Availability of an online processing system
RA14	0.035	Availability of a convenient, unscheduled graphic device

[a]Any value greater than 0.01 results in rejection.

[b]All projects show the same value for the measure.

Table 4-1. Measures Excluded From Analysis (3 of 3)

Measure Code	Rejection Criterion[a]	Measure Description
RA18	0.034	Availability of an independent testing group
WF01	b	Programmer experience with the application
WF17	b	Complexity of product's external communication
WF24	b	Complexity resulting from hardware development
WF25	b	Complexity resulting from security environment
WF33	0.171	Percentage of development in tertiary computer environment
WF38	0.172	Percentage of development in open computing environment, i.e., hands-on development
WF48	b	Percentage of effort for analysts
WF49	b	Percentage of effort for operators
WF64	b	Percentage of code for fallback and recovery
WF65	b	Percentage of code in "other" category
PS17	b	Code instruction mix rating
PS18	b	Personnel skill mix rating
PS19	b	Fraction of storage and timing capacity
PS20	b	Strictness of development standards

[a]Any value greater than 0.01 results in rejection.

[b]All projects show the same value for the measure.

4.2 FACTORS WITHIN CLASSES OF MEASURES

After screening the initial set of measures, researchers performed a factor analysis for each of the seven classes of measures defined in Section 2.2. Appendix A of Volume 1 reproduces the results of those analyses. Table 4-2 summarizes some important features of these analyses.

The table shows that in all cases five or six factors were able to explain at least 73 percent of the variance of the class of measures under consideration. The best case is that of the Development Team Background class of measures in which 5 factors accounted for 86 percent of the variance (or information content) of the 144 measures in that class. The 38 factors produced by the 7 factor analyses form the combined factors data set.

These results demonstrate that by focusing on factors the number of measurements collected during software development can be significantly reduced without much loss of information. Section 5 suggests the measures corresponding to these factors that can be most easily and advantageously collected.

The following subsections describe the results of the factor analyses of classes of measures in more detail. Each factor is named, and correlated measures are described. Correlations between factors and measures of less than 0.56 are not considered in the discussion except when they form part of a pattern. This value is the boundary of the 0.01 significance region for a correlation coefficient from a sample of size 20. A measure having a correlation with a factor of 0.561 or greater is termed "strongly" correlated with that factor. "Moderately" correlated refers to correlations greater than or equal to 0.444 (0.05 significance region) but less than 0.561.

Table 4-2. Summary of Factor Analyses of Classes of Measures

Class of Measures	No. of Measures	No. of Factors	Percentage of Variance	Detailed Table[1]
Software Engineering Practices	43	5	80	A-1
Development Team Ability	110	6	82	A-2
Difficulty of Project	54	5	74	A-3
Process and Product Characteristics	47	5	85	A-4
Development Team Background	144	5	86	A-5
Resource Model Parameters	73	6	73	A-6
Additional Detail	137	6	83	A-7

[1]Found in Appendix A of Volume 1.

4.2.1 SOFTWARE ENGINEERING CLASS

The factor analysis of the Software Engineering class of measures produced a model containing five factors, which explain 80 percent of the variance of the class. Together they describe the general level of software engineering technology used during development and four other independent subgroups of technologies. Table A-1 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.1.1 Software Engineering Factors

The five Software Engineering factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.1 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 1 - General Software Engineering Practices (51 percent of variance). With the exception of

    a. MT09 (+0.06)--Use of top-down design procedures
    b. TS06 (+0.25)--Use of structured FORTRAN precompiler

all measures in this class are at least moderately correlated (0.444) with this factor; most are strongly correlated (0.561) with it.

The level of correlation is consistent with the application of software engineering technology in the flight dynamics area. In general, most methods, techniques, and practices are part of what has become, for some developers, a standard approach to software development. Depending on a particular team's motivation, especially the motivation provided by its project manager and leader, the degree of application of the approach varies from a beginner's reluctant use to an experienced advocate's aggressive use.

The most strongly correlated ($\geq$ 0.91) measures with this factor include the total use of design methods (MT81), coding methods (MT82), all methods (MT84), tools (TS81), documentation procedures (DC81), and overall software engineering (SE81). However, the total use of testing methods (MT83) has the lower correlation of 0.78 and points out a known weakness in the development process of this environment; that is, the testing approach is the least consistent aspect of the development process and is a major concern for development managers.

2. <u>Factor 2 - Batch Development (9 percent of variance)</u>. The only measure strongly correlated with this factor is

- TS10 (-0.61)--Use of terminals for interactive development. High use of terminals corresponds to low measure values.

Measures moderately correlated with this factor include

a. MT04 (+0.51)--Use of formal design review procedures

b. TS02 (+0.55)--Use of informal development training procedures

c. TS06 (+0.52)--Use of structured FORTRAN precompiler

d. DC04 (+0.54)--Use of semiformal quality assurance procedures for documentation

e. MT20 (-0.49)--Use of code configuration control procedures

This factor underscores the benefits of the electronics technology boom and progress in the development process; it also highlights an environmental deficiency, an archaic batch computing facility. It also emphasizes a development manager's problem resulting from the conflict of the environmental deficiency with the other two benefits.

The interactive developer has emerged in parallel with hardware and electronics technology gains. However, although the flight dynamics environment makes terminals available for development, in reality, it is primarily a batch environment with very unreliable computers (6- to 8-hour mean time to failure). Therefore, development managers have continually faced developers' increasing fascination for and dependence on the use of graphic terminals for development (TS10). Because development managers have not been able to establish the rigorous discipline necessary to develop software interactively with unreliable computers, teams that develop interactively tend to be less coordinated and to behave more like separate groups of individuals each with responsibility for a different piece of the system. Hence, it is difficult to control the configuration of the system's code (MT20).

This factor also shows improvements in the development process (MT04, TS02, TS06, and DC04), which have emerged in parallel with the interactive developer in this environment.

3. Factor 3 - Top-Down Design (8 percent of variance). The measures strongly correlated with this factor include

a. MT09 (+0.85)--Use of top-down design procedures

b. MT10 (+0.69)--Use of iterative enhancement design procedures

c. MT26 (+0.61)--Use of batch testing procedures

The projects in this sample are similar and provide design and/or implementation models for subsequent projects; as a result, top-down design is not used extensively. However, this factor shows that the projects that use top-down design methodology tend to rely on batch testing procedures. Factor 30 in Section 4.2.6 confirms this with a different class of measures (Models class). An alternative design technique, iterative enhancement (MT10), also shows this effect.

4. Factor 4 - Structured Implementation (7 percent of variance). The only measure strongly correlated with this factor is

- TS06 (+0.62)--Use of structured FORTRAN precompiler

Two other measures that are moderately correlated are

a. MT17 (+0.54)--Use of structured coding techniques

b. TS09 (-0.53)--Development of data generators for testing

This factor represents the use of a structured FORTRAN precompiler to aid in producing structured code. The inverse correlation with the development of data generators for testing is coincidental. Over the timespan of the projects in this sample, the use of a structured FORTRAN precompiler has increased from no use to total use. Over the same timespan, the availability of simulators and data support has increased significantly but not regularly; therefore, the need for and use of data generators decreased, but not necessarily proportionally.

5. Factor 5 - Development Team's Organization (5 percent of variance). None of the measures are strongly correlated with this factor. Measures that are moderately correlated include

a. TS07 (+0.47)--Use of standard computer system code checking tools

b. MT01 (-0.45)--Use of chief programmer; i.e., project leader directs all development activity

c. DC08 (-0.46)--Relevance of user's guide and system description

d. DC10 (-0.47)--Relevance of weekly/monthly progress reports

In this environment, the project leader is the lead programmer of the development team and is responsible for weekly/monthly reporting and quality assuring the user's guide and system description. The inverse correlation of using computer system code checking tools (TS07) with the degree of using a lead programmer (MT01) seems to be due to the effect of the smaller projects, which are generally led by more junior personnel who are not as familiar with the computer system as more senior project leaders.

4.2.1.2 Measures Unrelated to Software Engineering

The following list contains measures that are not correlated with any of the Software Engineering factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. TS02 (factor 2, +0.55)--Informal training in development

2. TS09 (factor 1, +0.55)--Development of data generators for testing

3. DC09 (factor 1, +0.56)--Formal treatment (edit text and prepare artwork) of user's guide and system description

4.2.2 DEVELOPMENT TEAM ABILITY CLASS

The factor analysis of the Development Team Ability class of measures produced a model containing six factors, which explain 82 percent of the variance of the class. Together they describe the general level of the technical staff's ability and five other independent effects. Table A-2 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.2.1 Development Team Ability Factors

The six Development Team Ability factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.2 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 6 - Technical Staff's Ability (36 percent of variance). The measures strongly correlated with this factor include

    a. AP03 (+0.75)--Contribution by expert 3

    b. AP08 (+0.57)--Application experience of programmers

    c. AP81 (+0.82)--Contribution by experts

    d. AP8x ($\geq$ +0.73)--Overall application experience of team (x = 2 and 4)

    e. MGxx ($\geq$ +0.82)--Management effectiveness of project leader (xx = 2, 8, 14, 20, and 26)

f. MGxx (≥ +0.61)--Overall management effectiveness of managers except development interface leader (xx = 81 through 85, 87, 88, and 93)

g. PFxy (≥ +0.65)--On-the-job performance of programmers alone and technical staff (x = 0 through 3; y = 1 though 4)

h. ABxx (≥ +0.90)--Overall team ability (xx = 81 through 92)

This factor indicates the overall ability of the technical staff with emphasis on contributions from experts (AP81), the project leader's effectiveness during implementation and testing (MG14, MG20, and MG26), and the on-the-job performance of the programmers weighted by the project manager and leader (PFx2), i.e., the basic team.

2. <u>Factor 7 - Development Interface Managers' Effectiveness and Performance (19 percent of variance)</u>. The measures strongly correlated with this factor include

a. AP09 (+0.63)--Application experience of analysts

b. MGxx (≥ +0.56)--Management effectiveness of development interface manager and leader (xx = 5, 6, 11, 12, 17, 18, 23, 24, 29, 30, 91, and 92)

c. MGxx (≥ +0.64)--Management effectiveness of project manager during testing and overall life of project (xx = 19, 25, and 87)

d. MGxx (≥ +0.60)--Overall management effectiveness during implementation and testing (xx = 83 through 85)

e. PFx9 (≥ +0.64)--On-the-job performance of development interface manager (x = 0 through 3)

f. MG03 (-0.66)--Management effectiveness of analysis manager during preliminary design

g. PFxy ($\leq$ -0.56)--On-the-job performance of development project and analysis managers and analysis interface manager (x = 0 through 3; y = 5, 6, and 8)

This factor represents the effectiveness and on-the-job performance of the development interface manager and the effectiveness of the development interface leader. This factor also shows a correlation with the analyst's application experience (AP09) and an inverse correlation with the analysis manager's on-the-job performance (PFxy).

3. Factor 8 - Managers' Stability and Performance (11 percent of variance). The measures strongly correlated with this factor include

a. MG09 (+0.68)--Management effectiveness of analysis manager during detailed design

b. MGxx ($\geq$ +0.72)--Management effectiveness of analysis leader during testing (xx = 22 and 28)

c. MGxx ($\geq$ +0.57)--Stability of development project leader and overall stability of managers (xx = 32, 35, and 86)

d. PFxy ($\geq$ +0.58)--On-the-job performance of development project and interface managers (x = 0 through 3; y = 7 and 9)

This factor represents both the on-the-job performance of the development team managers (i.e., the project manager and leader and the development interface manager and leader) and the stability of (few number of changes in) those positions. There are also correlations with the analysis manager's effectiveness during detailed design and the analysis leader's effectiveness during testing.

In this environment, the analysis manager has considerable control over the definition of the functional specifications and requirements and changes to them. Most of the activity in these areas occurs before the critical design review (CDR). The analysis leader becomes a more prominent figure during implementation and is the key individual involved in preparing for and conducting acceptance testing.

4. Factor 9 - Analysis Manager's Effectiveness (7 percent of variance). The measures strongly correlated with this factor include

a. MGxx (≥ +0.60)--Management effectiveness of analysis manager during implementation and system testing (xx = 15 and 21)

b. MG89 (+0.74)--Overall effectiveness of analysis manager

c. AP83 (-0.65)--Development team familiarity with project and teammates

This factor represents the effectiveness of the analysis manager. It appears that the analysis manager is most effective when members of the development team do not participate in functional specifications and requirements definition (AP10, -0.56) and do not work together much before the project (AP12, -0.45). AP83 is the sum of AP10 through AP12.

5. Factor 10 - Analysis Leader's Effectiveness (5 percent of variance). The measures strongly correlated with this factor include

a. MGxx (≥ +0.58)--Management effectiveness of analysis leader during detailed design and implementation (xx = 10 and 16)

b. MG90 (+0.59)--Overall effectiveness of analysis leader

c. AP04 (-0.66)--Contribution by expert 4

This factor is named for MG90, although the analysis leader's effectiveness during detailed design (MG10) is the most strongly correlated (+0.68) measure. The inverse correlation with contributions by expert 4 (AP04) is partially coincidental; that is, the higher level organization frequently staffs the development team with more senior personnel when there is a potentially weak analysis team and vice versa.

6. Factor 11 - Project Manager's Experience and Stability (5 percent of variance). The only measure strongly correlated with this factor is

- MG31 (-0.69)--Stability of development project manager

However, the project manager's experience with the application (AP06) is moderately correlated (+0.52) with the factor. The inverse correlation with MG31 indicates that more experienced project managers are likely to be promoted to higher level management positions or moved to manage new projects.

4.2.2.2 Measures Unrelated to Development Team Ability

The following list contains measures that are not correlated with any of the Development Team Ability factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. AP05 (factor 10, +0.55)--Contribution by expert 5
2. AP06 (factor 11, +0.52)--Project manager's experience
3. AP07 (factor 6, +0.47)--Project leader's experience
4. AP10 (factor 9, -0.56)--Development team participation in requirements definition

5. AP11 (factor 11, -0.35)--Development team participation in design

6. AP12 (factor 12, -0.45)--Number of development team interactions before start of project

7. MG01 (factor 6, +0.50)--Effectiveness of project manager during preliminary design

8. MG04 (factor 9, +0.47)--Effectiveness of analysis leader during preliminary design

9. MG06(factor 7, +0.50)--Effectiveness of development interface leader during preliminary design

10. MG07 (factor 6, +0.55)--Effectiveness of project manager during detailed design

11. MG13 (factor 6, +0.57)--Effectiveness of project manager during implementation

12. MG27 (factor 8, -0.48)--Effectiveness of analysis manager during acceptance testing

13. MG33 (factor 9, -0.39)--Stability of analysis manager

14. MG34 (factor 7, -0.53)--Stability of analysis leader

15. PF15 (factor 6, +0.55)--On-the-job performance of development project managers during implementation

4.2.3 DIFFICULTY OF PROJECT CLASS

The factor analysis of the Difficulty of Project class of measures produced a model containing five factors, which explain 74 percent of the variance of the class. Together they describe the general level of project difficulty and four other independent effects. Table A-3 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.3.1 Difficulty of Project Factors

The five Difficulty of Project factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.3 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 12 - Project Difficulty (30 percent of variance). The measures strongly correlated with this factor include

   a. CPxx (≥ +0.61)--Complexity of normal processing (xx = 3 through 5)

   b. CP07 (+0.93)--Number of subsystems

   c. CP08 (+0.67)--Number of data sets

   d. CP10 (+0.60)--Number of new algorithms

   e. CPxx (≥ +0.59)--Overall complexity and totals of constraints, processing, and communications (xx = 81, 82, 83, and 85)

   f. INxx (≥ +0.58)--Overtime conditions (xx = 1 and 2)

g. IN06 (+0.73)--Staffing problems during testing phases

h. IN11 (+0.81)--Development team with poor attitude

i. IN13 (+0.58)--Project leader turnover

j. INxx ($\geq$ +0.60)--Totals of overtime conditions, staffing problems, team leadership problems, and overall internal influences (xx = 81 through 84)

k. EX01 (+0.76)--Changing requirements

l. EX06 (+0.73)--Unresponsiveness of development interface leader

m. EX07 (+0.68)--Number of subsystems developed by external development group

n. EXxx ($\geq$ +0.63)--Overall poor quality and instability of requirements and problems with external development group (xx = 81 and 83)

o. DF81 (+0.92)--Overall difficulty of project, including complexity and effects of internal and external influences

This factor represents the overall difficulty of a project. The three most significant effects are the number of subsystems to be developed (CP07, +0.93), the development team's attitude (IN11, +0.81), and changing requirements (EX01, +0.76).

2. <u>Factor 13 - External Support (18 percent of variance)</u>. The measures strongly correlated with this factor include

a. EX02 (+0.65)--Incompleteness of requirements

b. EXxx ($\geq$ +0.75)--Lack of analysis support (xx = 3 and 4)

c. EXxx ($\geq$ +0.77)--Simulator unavailability and poor data support (xx = 10 and 12)

d. EX13 (+0.67)--Unresponsiveness of analysis leader

e. EX18 (+0.58)--Poor hardware support

f. EXxx ($\geq$ +0.61)--Total lack of support from external groups and poor simulator and system software/hardware support (xx = 82, 84, 86, and 87)

This factor represents the effects of poor external support, especially poor analysis and simulator support.

3. Factor 14 - Analysis Leader's Responsiveness and Schedule (10 percent of variance). The factors strongly correlated with this factor include

a. EX14 (+0.74)--Analysis leader turnover

b. EX85 (+0.62)--Overall unresponsiveness associated with analysis leader

c. CP11 (-0.72)--Development schedule difficulty

This factor demonstrates an environmental effect. When schedules are difficult (short), the higher level organization will not encourage, suggest, or allow a change in analysis leaders because there may not be enough time for an effective and efficient phase-in of a new analysis leader. Furthermore, analysis leaders are reliable senior personnel responsible for accepting the software; therefore, with a difficult schedule, their sense of urgency intensifies, they are more cooperative, and they are more responsive to development problems.

4. Factor 15 - Analysis Leader's General Responsiveness (8 percent of variance). The measures strongly correlated with this factor include

a. EX16 (+0.62)--Unresponsiveness of analysis leader during late stages of development

b. EX85 (+0.56)--Overall unresponsiveness associated with the analysis leader

This factor also demonstrates an environmental effect. When there are few changes in analysis leadership (analysis manager and leader), there is a higher probability that the analysis leader will be more responsive in the later stages of development. Combined with factor 14, the development team gets its best analytical support when the schedule is difficult and when there are few changes in analysis leadership.

5. Factor 16 - High-Level Development Support (8 percent of variance). The measures strongly correlated with this factor include

a. EX05 (+0.59)--Unresponsiveness of development interface manager

b. EX17 (+0.59)--System software support problems

c. EX86 (+0.57)--Total system software and hardware support problems

d. IN05 (-0.66)--Development team turnover

This factor demonstrates a subtle environmental effect. When the development interface manager (who is the final authority for development direction, cost, and contact with customer, support, and contractor groups) is unresponsive to development problems and when there is poor support for system support software and hardware (which is controlled indirectly by the development interface manager), there is little development team turnover. Apparently, when the development team is not supported at the highest technical level, members stay with the job until it is complete; i.e., they do not desert their teammates when development conditions are difficult. However, it is not likely that anyone encourages the development interface manager to be unsupportive.

4.2.3.2 Measures Unrelated to Difficulty of Project

The following list contains measures that are not correlated with any of the Difficulty of Project factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. CP01 (factor 12, +0.54)--Memory storage constraints
2. CP02 (factor 14, +0.54)--Execution timing constraints
3. CP06 (factor 12, +0.28)--Number of system programs that communicate
4. CP09 (factor 15, +0.52)--Amount of old code used
5. CP84 (factor 12, +0.49)--Total of unrelated complexity measures
6. IN07 (factor 14, -0.55)--Need for extra help during development
7. IN08 (factor 14, -0.52)--Unresponsiveness of project manager during earlier phases of development
8. IN09 (factor 13, -0.54)--Project manager turnover
9. IN10 (factor 12, +0.53)--Unresponsiveness of project manager during later phases of development
10. EX11 (factor 13, +0.53)--Incorrectness of simulator
11. EX15 (factor 15, +0.55)--Unresponsiveness of analysis leader during later phases of development

4.2.4 PROCESS AND PRODUCT CHARACTERISTICS CLASS

The factor analysis of the Process and Product Characteristics class of measures produced a model containing five factors, which explain 85 percent of the variance of the class. Together they describe the general level of process and product quality and four other independent effects. Table A-4 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.4.1 Process and Product Characteristics Factors

The five Process and Product Characteristics factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.4 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 17 - Process and Product Quality (43 percent of variance). With the exception of

    a. PR01 (+0.42)--Project cost
    b. PRxx ($\geq$ +0.27)--Size of modules (xx = 4 through 7)

all Software Product (PR) category measures and all Product/Process Performance (PP) category measures are strongly correlated with this factor. The most strongly correlated single measure, i.e., not a sum, is development planning and follow-through (PP08, +0.97). The implication, of course, is that higher quality development processes and products result directly from good planning and following through with the plans.

2. Factor 18 - Resource Availability (21 percent of variance). With the exception of

a. RA01 (+0.13)--Availability of formal training for development

b. RA06 (+0.39)--Availability of simulator support

c. RAxx (≤ +0.49)--Availability of development support personnel (xx = 16 and 17)

all Resources Available (RA) category measures are strongly correlated with this factor. The two most strongly correlated (+0.95) measures are the availability of support documentation describing the development process (RA03) and the availability of instruction in the use of support software (RA04).

3. Factor 19 - Module Size (11 percent of variance). The measures strongly correlated with this factor are

- PRxx (≤ -0.55)--Size of modules (xx = 4 through 7 and 81)

This factor is simply a measure of the average size of modules in the product, assuming that small modules are better (i.e., easier to design, implement, test, and maintain). Larger values of the measures correspond to smaller module sizes.

4. Factor 20 - Support Software Support (6 percent of variance). The measures strongly correlated with this factor include

a. RA06 (+0.64)--Availability of simulator support

b. RA82 (+0.81)--Availability of support for system support software

This factor primarily represents the availability of personnel to maintain system support software and to provide instruction in its use. It also represents the availability of a data simulator.

5. Factor 21 - Formal Training (4 percent of variance). The only measure strongly correlated with this factor is

- RA01 (-0.58)--Availability of formal training for development

The factor is self-explanatory; however, the availability of librarians (RA16) is moderately positively correlated (+0.52). Over the timespan of this sample, librarians have always been available for a fairly high level of support. Unfortunately, because of expense and time constraints, formal training in development is very limited.

4.2.4.2 Measures Unrelated to Process and Product Characteristics

The following list contains measures that are not correlated with any of the Process and Product Characteristics factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. RA16 (factor 21, +0.52)--Availability of librarians
2. RA17 (factor 18, +0.49)--Availability of dedicated experts for help
3. PR01 (factor 21, -0.43)--Cost of project
4. PR04 (factor 19, -0.55)--Size of newly developed modules

4.2.5 DEVELOPMENT TEAM BACKGROUND CLASS

The factor analysis of the Development Team Background class of measures produced a model containing five factors, which explain 86 percent of the variance of the class. Together they describe the level of the technical staff's applicable experience and reputation and four other independent effects. Table A-5 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.5.1 Development Team Background Factors

The five Development Team Background factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of the measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.5 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 22 - Technical Staff's Applicable Experience and Reputation (41 percent of variance). The measures strongly correlated with this factor include

   a. RKxy ($\geq$ +0.56)--In general, the reputation of programmers, technical staff, and project managers alone and combined with analysis managers (x = 0 through 3; y = 1 through 6). (The sign of the correlation is reversed relative to that reported in Appendix A of this volume because low values correspond to high ranks.)

   b. YPxy ($\geq$ +0.62)--In general, the professional experience of programmers and development organization technical staff except for testing (x = 0, 1, and 3; y = 1, 2, 3, and 6)

c. YAxy (≥ +0.60)--In general, the applicable experience of programmers, technical staff, and managers, excluding development interface managers (x = 0 through 3; y = 1 through 6)

d. YExy (≥ +0.63)--In general, the environment experience of programmers, development organization technical staff, and project managers (x = 0 through 3; y = 1, 2, 3, and 5)

e. ZZx9 (≤ -0.71)--Experience of development interface managers (ZZ = RK, YP, YA, and YE; x = 0 through 3)

This factor basically represents the technical staff's applicable experience and reputation (rank), where the technical staff includes the programmers (y = 1 through 4) and some fraction of the project managers, (y = 2 through 7), the analysis managers (y = 3, 6, and 8), and the development interface managers (y = 4, 7, and 9). The factor shows that reputation is correlated with type of experience in the following order: applicable, environment, and professional. The inverse correlation with the development interface managers results because their organization is more stable; therefore, they tend to have more experience than the development organization for the projects in the sample.

2. <u>Factor 23 - Technical Staff's Professional Experience (22 percent of variance)</u>. The measures strongly correlated with this factor include

a. YPxy (≥ +0.57)--Professional experience of programmers, technical staff, and project and development interface managers (x = 0 through 3; y = 1, 2, 3, 4, 5, and 7)

b. YAx7 ($\geq$ +0.73)--Applicable experience of project and development interface managers (x = 0 through 3)

c. YAx4 ($\geq$ +0.61)--Applicable experience of programmers and development managers for testing and overall life of the project (x = 2 and 3)

d. RK06 (-0.57)--Reputation of project and analysis managers for design

e. RK28 (-0.60)--Reputation of analysis managers for testing

f. YAx8 ($\leq$ -0.58)--Applicable experience of analysis managers (x = 0 through 3)

g. YE18 (-0.58)--Environment experience of analysis managers for implementation

Basically, this factor represents the technical staff's professional experience. It also shows inverse correlations with the analysis manager's experience (especially applicable experience) for different phases of development.

3. <u>Factor 24 - Development Interface Managers' Environment Experience (10 percent of variance)</u>. The measures strongly correlated with this factor include

a. RKx7 ($\geq$ +0.57)--Reputation of development interface managers (x = 0, 2, and 3)

b. YExx ($\geq$ +0.56)--Environment experience of development interface managers alone and combined with programmers (xx = 7, 14, 17, 24, 27, 34, and 37)

This factor represents the environment experience of the development interface managers. The most strongly correlated (+0.71) measure is YE14, which combines their experience with the basic development team's experience.

4. Factor 25 - Project and Analysis Managers' Environment Experience for Implementation (7 percent of variance). The measures strongly correlated with this factor include

a. YA05 (+0.58)--Applicable experience of project managers for design

b. YE16 (+0.59)--Environment experience of project and analysis managers for implementation

c. YEx8 ($\geq$ +0.57)--Environment experience of analysis managers overall and for testing (x = 2 and 3)

This factor is named for the most strongly correlated measure, YE16.

5. Factor 26 - Analysis Managers' Environment Experience for Testing (6 percent of variance). The measures strongly correlated with this factor include

a. YE26 (+0.59)--Environment experience of project and analysis managers for testing

b. YE28 (+0.65)--Environment experience of analysis managers for testing

c. RK17 (-0.62)--Reputation of development project and interface managers for implementation

This factor is named for the most strongly correlated measure, YE28.

4.2.5.2 Measures Unrelated to Development Team Background

The following list contains measures that are not correlated with any of the Development Team Background factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. RK08 (factor 23, -0.45)--Reputation of analysis managers during design

2. RK15 (factor 26, -0.54)--Reputation of development project managers during implementation

3. YPx8 (factor 23, ≥ +0.45)--Professional years of experience of analysis managers during all phases (x = 0 through 3)

4. YE08 (factor 23, +0.56)--Environment years of experience of analysis managers during design

4.2.6 MODELS CLASS

The factor analysis of the Models class of measures for resource estimation models produced a model containing six factors, which explain 73 percent of the variance of the class. Together they describe the system's size and five other independent effects. Table A-6 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.6.1 Models Factors

The six Models factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of the measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.6 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 27 - System Size (24 percent of variance). The measures strongly correlated with this factor include

    a. WFxx ($\geq$ +0.66)--Overall complexity and size-related complexity measures (xx = 14, 15, 16, 22, 23, and 85)

    b. WFxx (+0.87)--Total effort (xx = 51 and 52)

    c. WFxx ($\geq$ +0.84)--Delivered and developed graphics macros, FORTRAN, and total source code (xx = 68 through 70 and 72 through 74). (Developed assembler code (WF67) has a correlation coefficient of +0.66.)

    d. WF75 (+0.68)--Number of data base items

e. WF76 (+0.93)--Number of pages of documentation

f. PS09 (+0.72)--Schedule length

g. WF44 (-0.62)--Use of chief programmer concept

h. PS01 (-0.62)--Percentage of calendar schedule spent to get to CDR

This factor represents the system's size. It shows that the larger a system becomes, the less likely it is that a single person (WF44) can direct all development activities. It also shows that the larger the system, the greater the proportion of calendar schedule needed to implement and test the system (PS01). The number of pages of documentation (WF76) is the most strongly correlated (+0.93) measure.

2. Factor 28 - Programmers' Qualifications (14 percent of variance). The measures strongly correlated with this factor include

a. WFxx ($\geq$ +0.59)--Programmer qualifications and graphics, application, and overall experience (xx = 4, 7, 8, and 81)

b. WF54 (+0.65)--Percentage of work schedule needed to produce accepted software

c. WFxx ($\geq$ +0.65)--Percentage of code that is mathematical or computational (xx = 61 and 62)

d. PSxx ($\geq$ +0.72)--Percentage of calendar schedule spent in design and implementation rather than in testing only and wrapping up project (xx = 2 and 8)

e. PSxx ($\geq$ +0.62)--Reduced complexity of project because of programmer experience (xx = 10, 11, and 81)

f. WF12 (-0.57)--Complexity of customer interface

This factor represents the programmers' overall qualifications. It shows that more experienced programmers (1) spend little time on the project after the system is accepted (WF54), (2) spend less time in the testing phases (PS02 and PS08), and (3) tend to work on systems that are more mathematical and computational (WF62) rather than on systems that are nonmathematical and require input/output (I/O) formatting (WF61). It may be coincidental, but the factor also shows that more experienced programmers tend to have a less complicated customer interface (WF12).

3. <u>Factor 29 - Testing Strategy (13 percent of variance)</u>. The measures strongly correlated with this factor include

a. WF02 (+0.66)--Participation in requirements definition

b. WFxx ($\geq$ +0.67)--Large amounts of graphics code and graphics testing (xx = 19, 31, 32, 36, 37, and 66)

c. WF63 (+0.57)--Percentage of code needed for central processing unit (CPU) and (I/O) control

d. WF47 (+0.69)--Percentage of programmer effort

e. WF46 (-0.78)--Percentage of administrative management effort

This factor identifies a testing strategy (correlated with code type) and possibly a management deficiency. Most of the software developed in this sample was developed for interactive operation, although it must also be possible to execute the software through batch operation. One method of testing the software is to use a graphic device as in normal operational use; a certain amount of testing must be done in this manner. However, graphics test time is difficult to obtain during standard hours. Furthermore, development groups are given lowest priority during standard hours.

Therefore, more experienced managers and senior personnel try to discourage a strong dependence on graphics test time because programmers must work nonstandard hours to get efficient test time.

The possible management deficiency is that when programmers appear to be hard at work (graphics testing), managers tend to think that everything is all right and to pay less attention to the project (WF46). In general, however, systems tested primarily through graphics testing do not have better operational performance records than those tested with more emphasis on batch methods.

4. Factor 30 - New Project Type (10 percent of variance). The measures strongly correlated with this factor include

a. WF39 (+0.59)--Percentage of batch testing

b. WF43 (+0.70)--Percentage of top-down development

c. PS11 (+0.62)--Reduced complexity of project because of programmer experience

d. PS14 (+0.65)--Percentage of new design

e. PS15 (+0.68)--Percentage of new code

This factor represents the new project type, i.e., mostly new design (PS14) and new code (PS15). It shows that development teams developing systems with less of a design/implementation model (1) tend to use top-down development techniques (WF43), (2) tend to rely on batch testing techniques (WF39), and (3) are composed of more experienced personnel (PS11). In addition, see factor 3 in Section 4.2.1.

5. Factor 31 - Code Reading and Testing (6 percent of variance). None of the measures are strongly correlated with

this factor. Measures that are moderately correlated with this factor include

a. WF42 (+0.52)--Amount of code reading

b. PS07 (+0.55)--Percentage of calendar schedule spent during documentation phase

c. PS05 (-0.45)--Percentage of calendar schedule spent during testing phase

d. PS06 (-0.52)--Percentage of calendar schedule spent during testing activity

This factor shows that teams that rely on code reading (WF42) as a code validation technique spend less time in the testing phases (PS05 and PS06).

6. <u>Factor 32 - Design Team Size (6 percent of variance)</u>. None of the measures are strongly correlated with this factor. Measures that are moderately correlated with this factor include

a. WF05 (+0.47)--Programmer familiarity with development computer

b. WFxx ($\geq$ 0.45)--Complexity of interprogram communications, data base structures, and execution timing constraints (xx = 16, 18, and 21)

c. WF03 (-0.48)--Percentage of programmers participating in design

d. WF50 (-0.47)--Percentage of support service support

This factor shows that projects with relatively small design teams (WF03) are composed of programmers who are experienced with the development computer (WF05) and who have to design a system with complex interprogram communications (WF16), data base structures (WF18), and execution timing constraints (WF21). In general, the use of a smaller design team is a development philosophy that has evolved over the past few years in this environment; that is, it is desirable to start projects with smaller, more experienced staffs to get a better grasp of the problem before plunging ahead.

4.2.6.2 Measures Unrelated to Models

The following list contains measures that are not correlated with any of the Models factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. WF03 (factor 32, -0.49)--Percentage of programmers participating in design
2. WF05 (factor 28, +0.54)--Programmer familiarity with development computer
3. WF06 (factor 30, +0.39)--Programmer familiarity with programming language
4. WF09 (factor 32, +0.40)--Degree to which programmers worked together before project
5. WF13 (factor 30, +0.49)--Number of customer-originated design changes
6. WF18 (factor 27, +0.55)--Complexity of data base structures
7. WF2C (factor 27, +0.55)--Memory storage constraints
8. WF21 (factor 27, +0.46)--Execution timing constraints
9. WF34 (factor 32, -0.48)--Percentage of programmers participating in design
10. WF35 (factor 28, +0.49)--Percentage of programmers who worked together before project
11. WF40 (factor 29, -0.47)--Percentage of development that is interactive (TSO)

12. WF41 (factor 32, +0.37)--Percentage of code that is structured

13. WF42 (factor 31, +0.52)--Percentage of code for which code reading is performed

14. WF45 (factor 29, -0.46)--Percentage of effort that is technical management

15. WF50 (factor 30, +0.52)--Percentage of effort that is support services charges

16. WF71 (factor 27, +0.54)--Number of delivered lines of code (LOC) that is assembler language

17. PS03 (factor 27, +0.50)--Percentage of calendar schedule spent during implementation phase

18. PS04 (factor 27, +0.53)--Percentage of calendar schedule spent during implementation activity

19. PS05 (factor 28, -0.50)--Percentage of calendar schedule spent during testing phase

20. PS06 (factor 27, +0.53)--Percentage of calendar schedule spent during testing activity

21. PS07 (factor 31, +0.55)--Percentage of calendar schedule spent during documentation phase

22. PS12 (factor 28, -0.55)--Complexity of product

23. PS13 (factor 30, +0.51)--Complexity of external development effects

24. PS16 (factor 30, +0.54)--Percentage of new testing

4.2.7 ADDITIONAL DETAIL CLASS

The factor analysis of the Additional Detail class of measures produced a model containing six factors, which explain 83 percent of the variance of the class. Together they describe the system's size in terms of effort and five other independent effects. Table A-7 of Appendix A (Volume 1) presents details of the analysis. The following subsections describe the factors and list the unrelated measures.

4.2.7.1 Additional Detail Factors

The six Additional Detail factors are described below. Each description is composed of the factor's name, the percentage of the variance the factor explains, a list of the measures correlated with the factor, and a narrative. The measures correlated with each factor are listed in the order in which they are listed in Section A.7 of Appendix A (Volume 2), first for the positively correlated measures and then for the negatively correlated measures. Correlations appear in parentheses following the measure codes.

1. Factor 33 - Effort-Related System Size (30 percent of variance). The measures strongly correlated with this factor include

    a. MSxx (≥ +0.60)--Number of subsystems, input data sets, and total data sets in product; number of programs, subsystems, and total data sets needed in normal processing (xx = 2, 3, 6, 11, 12, and 16)

    b. MXxx (≥ +0.70)--Pages of documentation (xx = 21 through 25)

    c. MSxx (≥ +0.87)--Average staff size (xx = 26 through 28)

    d. SWxy (≥ +0.57)--Basically, all representations that are proportional to LOC, i.e., components, modules, executable LOC, decisions, library changes, software changes, and errors for newly developed, extensively modified, slightly modified, and total representations. Usually, old, assembler, and graphics macros representations are not strongly correlated. (In general, x = 0, 2, 4, 5, 6; y ≠ 4 or 9)

e. SW84 (+0.56)--Decisions per module with executable code

f. SW87 (+0.62)--Executable LOC per baseline diagram component

g. ESxx (≥ +0.68)--All size, effort, and process activity measures except use of tertiary development computer (ES19) (xx = 1 through 18)

This factor represents the activities related to major effort areas. Measures that generally represent minor effort areas, e.g., the use of unchanged (old) code, and measures that represent smaller efforts, e.g., the use of assembler code (on the average, less than 2 percent of the product), have the weakest correlations.

2. <u>Factor 34 - Data Base Size (10 percent of variance)</u>. The measures strongly correlated with this factor include

a. MS20 (+0.60)--Total data base size

b. SWxx (≤ -0.58)--Slightly modified and old LOC and executable LOC of graphics macros; old LOC and executable LOC of FORTRAN (xx = 18, 19, 24, 38, 39, and 44)

In general, the input and output data base size requirements do not vary significantly from project to project in this environment. Therefore, when a project has unusually large data base requirements (MS20), the likelihood is small that the project will have many similarities to other projects. Hence, fewer old graphics macros and less old FORTRAN code can be reused (an inverse correlation with SWxx). The implication is that projects with large data bases probably require more effort to develop than the average project. Factor 30 (new project type) in Section 4.2.6 is moderately correlated (+0.47) with number of items in the data base (WF23).

3. Factor 35 - Internal Data Set Communication (8 percent of variance). The measures strongly correlated with this factor include

   a. SWxx (≥ +0.58)--Old and total assembler LOC and executable LOC (xx = 14, 15, 34, and 35)

   b. MSxx (≤ -0.58)--Number of I/O data sets in product and number needed for normal processing; number of I/O data base items needed for normal processing (xx = 8, 14, and 18)

   c. SWxx (≤ -0.56)--Extensively modified baseline diagram components, decision modules, assembler LOC, and executable LOC (xx = 2, 7, 12, and 32)

This factor represents the data processing system, i.e., systems that preprocess data (e.g., for screening or calibration) or systems that postprocess data (e.g., for smoothing, quality assurance, or packaging). These systems tend to use larger numbers of internal data sets to manipulate data. The factor also indicates that data processing systems tend to use large amounts of extensively modified code and small amounts of assembler code.

4. Factor 36 - Use of Old Code (6 percent of variance). The measures strongly correlated with this factor include

   a. SW09 (+0.65)--Number of old modules

   b. SWx1 (≤ -0.57)--New assembler LOC and executable LOC (x = 1 and 3)

This factor represents the use of old code. It indicates that as more old code is used, the less likely it is that new assembler code will be developed. Several other old code type measures are moderately positively correlated.

5. Factor 37 - Code Error Content (5 percent of variance). The measures strongly correlated with this factor include

a. SW76 (-0.58)--Errors per 1000 LOC during development
b. SW79 (-0.57)--Errors per baseline diagram component during development

This factor represents the number of errors in the code. Several other error measures are moderately negatively correlated.

6. Factor 38 - Code Complexity (4 percent of variance). The measures strongly correlated with this factor include

a. MS15 (+0.59)--Number of output data sets
b. SW82 (+0.67)--Decisions per 1000 executable LOC
c. SW86 (-0.65)--Executable LOC per 1000 LOC
d. SW88 (-0.59)--Executable LOC per module

This factor represents the complexity of the code as measured by decisions, i.e., number of simple arguments in IF, IF-THEN-ELSE, DO, and DOWHILE statements. It shows that as the number of decisions per thousand executable LOC (SW82) increases, the number of executable LOC per thousand LOC (SW86) and per module (SW88) decreases.

4.2.7.2 Measures Unrelated to Additional Detail

The following list contains measures that are not correlated with any of the Additional Detail factors at the 0.01 significance level. The factor with which each measure is most strongly correlated and the value of that correlation appear in parentheses after the measure code.

1. MS01 (factor 35, +0.53)--Number of programs in developed product
2. MS04 (factor 35, -0.56)--Number of I/O data sets in developed product
3. MS05 (factor 33, +0.47)--Number of output data sets in developed product
4. MS07 (factor 33, +0.46)--Number of input data base items in developed product
5. MS09 (factor 35, +0.42)--Number of output data base items in developed product
6. MS10 (factor 34, +0.56)--Total number of data base items in developed product
7. MS13 (factor 33, +0.46)--Number of input data sets needed for normal processing
8. MS17 (factor 34, +0.28)--Number of input data base items needed for normal processing
9. MS19 (factor 35, +0.43)--Number of output data base items needed for normal processing
10. SW04 (factor 36, +0.56)--Number of unchanged (old) baseline diagram components in product
11. SW17 (factor 33, +0.49)--Number of extensively modified LOC of graphics macros
12. SW29 (factor 36, +0.55)--Total number of old LOC
13. SW33 (factor 33, +0.55)--Number of slightly modified executable LOC of assembler code
14. SW37 (factor 33, +0.50)--Number of extensively modified executable LOC of graphics macros
15. SW49 (factor 34, -0.54)--Total number of old executable LOC

16. SW69 (factor 33, +0.51)--Number of software errors in old code

17. SW71 (factor 38, +0.37)--Percentage of comments in newly developed code

18. SW72 (factor 33, +0.40)--Percentage of comments in extensively modified code

19. SW73 (factor 33, +0.49)--Percentage of comments in slightly modified code

20. SW74 (factor 33, -0.21)--Percentage of comments in old code

21. SW75 (factor 33, +0.31)--Percentage of comments in all code

22. SW77 (factor 37, -0.51)--Errors per 1000 executable LOC

23. SW78 (factor 38, +0.44)--Errors per 1000 decisions

24. SW80 (factor 37, -0.56)--Errors per decision module

25. SW81 (factor 34, -0.50)--Decisions per 1000 LOC

26. SW83 (factor 33, +0.49)--Decisions per baseline diagram component

27. SW85 (factor 38, -0.42)--Ratio of coded LOC to expanded LOC, i.e., expansion from INCLUDE blocks of code

28. SW89 (factor 38, +0.33)--Number of library data sets changed per implementation change

29. SW90 (factor 35, +0.38)--Percentage of errors in implementation changes

30. ES19 (factor 33, -0.15)--Number of computer hours used on tertiary development computer

4.3 SUMMARY ANALYSIS OF CLASS FACTORS

The analyses described in Section 4.2 identify 38 principal factors among the 7 classes of measures; this number of factors is substantially fewer than the 608 measures originally used in the analyses. The information contained in each set of measures (38 and 608) can be displayed for comparison using the cluster analysis technique discussed in Section 3.3.

Figure 4-1 shows the results of a cluster analysis of the 608 measures that passed the test of normality (see Section 4.1). Levels of similarity between projects are indicated in the table by the number of horizontal lines of asterisks connecting them. For example, Figure 4-1 can be used to divide the sample of 20 systems into 2 groups, or clusters, by tracing across the graph at the level where the "number of clusters" is equal to 2. The 20 systems appear to be divided into these 2 clusters on the basis of size. This result verifies our intuitive understanding that essential differences exist between small and large projects.

System 730, which was grouped by cluster analysis with the small systems, is the only exception to the classification of systems with fewer than 30,000 lines of code as being small (see Section 2.1). Thus, System 730 is closer to the pattern of small systems than to that of large systems. Furthermore, it is the smallest of the large systems (with 33,000 lines of code). This suggests that the classification criterion should be adjusted to include this system in the small group.

The importance of size measures is reflected in the results of the factor analyses: size factors are identified within three of the seven classes of measures. However, one property of factors is that they combine the effects of related

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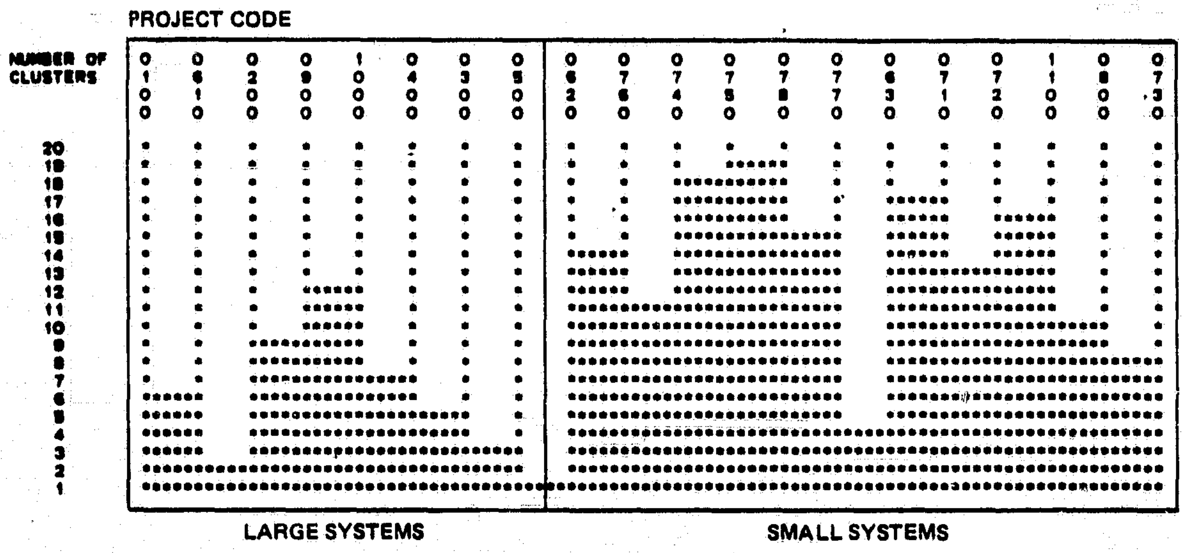

Figure 4-1. Cluster Map Based on Screened Measures

measures. Thus, the relative weights of the most frequently occurring measures, such as size, are reduced.

Figure 4-2 shows the result of a cluster analysis of the 38 factors identified in Section 4.2. Note that the classification of projects into two groups on the basis of size has been preserved, although the structure within these groups as shown in Figure 4-2 is different from that of Figure 4-1. The preservation of this basic classification confirms that the factor analyses of classes of measures have been successful in extracting the major descriptive qualities from the original screened measures.

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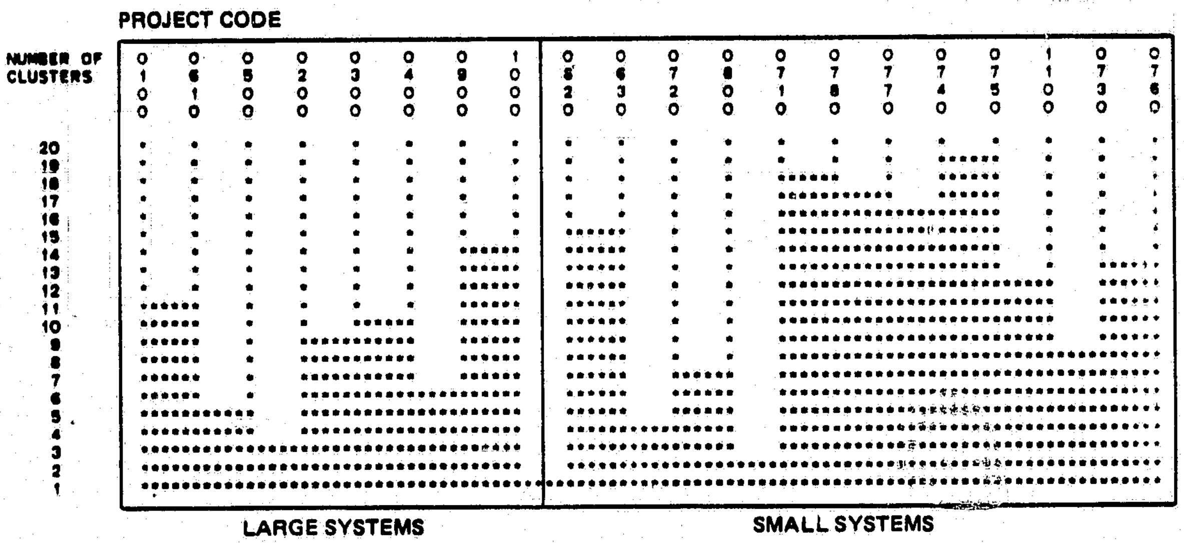

Figure 4-2. Cluster Map Based on Combined Factors

4.4 FACTOR ANALYSIS OF CLASS FACTORS

The factor analysis of the combined (class) factors data set produced a model containing 5 high-level factors, which explain 64 percent of the variance of the 38 class factors. Together they describe the small and large systems and the experience levels of the development teams. The details of this factor analysis are reproduced in Table B-1 of Appendix B. The following subsections summarize these results. The high-level factors and the unrelated class factors are listed.

4.4.1 HIGH-LEVEL FACTORS

The five high-level factors are described below. Each description is composed of the high-level factor's name, the percentage of the variance the high-level factor explains, a list of class factors correlated with the factor, and a narrative. The class factors correlated with each factor are listed in numerical order, first for the positively correlated class factors and then for the negatively correlated class factors. Correlations appear in parentheses following the class factor number.

The descriptive names applied to factors in this section are intended to suggest the types of values that tend to occur together, based on the analysis of the factor pattern shown in Table B-1b of Appendix B. For example, two groups of attributes can be defined that are characteristic of small systems and of large systems. Depending on its size, any given system would possess all these attributes to a greater or lesser degree. Therefore, this section describes a set of profiles or patterns with which any given development project can be compared.

1. <u>High-Level Factor 1 - Small System Profile (16 percent of variance)</u>. The factors strongly correlated with this high-level factor include

a. Factor 8 (+0.60)--Stability and high performance of development team managers, i.e., project manager and leader and development interface manager and leader (MG and PF)

b. Factor 13 (+0.67)--Poor external support (EX)

c. Factor 17 (+0.79)--High-quality process and product (PR and PP)

d. Factor 12 (-0.62)--Less complex and difficult project (CP, IN, EX, and DF)

e. Factor 26 (-0.63)--Low level of environment experience of analysis managers for testing (RK and YE)

f. Factor 27 (-0.60)--Small system size (WF and PS)

g. Factor 33 (-0.61)--Low effort-related system size (MS, SW, and ES)

Factors that are moderately correlated include

a. Factor 1 (+0.52)--Moderately high general use of software engineering practices (MT, TS, DC, and SE)

b. Factor 5 (+0.54)--Moderately high use of chief programmer. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (MT, TS, and DC)

c. Factor 6 (+0.50)--Moderate level of ability of technical staff (AP, MG, PF, and AB)

d. Factor 29 (+0.47)--Moderate tendency to use graphics test time rather than batch testing methods (WF)

e. Factor 35 (+0.48)--Moderately large number of data sets for internal communication. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (MS and SW)

f. Factor 37 (-0.49)--Smaller number of errors in the code during development. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (SW)

This high-level factor represents the typical small system development pattern. In this environment, small systems generally

- Tend to be mainly utility data processing applications, such as preprocessing for data reduction and calibration or postprocessing for data smoothing, quality assurance, and packaging. Therefore, small systems use more internal data sets for communication (factor 35) to manipulate data. Because small systems are usually data manipulation and inspection systems, they tend to have a large amount of interactive graphic code and, therefore, are primarily tested graphically (factor 29).

- Are not complex or difficult (factor 12). They are developed with a high-quality process that produces a high-quality product (factor 17), which has moderately fewer development errors per thousand LOC (factor 37).

- Tend to have chief programmers (factor 5) because the systems are small enough for a single person to direct all technical activity.

- Have moderately able technical staffs (factor 6), who use software engineering practices to a moderately high degree (factor 1).

- Have more stable team management (factor 8) because the development schedules are relatively short.

- Have poor external support (factor 13) because small systems are generally not so critical in terms of cost and schedule impact compared with larger projects being developed at the same time. This is reenforced by the low level of environment experience of the analysis managers assigned responsibility for small systems during the testing phases (factor 26).

2. <u>High-Level Factor 2 - Large System Profile (14 percent of variance)</u>. The factors strongly correlated with this high-level factor include

   a. Factor 31 (+0.58)--High use of code reading and less time spent during testing phases (WF and PS)

   b. Factor 33 (+0.64)--Large effort-related system size (MS, SW, and ES)

   c. Factor 2 (-0.67)--High use of interactive development techniques (MT, TS, and DC)

   d. Factor 4 (-0.59)--Low use of structured implementation (MT and TS)

   e. Factor 7 (-0.64)--Ineffectiveness and low performance of development interface managers (AP, MG, and PF)

   f. Factor 14 (-0.60)--Difficult schedule and responsive analysis leader (CP and EX)

Factors that are moderately correlated include

   a. Factor 12 (+0.54)--Moderately complex and difficult project (CP, IN, EX, and DF)

   b. Factor 27 (+0.47)--Moderately large system size (WF and PS)

c. Factor 10 (-0.54)--Moderate overall ineffectiveness of analysis leader as a manager (AP and MG)

d. Factor 18 (-0.56)--Moderately low availability of resources (RA)

e. Factor 19 (-0.44)--Large average module size. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (PR)

f. Factor 23 (-0.45)--Moderately low level of professional experience of technical staff (RK, YP, YA, and YE)

This high-level factor represents the typical large system development pattern. In this environment, large systems generally

- Are moderately complex and difficult (factor 12).

- Have schedules with more than average difficulty; therefore, the analysis leader's responsiveness tends to be higher for larger projects (factor 14).

- Have technical staffs with a moderately low level of professional experience (factor 23). However, they tend to use primarily interactive development techniques (factor 2) and code reading to validate code (factor 31). Because larger systems tend to reuse more code from previously developed systems than do smaller systems, structured implementation is used less (factor 4) and the average module size in the system is moderately larger than the average size in this sample (factor 19).

- Have moderately low availability of resources (factor 18), which cannot be adequately supplied in a decaying, archaic computing environment. Therefore, the effectiveness of the development interface managers is generally low (factor 7).

3. High-Level Factor 3 - High Use of Software Engineering Technology (12 percent of variance). The factors strongly correlated with this high-level factor include

a. Factor 1 (+0.67)--High general use of software engineering practices (MT, TS, DC, and SE)

b. Factor 6 (+0.60)--High level of ability of technical staff (AP, MG, PF, and AB)

c. Factor 18 (+0.58)--High availability of resources (RA)

d. Factor 30 (+0.56)--New project type (WF and PS)

e. Factor 8 (-0.61)--Overall instability of managers (MG and PF)

Factors that are moderately correlated include

a. Factor 2 (+0.50)--Moderately high use of batch development techniques (MT, TS, and DC)

b. Factor 14 (+0.52)--Less than average schedule difficulty and moderately unresponsive analysis leader (CP and EX)

c. Factor 22 (+0.52)--Moderately high level of applicable experience and good reputation of technical staff (RK, YP, YA, and YE)

d. Factor 38 (+0.48)--Moderately complex code (MS and SW)

e. Factor 25 (-0.51)--Moderately low level of environment experience of project and analysis managers for implementation (YA and YE)

This high-level factor represents the high use of software engineering technology. In general, software engineering practices are used to the highest degree when

- The technical staff has a moderately high level of ability (factor 6) and a moderately high level of applicable experience (factor 22)

- The software product is mostly new design and code (factor 30)

- The team has reasonable access to resources (factor 18)

This trend occurs even though there is not much stability among the interfacing managers and leaders (factors 8 and 14).

This trend is not surprising because most programmers do not want to work with old code. High performers are more flexible, willing to embrace new technologies, able to see the benefits of them, and can find ways to obtain resources. While it is possible to train personnel and to improve their performance, it is not possible to get rid of old code because its use is deemed cost effective. The development manager's job of training programmers to use modern programming practices while modifying, enhancing, or rebuilding old systems is not an easy one.

The projects characterized by high use of software technology, high level of personnel ability, and mostly new software tend to

- Have schedules with less than average difficulty (factor 14)

- Use primarily batch development techniques (factor 2)

- Produce moderately complex code (factor 38) compared with the average complexity in this sample, measured by the number of decisions per 1000 executable LOC

4. <u>High-Level Factor 4 - Small Design Team (11 percent of variance)</u>. The factors strongly correlated with this high-level factor include

a. Factor 21 (+0.62)--High degree of formal training. The sign of the correlation is reversed because the sign of the correlation of the principal measure is negative (RA)

b. Factor 32 (+0.74)--Small design team (WF)

c. Factor 15 (-0.86)--Very responsive analysis leader (EX)

Factors that are moderately correlated include

a. Factor 19 (+0.50)--Small average module size. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (PR)

b. Factor 34 (+0.56)--Large data base size (MS and SW)

c. Factor 5 (-0.51)--Moderately low use of chief programmer. The sign of the correlation is reversed because the signs of the correlations of the principal measures are negative (MT, TS, and DC)

d. Factor 9 (-0.49)--Ineffectiveness of analysis managers (AP and MG)

This high-level factor represents the small design team. In general, team members have been formally trained in development (factor 21) and work with systems that have complex interprogram communications, data base structures, and execution timing constraints (factor 32). This trend is reenforced by the fact that the systems have moderately large data bases (factor 34). Although there is no correlation with system size, this factor indicates moderately low use of the chief programmer (factor 5). The average module size tends to be smaller (factor 19) than the average as a result of formal training.

5. <u>High-Level Factor 5 - Highly Qualified Team (11 percent of variance)</u>. The factors strongly correlated with this high-level factor include

a. Factor 20 (+0.61)--High level of support for support software (RA)

b. Factor 28 (+0.58)--Highly qualified programmers (WF and PS)

Factors that are moderately correlated include

a. Factor 6 (+0.53)--Moderate level of ability of technical staff (AP, MG, PF, and AB)

b. Factor 10 (+0.44)--Moderately effective analysis managers (AP and MG)

c. Factor 31 (+0.48)--Moderate use of code reading and moderately less time spent during testing phases (WF and PS)

d. Factor 11 (-0.51)--Instability of experienced project manager. The sign of the correlation is reversed because the sign of the correlation of the principal measure is negative (MG)

e. Factor 13 (-0.48)--Moderately good external support (EX)

f. Factor 16 (-0.47)--Moderately good high-level development support and moderately high team turnover (IN and EX)

g. Factor 34 (-0.46)--Small data base size (MS and SW)

This high-level factor summarizes the qualifications of the development team for the application. The characteristics of a highly qualified team are highly qualified programmers (factor 28), a technical staff with a moderately high level of ability (factor 6), an experienced project manager (factor 11), a moderately effective analysis manager (factor 10), and a moderately supportive development interface manager (factor 16). This development interface manager is directly and indirectly responsible for a high level of support for support software (factor 20) and hardware (factor 16), as well as for simulator data and analysis support (factor 13). However, the team is likely to lose its project manager (factor 11) and to have a high turnover of programmers (factor 16).

4.4.2 UNRELATED CLASS FACTORS

The following list contains class factors that are not correlated with any of the high-level (hereafter referred to as HL) class factors at the 0.01 significance level. The factor with which each class factor is most strongly correlated and the value of that correlation appear in parentheses following the class factor number.

1. Factor 3 (HL factor 5, -0.40)--Low use of top-down design techniques (MT)

2. Factor 5 (HL factor 1, +0.54)--High use of chief programmer. The sign is reversed (MT, TS, and DC)

3. Factor 9 (HL factor 4, -0.49)--Ineffectiveness of analysis managers (AP and MG)

4. Factor 10 (HL factor 2, -0.54)--Ineffectiveness of analysis leader (AP and MG)

5. Factor 11 (HL factor 5, -0.51)--Instability of experienced project manager. The sign is reversed (MG)

6. Factor 16 (HL factor 5, -0.47)--Good high-level development support and high team turnover (IN and EX)

7. Factor 19 (HL factor 4, +0.50)--Small average module size. The sign is reversed (PR)

8. Factor 22 (HL factor 3, +0.52)--High level of applicable experience and good reputation of technical staff (RK, YP, YA, and YE)

9. Factor 23 (HL factor 2, -0.45)--Low level of professional experience of technical staff (RK, YP, YA, and YE)

10. Factor 24 (HL factor 1, +0.44)--Low level of environment experience of development managers (RK and YE)

11. Factor 25 (HL factor 3, -0.51)--Low level of environment experience of project and analysis managers for implementation (YA and YE)

12. Factor 29 (HL factor 1, +0.47)--Tendency to use graphics test time rather than batch testing methods (WF)

13. Factor 34 (HL factor 4, +0.56)--Large data base size (MS and SW)

14. Factor 35 (HL factor 1, +0.48)--Large number of data sets for internal communication (MS and SW)

15. Factor 36 (HL factor 4, +0.44)--High use of old code (SW)

16. Factor 37 (HL factor 1, -0.49)--Small number of errors in code. The sign is reversed (SW)

17. Factor 38 (HL factor 3, +0.48)--Complex code (MS and SW)

Factors 3, 24, and 36 are the only class factors not correlated with any high-level factor at the 0.05 significance level.

SECTION 5 - CONCLUSIONS

This section summarizes the conclusions derived from the analysis of the SEL software management measures collected for 20 independent software development projects. Section 5.1 summarizes the findings stated either explicitly or implicitly in Section 4, and Section 5.2 recommends a course of action based on these findings.

5.1 FINDINGS

The findings are presented below in the order in which they were derived by the analytical procedure (see Figure 3-1).

Test of Normality. This test shows that not all measures are appropriate; that is, some measures fail to differentiate one group of projects from another. Approximately one-half of the measures rejected by the test of normality are measures that were developed for another environment or for use with several environments. The results of additional analyses of SEL measures will not change their status.

The development managers should discard these measures unless there are

- Anticipated changes in the development process and environment
- Plans for expansion of the organization's line of business
- Intentions to combine SEL data with data from other environments that use the same or similar measures

Factor Analysis of the Seven Classes of Measures. This analysis

1. Shows that by producing descriptive factors, a large set of measures can be reduced by approximately an order of magnitude.

2. Provides a basis for selecting the most important measures by their correlations with the descriptive factors and the ease with which measurements can be made.

3. Shows that many measures are related to system size. Apparently, whether consciously or not, managers tend to evaluate various effects with respect to system size (for example, complexity ratings).

Cluster Analysis of the Seven Classes of Measures. This analysis

1. Shows that the major distinction made among projects by the factors is system size and that System 730 was misclassified as a large project.

2. Confirms that the Walston-Felix (WF) category of measures is an excellent set of measures and that, to a large extent, the SEL measures are basically an expansion and elaboration of the WF measures. The reader can see this by comparing Figure 4-1 (cluster map for all screened SEL measures) with Figure A.6.1-2 in Appendix A of Volume 2 (cluster map for WF category). The comparison shows that the cluster maps are very nearly identical in project pairings, although differences in the levels of similarity exist. There is one exception to this generalization: System 200's high degree of similarity with System 900 rather than with System 300.

Because the cluster maps (see Figure 4-1) of the small project group and the large project group, separately, are not similar to a cluster map of any other individual category of measures, the levels of similarity within the two groups are a reflection of the effects of all classes of measures, i.e., software engineering, experience, complexity, and product effects. The differences in the levels of similarity indicated by comparison of the cluster map in Figure 4-1 and the cluster map for the WF measures (see Figure A.6.1-2) result from the finer detail added by the SEL measures.

Factor Analysis of the 38 Class Factors. This analysis

1. Shows that the major distinction made among projects is still system size; however, experience-related effects are obvious.

2. Points out subtle environmental quirks and weaknesses and, therefore, can alert development managers to take preventive steps, plan better for contingencies, and generally improve the process through proper training. Two of the important effects are as follows:

a. The high use of software engineering technology is strongly correlated with the level of ability of the technical staff and the degree to which a system is new, i.e., amount of new design and code. An obvious relationship of high technology use with team ability has been discussed within the SEL over the past few years. However, the relationship with the degree of system newness had not been apparent. The desire of programmers to completely develop something on their own (i.e., not constrained by large amounts of existing code) so that they can improve their skills is a familiar lament when assignments are made. Even though sound software engineering methodology is taught and its use is encouraged and enforced, programmers are apparently more highly motivated to use the methodology when they are satisfying career objectives.

In this environment, the development manager is faced with a difficult challenge in training personnel to use better technologies and in motivating them to use the technologies for maintenance, enhancement, and rebuilding activities where fairly large amounts of reused code are involved.

b. Although some current thinking is to use highly qualified teams to make large improvements in productivity and/or reliability, in this environment, highly qualified teams are likely to be unstable because experienced project managers and leaders are likely to be promoted and because career-minded programmers do not want to work in the same computing environment or with the same application very long.

Therefore, in this environment, higher level managers will have to be very creative in forming highly qualified teams and in helping team members to set career goals. Otherwise, team members are likely to leave the project for one reason or another to improve their skills, and the very purpose of bringing such a team together is defeated.

3. Shows that the data are not ideally represented for determining what is related to productivity or reliability. For example, only the Development Team Background class factor that accounts for the least amount of the variance within the class (factor 26) is strongly correlated with any of the combined factors, although all five class factors are moderately correlated with the combined factors. Years of experience (YOE), which obviously has a direct bearing on the outcome of a software development process, can be represented better. For example, an average person with 25 YOE is not likely to be 25 times better or faster than an average person with 1 YOE; however, he/she may be 7 times better or faster. No attempt to find a suitable transformation for years of experience or to normalize system size in terms of effort or errors was planned for this analysis; however, it is planned for future analysis.

Cluster Analysis of the 38 Class Factors. This analysis

1. Shows that the major distinction made among projects by the factors is still system size. The preservation of this distinction, in spite of the dilution of the effect of explicit size measures (Section 4.3), suggests that the effect of size is implicit in many not obviously related measures. For example, more experienced personnel may be regularly assigned to larger projects. Thus, team experience would be related to project size, although not obviously so.

2. Shows that the analytical technique reduces confounding effects (primarily overwhelming information in terms of system size) and points out a second major distinction among the small and the large projects: experience. The reader can see this by comparing the small project group in Figure 4-2 (cluster map for combined factors) with Figure A.5.3-4 in Appendix A of Volume 2 (cluster map of Years of Applicable Experience (YA) category). Excluding System 730, which was misclassified, comparison with the cluster maps of each category shows that the YA category has the same project pairings, considering small differences in the levels of similarity. This is encouraging because the outcome of a small development project is considered by many to be primarily related to the developers' experience.

The reader can see the experience relationship among the large projects by comparing the large project group in Figure 4-2 (cluster map for combined factors) with Figure A.2.1-3 in Appendix A of Volume 2 (cluster map of Experience With Application (AP) category). Excluding System 730, which was misclassified, comparison with the cluster maps of each category shows that the AP category is very nearly identical in project pairings, although there are some differences in levels of similarity.

The fact that different kinds of experience measures differentiate the small projects from the large projects is explained as follows. In general, smaller projects are usually staffed with more junior personnel in the environment; that is, they have little experience with the application, but they have varying degrees of applicable experience. Larger projects, however, are staffed with personnel who also have varying degrees of applicable experience and varying degrees of experience with the application.

The differences within the small and large project groups in the cluster map in Figure 4-2 are primarily because of experience levels. The differences between the cluster map in Figure 4-1, which closely resembles the cluster map for the Walston-Felix measures, and the cluster map in Figure 4-2 is a result of the finer detail in experience data provided by the SEL measures after the effects of system size have been reduced.

5.2 RECOMMENDATIONS

The analysis described in Section 4 and summarized in Section 5.1 identifies a number of significant software development qualities (or factors). That analysis evaluates the effectiveness of a large set of management measures with respect to those qualities. Thus, a basis has been established for defining a more concise set of software development measures. The measures considered cover every aspect of software development experienced by the SEL.

Although the complete set of 608 measures could be collected from every software development effort monitored, that process would be a tedious and time-consuming (expensive) process. The foregoing analysis demonstrates that a smaller set of measures oriented toward the basic qualities (factors) present in the data can be found. This smaller set contains most of the information of the original measures. A set of

38 appropriately selected measures retains about 80 percent of the information content of the complete set of 608.

Tables 5-1 through 5-7 identify the elements of such a concise set of measures. The measure(s) corresponding to each factor in the table is, in most cases, the measure most highly correlated with it. However, another highly correlated measure was sometimes selected because it appeared more representative or easier to obtain. Additional measures are included in the tables where additional information is desirable. A total of 78 measures is listed. The set of measures listed in these tables, then, constitutes the SEL's recommendation of management measures that should be collected and monitored during software development.

Figure 5-1, at the end of this section, demonstrates the accuracy of this set of 78 important measures. The cluster map shown in the figure preserves the size effect previously noted (see Sections 4.3 and 5.1), although it provides more detail. Note that three clusters are defined that correspond to large, intermediate, and small systems. The intermediate cluster is composed of the three smallest of the large systems. Furthermore, transpositions of the order of systems in the graph can be made (while preserving the relationships among the systems), which would produce a ranking of the systems from largest to smallest in terms of developed lines of code, with one exception. Thus, not only is project size a major characteristic, but, based on this analysis, developed lines of code is the most important measure of a software project of this application type in this environment.

These recommendations should not, however, be construed to imply that the study of software measures is complete. The SEL and other researchers are still engaged in an extensive review and analysis of measures. The study documented in this report considers only one set of measures. Furthermore, it does not analyze all the interrelationships of these measures or their specific applications. Those issues will be considered in a future document (Reference 13). However, this document does show how a relatively small set of measures can be defined in such a manner as to fully characterize or describe the software development process experienced by the SEL.

Table 5-1. Important Measures in the Software Engineering Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRE-LATION	MEASURE DESCRIPTION
1	1	GENERAL SOFTWARE ENGINEERING PRACTICES	MT15	+0.88	USE OF MODULE STUBS DURING IMPLEMENTATION TO PROMOTE THREAD TESTING
			TS03	+0.92	METHODOLOGY REENFORCEMENT BY PROJECT MANAGER AND PROJECT LEADER
			DC03	+0.75	USE OF DESIGN DECISION NOTEBOOK
2	2	BATCH DEVELOPMENT	TS10	+0.61	NONUSE OF TERMINALS FOR DEVELOPMENT, i.e., USE OF NONINTERACTIVE (BATCH) DEVELOPMENT TECHNIQUES
3	3	TOP-DOWN DESIGN	MT09	+0.85	USE OF TOP-DOWN DESIGN TECHNIQUES FOR NEW FUNCTIONS
4	4	STRUCTURED IMPLEMENTATION	TS06	+0.62	USE OF STRUCTURED FORTRAN PRECOMPILER TO AID IN PRODUCING STRUCTURED CODE
5	5	DEVELOPMENT TEAM'S ORGANIZATION	DC10	−0.47	RELEVANCE OF WEEKLY AND MONTHLY PROGRESS REPORTS IN REFLECTING PROJECT STATUS

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Table 5-2. Important Measures in the Development Team Ability Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRELATION	MEASURE DESCRIPTION
6	1	TECHNICAL STAFF'S ABILITY	AP03	+0.75	CONTRIBUTION FROM ESTABLISHED EXPERT (EXPERT 3) IN THE APPLICATION AND/OR ENVIRONMENT
			MGxx	~+0.85	EFFECTIVENESS OF THE PROJECT LEADER AS A MANAGER (xx = 2, 8, 14, 20, AND 26)
			PFx4	~+0.77	ON-THE-JOB PERFORMANCE OF THE DEVELOPMENT TEAM'S TECHNICAL STAFF, i.e., PROGRAMMERS, PROJECT MANAGER AND LEADER, AND DEVELOPMENT INTERFACE MANAGER AND LEADER (x = 0 THROUGH 3)
7	2	DEVELOPMENT MANAGERS' EFFECTIVENESS AND PERFORMANCE	AP09	+0.63	ANALYSTS' EXPERIENCE WITH THE APPLICATION
			MG17	+0.78	EFFECTIVENESS OF THE DEVELOPMENT INTERFACE MANAGER DURING IMPLEMENTATION
			PFx9	~+0.66	ON-THE-JOB PERFORMANCE OF THE DEVELOPMENT INTERFACE MANAGER (x = 0 THROUGH 3)
8	3	DEVELOPMENT TEAM MANAGERS' STABILITY AND PERFORMANCE	MG32	+0.57	PROJECT LEADER TURNOVER, i.e., REPLACEMENT
			MG35	+0.70	NUMBER OF CHANGES IN MANAGERS AND LEADERS FOR PROJECT, ANALYSIS, AND DEVELOPMENT INTERFACE
			PF17	+0.87	ON-THE-JOB PERFORMANCE OF THE PROJECT MANAGER AND LEADER AND THE DEVELOPMENT INTERFACE MANAGER AND LEADER DURING IMPLEMENTATION
9	4	ANALYSIS MANAGER'S EFFECTIVENESS	MG15	+0.64	EFFECTIVENESS OF THE ANALYSIS MANAGER DURING IMPLEMENTATION
10	5	ANALYSIS LEADER'S EFFECTIVENESS	MG10	+0.68	EFFECTIVENESS OF THE ANALYSIS LEADER AS A MANAGER DURING DETAILED DESIGN
11	6	PROJECT MANAGER'S EXPERIENCE AND STABILITY	AP06	+0.52	PROJECT MANAGER'S EXPERIENCE WITH THE APPLICATION
			MG31	–0.69	STABILITY OF (CHANGE IN) PROJECT MANAGER

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Table 5-3. Important Measures in the Difficulty of Project Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRELATION	MEASURE DESCRIPTION
12	1	PROJECT DIFFICULTY	CP07	+0.93	NUMBER OF SUBSYSTEMS TO BE DEVELOPED
			IN11	+0.81	DEVELOPMENT TEAM'S ATTITUDE, i.e., TEAM'S MOTIVATION AND SENSE OF URGENCY
			EX01	+0.76	CHANGING FUNCTIONAL SPECIFICATIONS AND REQUIREMENTS
13	2	EXTERNAL SUPPORT	EX1y	~+0.78	AVAILABILITY OF SIMULATOR FOR TEST DATA AND SUPPORT FOR DATA NEEDS (y = 0 AND 2)
14	3	ANALYSIS LEADER'S RESPONSIVENESS AND SCHEDULE	CP11	−0.72	DIFFICULTY OF DEVELOPMENT SCHEDULE
			EX14	+0.74	ANALYSIS LEADER TURNOVER, i.e., REPLACEMENT. THE EFFECT IS DIRECTLY PROPORTIONAL TO THE DEVELOPMENT PHASE, i.e., THE LATER THE REPLACEMENT OCCURS, THE WORSE THE EFFECT IS
15	4	ANALYSIS LEADER'S GENERAL RESPONSIVENESS	EX16	+0.62	ANALYSIS LEADER'S RESPONSIVENESS TO DEVELOPMENT TEAM'S PROBLEMS IN THE LATER (PRIMARILY TESTING) PHASES OF DEVELOPMENT
16	5	HIGH-LEVEL DEVELOPMENT SUPPORT	IN05	−0.66	DEVELOPMENT TEAM TURNOVER
			EX05	+0.59	RESPONSIVENESS OF DEVELOPMENT INTERFACE MANAGER TO DEVELOPMENT TEAM'S PROBLEMS

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Table 5-4. Important Measures in the Process and Product Characteristics Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRE-LATION	MEASURE DESCRIPTION
17	1	PROCESS AND PRODUCT QUALITY	PR03	+0.92	MANAGERS' CONFIDENCE IN PRODUCT
			PP08	+0.97	LEVEL OF DEVELOPMENT PLANNING AND FOLLOWING THROUGH WITH THE PLANS
18	2	RESOURCE AVAILABILITY	RA03	+0.95	AVAILABILITY OF DOCUMENTATION DESCRIBING THE DEVELOPMENT PROCESS
			RA04	+0.95	AVAILABILITY OF SUPPORT PERSONNEL TO PROVIDE INSTRUCTION IN USE OF SYSTEM SUPPORT SOFTWARE
19	3	MODULE SIZE	PR05	−0.90	SIZE OF EXTENSIVELY MODIFIED MODULES
20	4	SUPPORT SOFTWARE SUPPORT	RA82	+0.81	AVAILABILITY OF SUPPORT PERSONNEL TO PROVIDE INSTRUCTION IN THE USE OF AND MAINTENANCE FOR SYSTEM SUPPORT SOFTWARE; AVAILABILITY OF SIMULATOR FOR DATA SUPPORT
21	5	FORMAL TRAINING	RA01	−0.58	AVAILABILITY OF FORMAL TRAINING IN THE DEVELOPMENT PROCESS

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Table 5-5. Important Measures in the Development Team Background Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRELATION	MEASURE DESCRIPTION
22	1	TECHNICAL STAFF'S APPLICABLE EXPERIENCE AND REPUTATION	YAx3	~+0.84	WEIGHTED YEARS OF APPLICABLE EXPERIENCE FOR THE PROGRAMMERS, THE PROJECT MANAGER AND LEADER, AND THE ANALYSIS MANAGER AND LEADER (x = 0 THROUGH 3)
23	2	TECHNICAL STAFF'S PROFESSIONAL EXPERIENCE	YPx2	~+0.66	WEIGHTED YEARS OF PROFESSIONAL EXPERIENCE FOR THE PROGRAMMERS AND THE PROJECT MANAGER AND LEADER
24	3	DEVELOPMENT MANAGERS' ENVIRONMENT EXPERIENCE	YEx7	~+0.61	WEIGHTED YEARS OF ENVIRONMENT EXPERIENCE FOR THE PROJECT MANAGER AND LEADER AND THE DEVELOPMENT INTERFACE MANAGER AND LEADER
25	4	PROJECT/ANALYSIS MANAGERS' ENVIRONMENT EXPERIENCE FOR IMPLEMENTATION	YE16	+0.59	WEIGHTED YEARS OF ENVIRONMENT EXPERIENCE FOR THE PROJECT MANAGER AND LEADER AND THE ANALYSIS MANAGER AND LEADER FOR IMPLEMENTATION PHASE
26	5	ANALYSIS MANAGER'S ENVIRONMENT EXPERIENCE FOR TESTING	YE26	+0.65	WEIGHTED YEARS OF ENVIRONMENT EXPERIENCE FOR THE ANALYSIS MANAGER AND LEADER FOR TESTING PHASES

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Table 5-6. Important Measures in the Models Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRELATION	MEASURE DESCRIPTION
27	1	SYSTEM SIZE	WF76	+0.93	TOTAL NUMBER OF PAGES OF DOCUMENTATION, i.e., DESIGN DOCUMENT, DESIGN DECISION NOTES, TEST PLANS, MODULE PROLOGS, USER'S GUIDE, AND SYSTEM DESCRIPTION
28	2	PROGRAMMERS' QUALIFICATIONS	WF04	+0.65	SUBJECTIVE EVALUATION OF PROGRAMMERS' OVERALL QUALIFICATIONS TO MEET PROJECT REQUIREMENTS
			WF07	+0.68	PROGRAMMERS' EXPERIENCE WITH THE APPLICATION; IN THIS CASE, INTERACTIVE GRAPHICS
29	3	TESTING STRATEGY	WF31	−0.76	METHOD OF TESTING; IN THIS CASE, PRIMARILY USING EITHER GRAPHICS TEST TIME OR BATCH METHODS
30	4	NEW PROJECT TYPE	WF43	+0.70	AMOUNT OF TOP-DOWN DEVELOPMENT PROCEDURES PLANNED AND USED
31	5	CODE READING AND TESTING	WF42	+0.52	AMOUNT OF CODE READING PLANNED AND USED
32	6	DESIGN TEAM SIZE	WF1y	~+0.46	COMPLEXITY OF INTERPROGRAM COMMUNICATION AND DATA BASE STRUCTURE (y = 6 AND 8)

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Table 5-7. Important Measures in the Additional Detail Class

OVERALL FACTOR	CLASS FACTOR	QUALITY	MEASURE CODE	CORRE-LATION	MEASURE DESCRIPTION
33	1	EFFORT-RELATED SYSTEM SIZE	MS02	+0.98	NUMBER OF SUBSYSTEMS TO BE DEVELOPED
			SW30 ES08	+0.99 +0.99	NUMBER OF LINES OF CODE TO BE DEVELOPED
34	2	DATA BASE SIZE	MS20	+0.60	TOTAL NUMBER OF DATA BASE ITEMS USED IN NORMAL PROCESSING
			SW44	−0.67	NUMBER OF UNCHANGED (OLD) LINES OF CODE OF FORTRAN THAT CAN BE USED
35	3	INTERNAL DATA SET COMMUNICATION	MS18	−0.67	NUMBER OF INPUT/OUTPUT (INTERNAL) DATA BASE ITEMS USED IN NORMAL PROCESSING
36	4	USE OF OLD CODE	SW09	+0.66	NUMBER OF UNCHANGED (OLD) MODULES THAT CAN BE USED
37	5	CODE ERROR CONTENT	SW76	−0.58	NUMBER OF ERRORS PER THOUSAND LINES OF CODE
38	6	CODE COMPLEXITY	SW82	+0.67	NUMBER OF DECISIONS PER THOUSAND LINES OF EXECUTABLE CODE

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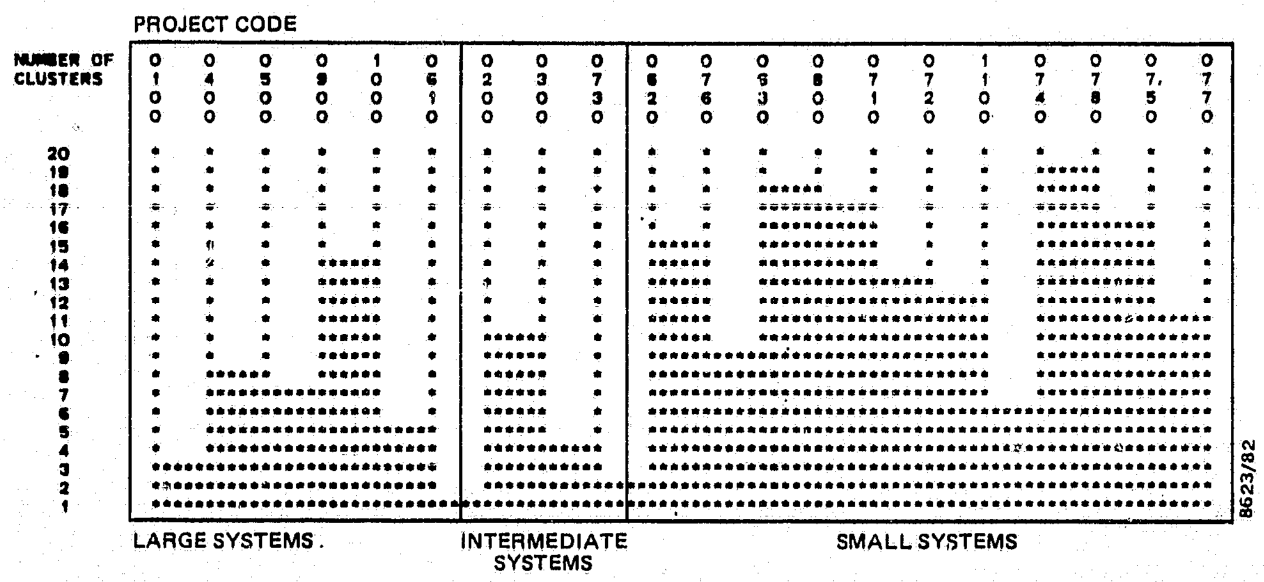

Figure 5-1. Cluster Map Based on Important Measures

APPENDIX A - FACTOR ANALYSES OF CLASSES OF MEASURES

This appendix reproduces the output of factor analyses of each of the classes of measures defined in Section 2.2. These classes are as follows:

1. Software engineering practices (Table A-1)
2. Development team ability (Table A-2)
3. Difficulty of project (Table A-3)
4. Process and product characteristics (Table A-4)
5. Development team background (Table A-5)
6. Resource model parameters (Table A-6)
7. Additional detail (Table A-7)

The data used is that of the 20 independent systems described in Section 2.1. The output of the factor analysis procedure includes three types of information that are essential to interpreting its results. These information types are

- Factor loading--percentage of the variance in the data accounted for by each factor; shows the relative importance of factors
- Factor pattern--correlations of all measures with all factors; shows the underlying structure of the data
- Communality--percentage of each measure's variance accounted for by all factors; shows how well each measure is explained by the factor model

The information presented in the seven tables (one for each class of measures) is divided into three subtables (one for each type of information). The statistical software used to generate these tables is described in Reference 7.

Table A-1a. Factor Analysis of Software Engineering: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11
EIGENVALUES	22.084404	4.020055	3.337928	2.853782	2.128184	1.758555	1.229209	0.936898	0.811593	0.688794	0.663234
PORTION	0.514	0.093	0.078	0.066	0.049	0.041	0.029	0.022	0.019	0.016	0.015
CUM PORTION	0.514	0.607	0.685	0.751	0.801	0.841	0.870	0.892	0.911	0.927	0.942
	12	13	14	15	16	17	18	19	20	21	22
EIGENVALUES	0.556316	0.463312	0.428871	0.304331	0.244641	0.216075	0.167510	0.106310	0.000000	0.000000	0.000000
PORTION	0.013	0.011	0.010	0.007	0.006	0.005	0.004	0.002	0.000	0.000	0.000
CUM PORTION	0.955	0.966	0.976	0.983	0.989	0.994	0.998	1.000	1.000	1.000	1.000
	23	24	25	26	27	28	29	30	31	32	33
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	34	35	36	37	38	39	40	41	42	43	
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

5 FACTORS WILL BE RETAINED.

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Table A-1b. Factor Analysis of Software Engineering: Factor Pattern

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
MT01	0.65412	-0.36591	0.03212	0.13958	-0.44579
MT03	0.82817	0.30168	-0.14137	0.03660	-0.22561
MT04	0.66301	0.51384	-0.04414	-0.36612	-0.17254
MT05	0.78560	-0.06966	-0.42953	-0.02395	-0.02932
MT06	0.68410	-0.24600	-0.12300	0.40725	-0.00814
MT07	0.66912	0.35899	0.12983	0.29645	0.29300
MT09	0.05991	0.05301	0.85423	-0.25046	0.07901
MT10	0.50122	-0.04133	0.69228	0.11456	0.10417
MT15	0.87982	0.10076	0.08286	-0.04060	0.14572
MT16	0.69220	-0.13719	0.48163	0.22519	-0.18853
MT17	0.60770	-0.15695	0.07222	0.53601	0.15992
MT18	0.68259	-0.23552	-0.07531	-0.33389	0.21901
MT19	0.68600	-0.39040	-0.32770	-0.00910	-0.01059
MT20	0.69800	-0.49412	-0.22288	0.15524	-0.17258
MT24	0.79364	0.07264	-0.16636	0.36873	0.08565
MT25	0.78035	-0.30995	-0.12795	0.39158	0.02263
MT26	0.44269	-0.31685	0.61013	-0.18347	0.35043
TS01	0.81534	-0.17987	0.04280	0.03540	-0.02190
TS02	0.48535	0.54916	-0.31222	-0.20768	0.08271
TS03	0.92165	-0.17537	-0.07379	0.02848	0.11740
TS05	0.69209	0.38974	0.18093	0.32264	0.19258
TS06	0.25324	0.52279	0.31770	0.61936	-0.08375
TS07	0.57278	-0.28142	-0.36014	0.00016	0.46884
TS08	0.81329	-0.15842	0.05945	-0.42848	-0.16942
TS09	0.54815	-0.12851	-0.07092	-0.52593	0.32561
TS10	0.44180	-0.61114	-0.18201	-0.12648	0.08919
TS11	0.67431	-0.15758	0.32634	-0.39925	0.29752
DC01	0.71489	0.20577	-0.25422	-0.22086	-0.08853
DC02	0.70969	0.37771	-0.12275	-0.25563	-0.14045
DC03	0.74857	0.01874	0.12675	-0.34648	-0.24992
DC04	0.57178	0.53910	0.11400	-0.04364	-0.11076
DC05	0.73291	0.43088	-0.20064	-0.08474	-0.19168
DC07	0.58307	0.35453	-0.49631	0.21784	0.30668
DC08	0.74801	0.12355	0.20934	-0.06824	-0.45807
DC09	0.55567	-0.31659	0.08320	0.20623	-0.30504
DC10	0.65934	-0.42099	0.13041	-0.06905	-0.47170
MT81	0.92138	0.22956	0.21450	0.07815	0.03771
MT82	0.92166	-0.27650	-0.02556	0.07680	0.02944
MT83	0.77617	0.18730	0.14552	0.03553	0.30447
MT84	0.97726	-0.04204	0.09337	0.08071	0.06979
TS81	0.93346	-0.01911	-0.00189	-0.13606	0.19991
DC81	0.91000	0.25939	-0.10142	-0.13807	-0.19449
SE81	0.99602	0.04733	0.01364	-0.04514	0.04152

Table A-1c. Factor Analysis of Software Engineering: Final Communality Estimates

MT01	MT03	MT04	MT05	MT06	MT07	MT09	MT10	MT15	MT16	MT17
0.781006	0.849094	0.869381	0.807948	0.709567	0.767175	0.805083	0.756160	0.813985	0.816192	0.712029
MT18	MT19	MT20	MT24	MT25	MT26	TS01	TS02	TS03	TS05	TS06
0.686525	0.730593	0.834918	0.806113	0.875228	0.825093	0.700705	0.684595	0.900230	0.804800	0.828995
TS07	TS08	TS09	TS10	TS11	DC01	DC02	DC03	DC04	DC05	DC07
0.756791	0.902375	0.704632	0.625763	0.833931	0.674658	0.746464	0.759272	0.644737	0.806993	0.853403
DC08	DC09	DC10	MT81	MT82	MT83	MT84	TS81	DC81	SE81	
0.833098	0.551502	0.856242	0.955178	0.933333	0.752666	0.976903	0.930185	0.962564	0.998247	

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Table A-2a. Factor Analysis of Development Team Ability: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11
EIGENVALUES	39.435268	20.830307	11.682730	7.419132	5.836954	5.476028	4.430306	3.822976	3.016301	1.916783	1.689835
PORTION	0.359	0.189	0.106	0.067	0.053	0.050	0.040	0.035	0.027	0.017	0.015
CUM PORTION	0.359	0.548	0.654	0.722	0.775	0.824	0.865	0.899	0.927	0.944	0.960

	12	13	14	15	16	17	18	19	20	21	22
EIGENVALUES	1.535069	0.886789	0.807219	0.505757	0.431243	0.191182	0.067506	0.018636	0.000000	0.000000	0.000000
PORTION	0.014	0.008	0.007	0.005	0.004	0.002	0.001	0.000	0.000	0.000	0.000
CUM PORTION	0.974	0.982	0.989	0.994	0.997	0.999	1.000	1.000	1.000	1.000	1.000

	23	24	25	26	27	28	29	30	31	32	33
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	34	35	36	37	38	39	40	41	42	43	44
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	45	46	47	48	49	50	51	52	53	54	55
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	56	57	58	59	60	61	62	63	64	65	66
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	67	68	69	70	71	72	73	74	75	76	77
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	78	79	80	81	82	83	84	85	86	87	88
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	89	90	91	92	93	94	95	96	97	98	99
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	100	101	102	103	104	105	106	107	108	109	110
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

6 FACTORS WILL BE RETAINED.

Table A-2b. Factor Analysis of Development Team Ability: Factor Pattern (1 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
AP03	0.74945	0.13129	-0.13148	-0.03463	-0.44099	0.05066
AP04	0.44775	-0.43135	-0.09481	0.03382	-0.66656	-0.18960
AP05	0.40423	0.28023	0.40416	-0.14507	0.55074	0.20188
AP06	0.22748	0.01513	0.17368	0.12358	0.25136	0.52101
AP07	0.47053	-0.33536	-0.02655	-0.04614	-0.14347	-0.27518
AP08	0.57121	-0.21763	-0.06572	-0.11288	0.27963	-0.18910
AP09	-0.00062	0.62678	0.40819	0.05230	0.32040	0.49250
AP10	-0.22461	-0.25883	0.05483	-0.55827	0.39812	0.35536
AP11	0.16360	0.27169	0.23358	-0.11007	-0.20459	-0.34805
AP12	-0.04072	-0.36359	-0.34433	-0.44759	-0.02551	-0.21032
MG01	0.50156	0.51715	0.01115	0.47[illegible]	0.01581	-0.42671
MG02	0.82695	0.08039	0.26296	0.28[illegible]	-0.06907	-0.10774
MG03	-0.02776	-0.65535	0.34435	0.27226	-0.23618	0.47150
MG04	0.20726	0.07173	-0.15197	0.47156	0.05291	0.10633
MG05	0.54669	0.56460	-0.29880	0.36383	0.02227	0.00795
MG06	0.38946	0.49921	-0.49153	0.06342	0.08031	-0.08819
MG07	0.55370	0.50727	-0.07300	0.43158	-0.06411	-0.33771
MG08	0.83326	-0.13424	0.37909	0.07160	-0.15303	-0.00465
MG09	-0.09555	-0.41701	0.68027	0.28499	-0.15684	0.39758
MG10	-0.46525	0.11593	0.00365	0.01027	0.67722	0.18606
MG11	0.54669	0.56460	-0.29880	0.36383	0.02227	0.00795
MG12	0.47290	0.60627	-0.37888	0.13262	0.02200	-0.03545
MG13	0.51412	0.42584	0.24679	-0.18948	-0.39778	-0.25526
MG14	0.88419	-0.15268	0.24594	-0.05698	-0.18857	0.05504
MG15	0.03522	-0.07389	0.42141	0.64076	0.29035	0.40090
MG16	-0.37676	0.37554	0.19873	-0.09295	0.57827	0.10571
MG17	0.46948	0.78253	-0.27259	0.19860	0.01847	0.16808
MG18	0.49225	0.71258	-0.25467	-0.11588	-0.19254	0.01749
MG19	0.47138	0.64306	-0.06603	-0.11737	-0.40237	0.03777
MG20	0.86524	-0.16309	0.14252	-0.25348	-0.23583	0.11331
MG21	0.38607	0.36327	-0.27772	0.59944	0.38589	-0.12122
MG22	0.02161	0.27316	0.72372	0.15900	0.34711	-0.21976
MG23	0.28731	0.68706	-0.48161	0.02146	0.04354	0.39314
MG24	0.34014	0.62697	-0.34786	-0.32436	-0.19492	0.31506
MG25	0.47138	0.64306	-0.06603	-0.11737	-0.40237	0.03777
MG26	0.86524	-0.16309	0.14252	-0.25348	-0.23583	0.11331
MG27	0.41570	0.18479	-0.48226	0.47416	0.21934	-0.15988
MG28	0.13413	0.14792	0.75324	0.00126	0.06304	-0.41490
MG29	0.30830	0.66064	-0.48162	0.06243	0.04199	0.36771
MG30	0.32000	0.64948	-0.27701	-0.23104	-0.12832	0.38532
MG31	0.29444	0.46235	0.24205	0.03508	0.00934	-0.69058
MG32	0.30289	0.06269	0.57022	0.45649	-0.00586	-0.11634
MG33	-0.26581	0.24341	0.09948	-0.39057	-0.00592	-0.36883
MG34	-0.14601	-0.53248	0.23786	0.24212	0.04719	0.38717
MG35	-0.13917	0.08347	0.69580	-0.00806	0.08582	-0.32106
PF01	0.68151	-0.38968	-0.27199	-0.00143	0.34701	-0.13446
PF02	0.65917	-0.47675	-0.28170	0.03046	0.27929	-0.10047
PF03	0.64936	-0.51685	-0.25324	0.06563	0.24835	-0.09562
PF04	0.68921	-0.36257	-0.13695	0.03972	0.31331	-0.10226

Table A-2b. Factor Analysis of Development Team Ability: Factor Pattern (2 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
PF05	0.42054	-0.71436	-0.25130	0.11768	-0.02653	0.11515
PF06	0.41597	-0.76292	-0.13421	0.22091	-0.08805	0.02935
PF07	0.19399	0.04908	0.57671	0.16376	-0.11920	0.14828
PF08	0.27481	-0.66361	0.22314	0.41898	-0.23111	-0.19806
PF09	-0.23977	0.67314	0.63408	0.01633	-0.06183	-0.00044
PF11	0.79501	-0.09897	-0.00828	-0.10503	0.33879	-0.25101
PF12	0.83688	-0.22769	0.10894	-0.14578	0.21124	-0.17465
PF13	0.83560	-0.30228	0.10679	-0.09190	0.19307	-0.15720
PF14	0.79502	-0.04521	0.33583	-0.15534	0.18701	-0.17693
PF15	0.54755	-0.48894	0.39411	-0.18243	-0.24338	0.12843
PF16	0.56687	-0.61250	0.31259	-0.01463	-0.20513	0.10507
PF17	0.25245	0.09718	0.86903	-0.15776	-0.25369	0.11466
PF18	0.34789	-0.69575	-0.11651	0.53133	0.01376	-0.00040
PF19	-0.26944	0.64020	0.64591	-0.00059	-0.05410	0.00427
PF21	0.73819	-0.07328	0.20595	-0.33606	0.27385	0.09629
PF22	0.76558	-0.16153	0.16430	-0.29598	0.22430	0.15861
PF23	0.77107	-0.20252	0.14616	-0.26750	0.20821	0.16292
PF24	0.72002	-0.00726	0.31713	-0.29575	0.20928	0.18629
PF25	0.59575	-0.55698	-0.10555	0.05482	-0.11531	0.39750
PF26	0.55840	-0.62177	-0.16100	0.11879	-0.14414	0.33627
PF27	0.25346	0.24934	0.62483	0.03287	-0.16065	0.44366
PF28	0.24131	-0.74084	-0.38087	0.36647	-0.24200	-0.01688
PF29	-0.26788	0.66459	0.61612	-0.01575	-0.05109	0.06182
PF31	0.85755	-0.21745	-0.02246	-0.17932	0.36972	-0.09208
PF32	0.87148	-0.33476	-0.01077	-0.16119	0.27945	-0.03520
PF33	0.86370	-0.39351	-0.00644	-0.11624	0.25595	-0.03056
PF34	0.88282	-0.15647	0.21392	-0.17614	0.28469	-0.01315
PF35	0.61073	-0.68434	0.04889	-0.02386	-0.16520	0.22991
PF36	0.57415	-0.74860	0.02636	0.11495	-0.16706	0.16498
PF37	0.27010	0.14812	0.84073	-0.02532	-0.21940	0.25393
PF38	0.32987	-0.75674	-0.04032	0.49859	-0.15245	-0.09214
PF39	-0.26054	0.66016	0.63326	0.00043	-0.05361	0.02156
AP81	0.82544	-0.04465	0.08501	-0.09586	-0.30452	0.07300
AP82	0.73387	-0.30394	-0.01084	-0.07440	0.26793	-0.09666
AP83	-0.04365	-0.22993	-0.08671	-0.65377	0.05624	-0.17942
AP84	0.77691	-0.24289	0.01148	-0.38602	-0.07428	-0.06936
MG81	0.71604	0.30107	-0.00259	0.55546	-0.04770	-0.08350
MG82	0.72258	0.39385	0.12675	0.44728	0.00451	-0.02063
MG83	0.70197	0.60360	0.18226	0.06471	-0.10184	0.07323
MG84	0.62050	0.67322	-0.23372	-0.00327	-0.02611	0.21808
MG85	0.63834	0.59954	-0.28512	-0.03078	-0.10413	0.22081
MG86	0.00196	0.09226	0.56803	0.08863	0.04078	-0.37424
MG87	0.60641	0.61764	0.03637	0.20249	-0.23567	-0.30745
MG88	0.90880	-0.09797	0.26061	-0.00704	-0.17695	0.02093
MG89	0.23643	-0.21304	0.21434	0.73504	0.14906	0.32365
MG90	-0.15241	0.32864	0.39395	0.25654	0.58715	-0.00750
MG91	0.43207	0.68094	-0.44018	0.18735	0.03721	0.24705
MG92	0.44517	0.71783	-0.38903	-0.15762	-0.11816	0.19559
MG93	0.74073	0.57723	0.06517	0.24867	-0.05170	0.00833

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Table A-2b. Factor Analysis of Development Team Ability: Factor Pattern (3 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
AB81	0.93825	-0.06112	-0.08056	0.14219	0.10598	-0.11013
AB82	0.93781	-0.08723	-0.07967	0.15914	0.07241	-0.09616
AB83	0.93713	-0.08703	-0.06046	0.17553	0.05284	-0.09294
AB84	0.94730	0.18691	0.09542	-0.14643	0.04893	-0.08254
AB85	0.95238	0.14652	0.13937	-0.15927	-0.00650	-0.04883
AB86	0.95726	0.13410	0.13956	-0.14306	-0.01923	-0.03986
AB87	0.90495	0.22260	-0.04198	-0.28124	0.06170	0.13453
AB88	0.91502	0.20223	-0.07352	-0.25834	0.02855	0.16014
AB89	0.91779	0.20420	-0.09058	-0.24493	0.01401	0.16029
AB90	0.97677	0.08909	0.02647	-0.10243	0.09289	-0.05920
AB91	0.98308	0.05881	0.03187	-0.09265	0.04784	-0.03619
AB92	0.98425	0.05017	0.03511	-0.07465	0.03302	-0.03487

Table A-2c. Factor Analysis of Development Team Ability: Final Communality Estimates

AP03	AP04	AP05	AP06	AP07	AP08	AP09	AP10	AP11	AP12	MG01	MG02	MG03
0.794438	0.876923	0.770396	0.432045	0.433005	0.504653	0.907426	0.716892	0.330252	0.497650	0.930781	0.857736	0.901046
MG04	MG05	MG06	MG07	MG08	MG09	MG10	MG11	MG12	MG13	MG14	MG15	MG16
0.307666	0.839854	0.660742	0.873650	0.884625	0.909674	0.723261	0.839854	0.754078	0.765860	0.907427	0.839893	0.676675
MG17	MG18	MG19	MG20	MG21	MG22	MG23	MG24	MG25	MG26	MG27	MG28	MG29
0.975094	0.865742	0.817192	0.928250	0.881075	0.792920	0.943462	0.872267	0.817192	0.928250	0.738029	0.783356	0.904326
MG30	MG31	MG32	MG33	MG34	MG35	PF01	PF02	PF03	PF04	PF05	PF06	PF07
0.819275	0.837271	0.642775	0.428421	0.572184	0.620982	0.828777	0.830170	0.828060	0.735418	0.778132	0.830507	0.435654
PF08	PF09	PF11	PF12	PF13	PF14	PF15	PF16	PF17	PF18	PF19	PF21	PF22
0.833878	0.916757	0.830717	0.860450	0.871438	0.837293	0.803206	0.847534	0.930783	0.901180	0.902592	0.789914	0.802272
PF23	PF24	PF25	PF26	PF27	PF28	PF29	PF31	PF32	PF33	PF34	PF35	PF36
0.798380	0.785034	0.850603	0.872291	0.740538	0.945294	0.899733	0.960498	0.976972	0.980831	0.961857	0.924430	0.5[illegible]9090
PF37	PF38	PF39	AP81	AP82	AP83	AP84	MG81	MG82	MG83	MG84	MG85	MG86
0.914980	0.963425	0.908048	0.797824	0.717726	0.525059	0.822047	0.921149	0.893806	0.910237	0.941118	0.908763	0.480748
MG87	MG88	MG89	MG90	MG91	MG92	MG93	AB81	AB82	AB83	AB84	AB85	AB86
0.941611	0.935243	0.814475	0.697038	0.941648	0.941860	0.950707	0.934115	0.933266	0.931682	0.972075	0.975706	0.976223
AB87	AB88	AB89	AB90	AB91	AB92							
0.971244	0.976768	0.978121	0.985345	0.983103	0.980385							

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Table A-3a. Factor Analysis of Difficulty of Project:
Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11
EIGENVALUES	16.101457	9.905812	5.318222	4.516378	4.048277	3.376015	2.601864	2.225693	1.448499	1.137400	0.925749
PORTION	0.298	0.183	0.098	0.084	0.075	0.063	0.048	0.041	0.027	0.021	0.017
CUM PORTION	0.298	0.482	0.580	0.664	0.739	0.801	0.849	0.891	0.917	0.939	0.956

	12	13	14	15	16	17	18	19	20	21	22
EIGENVALUES	0.556128	0.530939	0.339151	0.302701	0.251094	0.214231	0.114757	0.085632	0.000000	0.000000	0.000000
PORTION	0.010	0.010	0.006	0.006	0.005	0.004	0.002	0.002	0.000	0.000	0.000
CUM PORTION	0.966	0.976	0.982	0.988	0.992	0.996	0.998	1.000	1.000	1.000	1.000

	23	24	25	26	27	28	29	30	31	32	33
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	34	35	36	37	38	39	40	41	42	43	44
EIGENVALUES	0.000000	0.000000	0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	45	46	47	48	49	50	51	52	53	54
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

5 FACTORS WILL BE RETAINED.

Table A-3b. Factor Analysis of Difficulty of Project: Factor Pattern

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
CP01	0.54077	0.13034	0.17464	-0.50327	-0.05322
CP02	0.37262	-0.34207	0.54236	0.26256	0.13340
CP03	0.61733	-0.19477	0.55108	-0.07085	0.11587
CP04	0.71408	0.53199	0.14624	-0.30528	-0.12505
CP05	0.63774	-0.11896	0.00688	-0.24884	-0.55060
CP06	0.27724	0.19555	0.15225	-0.22812	-0.01588
CP07	0.32454	-0.16282	0.05870	-0.07337	-0.08205
CP08	0.66558	0.15044	0.17446	-0.50733	-0.22842
CP09	0.08355	-0.11093	0.13511	0.52367	0.16857
CP10	0.59723	0.24286	-0.31511	0.26636	0.25456
CP11	0.40588	0.02673	-0.72226	-0.16039	0.11984
IN01	0.58082	0.50466	-0.10205	0.25042	-0.17023
IN02	0.62007	0.27552	-0.01218	0.53130	0.03189
IN05	0.12528	0.47903	0.04955	-0.00115	-0.66003
IN06	0.72880	0.10525	-0.28458	0.11838	-0.41155
IN07	0.35878	-0.30484	-0.54534	0.02549	0.37515
IN08	0.31650	-0.22475	-0.51952	0.25942	-0.21232
IN09	0.49502	-0.53952	-0.27962	0.47250	-0.13519
IN10	0.52322	-0.49270	0.04866	0.40071	0.30300
IN11	0.80534	0.14777	0.15841	-0.22458	0.17143
IN12	0.57528	-0.40616	-0.08838	-0.03786	0.28938
EX01	0.76115	-0.33623	0.30302	0.02055	0.09837
EX02	0.17536	0.65355	0.00814	-0.05004	0.34808
EX03	-0.30632	0.75258	-0.13812	-0.24091	-0.21810
EX04	-0.29370	0.80748	-0.05222	-0.04315	0.22113
EX05	0.53027	0.08277	-0.03422	-0.05648	0.58681
EX06	0.72312	0.01960	0.20078	-0.26753	0.35866
EX07	0.67882	0.22587	-0.53161	0.09757	-0.07140
EX10	-0.22650	0.77049	-0.01255	0.16493	-0.07303
EX11	-0.27663	0.53207	0.10530	0.21154	-0.22056
EX12	0.29513	0.73451	-0.30254	0.04828	-0.04314
EX13	-0.08156	0.57468	0.12618	0.28515	-0.35611
EX14	-0.13628	0.21543	0.74614	0.22656	-0.19811
EX15	0.24665	-0.23260	0.11196	0.54730	-0.06179
EX16	0.13687	-0.20775	0.50663	0.62289	-0.23021
EX17	0.03433	0.42382	0.52874	0.02428	0.58904
EX18	-0.23760	0.57837	-0.23733	0.41331	0.27035
CP81	0.58745	-0.14317	0.45799	-0.14492	0.05432
CP82	0.82675	-0.02353	0.37858	-0.22598	-0.18796
CP83	0.77729	0.08585	0.16505	-0.34450	-0.13924
CP84	0.49075	0.03355	-0.40123	0.35110	0.26379
CP85	0.92181	-0.01521	0.19834	-0.11015	-0.00342
IN81	0.60739	0.32508	-0.08069	0.41626	-0.13798
IN82	0.81284	0.11516	-0.23244	-0.24769	-0.36035
IN83	0.59878	-0.54178	-0.18610	0.22760	-0.00548
IN84	0.89869	-0.14636	-0.18253	0.21844	-0.13958
EX81	0.75082	0.30154	0.24628	-0.02715	0.37878
EX82	0.10749	0.78788	-0.02597	-0.22382	0.32939
EX83	0.63107	0.50584	-0.45782	-0.02588	0.07616
EX84	-0.12620	0.76458	-0.04500	0.17212	-0.18249
EX85	0.03213	0.23031	0.62414	0.56080	-0.32121
EX86	-0.14932	0.61204	0.27016	0.23124	0.56902
EX87	0.26835	0.91123	0.08755	0.18093	0.08656
DF81	0.92249	0.34341	0.05837	0.11680	-0.01884

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Table A-3c. Factor Analysis of Difficulty of Project:
Final Communality Estimates

CP01	CP02	CP03	CP04	CP05	CP06	CP07	CP08	CP09	CP10	CP11
0.596039	0.636774	0.741170	0.925763	0.785972	0.191026	0.917179	0.805640	0.341955	0.650713	0.727201
IN01	IN02	IN05	IN06	IN07	IN08	IN09	IN10	IN11	IN13	EX01
0.754224	0.744248	0.683264	0.812460	0.665543	0.537563	0.855951	0.781835	0.775640	0.589011	0.794355
EX02	EX03	EX04	EX05	EX06	EX07	EX10	EX11	EX12	EX13	EX14
0.582140	0.786687	0.791812	0.636758	0.778387	0.810661	0.677676	0.518225	0.814700	0.685893	0.704257
EX15	EX16	EX17	EX18	CP81	CP82	CP83	CP84	CP85	IN81	IN82
0.490811	0.759555	0.823724	0.748724	0.608562	0.913781	0.776793	0.595311	0.919979	0.673478	0.919369
IN83	IN84	EX81	EX82	EX83	EX84	EX85	EX86	EX87	DF81	
0.795306	0.929943	0.859562	0.791627	0.870188	0.665828	0.861292	0.847134	0.950348	0.988168	

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Table A-4a. Factor Analysis of Process and Product Characteristics: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11	12
EIGENVALUES	20.181591	9.807037	5.032838	2.664181	2.044268	1.481540	1.314107	0.868366	0.859737	0.710255	0.468093	0.391723
PORTION	0.429	0.209	0.107	0.057	0.043	0.032	0.028	0.018	0.018	0.015	0.010	0.008
CUM PORTION	0.429	0.638	0.745	0.802	0.845	0.877	0.905	0.923	0.942	0.957	0.967	0.975

	13	14	15	16	17	18	19	20	21	22	23	24
EIGENVALUES	0.366580	0.247593	0.189834	0.159592	0.130518	0.054129	0.028020	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.008	0.005	0.004	0.003	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000
CUM PORTION	0.983	0.988	0.992	0.995	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000

	25	26	27	28	29	30	31	32	33	34	35	36
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	37	38	39	40	41	42	43	44	45	46	47
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

5 FACTORS WILL BE RETAINED.

Table A-4b. Factor Analysis of Process and Product Characteristics: Factor Pattern

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
PR01	0.42322	-0.41947	0.26893	-0.33023	-0.42843
PR02	0.81873	0.06867	0.29848	0.04724	0.03443
PR03	0.92228	0.10300	0.07309	0.14898	-0.03536
PR04	0.27144	-0.01322	-0.55304	-0.37382	-0.29477
PR05	0.11459	0.17588	-0.90403	0.16730	-0.02004
PR06	0.18268	0.39158	-0.72713	0.00752	0.11731
PR07	0.10536	0.01496	-0.58970	0.07765	0.29145
PR08	0.67524	-0.07024	-0.31971	-0.06277	0.12063
PR09	0.77747	0.30460	-0.01631	-0.05577	0.24902
PR10	0.91319	0.00513	-0.13234	0.03506	-0.18697
PR11	0.91272	-0.05821	-0.09071	0.14158	0.19709
PR12	0.91966	-0.12028	-0.06448	0.09422	0.13409
PR13	0.62085	-0.10683	0.47698	0.21077	0.03283
PR14	0.58753	0.12035	0.25951	-0.19206	0.19180
PP01	0.82988	0.24082	0.29384	0.23370	0.08925
PP02	0.93686	0.17856	0.04240	0.12590	0.14705
PP03	0.89048	0.16454	-0.30834	0.09079	0.19050
PP04	0.95238	0.09563	-0.04060	0.10168	0.12114
PP07	0.90186	0.18251	0.23492	-0.10681	-0.16263
PP08	0.97186	0.05158	0.08820	-0.02762	-0.02687
PP09	0.92697	0.01260	0.07682	0.01289	-0.04250
PP10	0.91962	0.20892	0.18039	0.08145	0.03390
PP11	0.72446	0.14832	0.04568	-0.51738	-0.09890
RA01	0.55135	0.12723	0.08950	-0.28342	-0.58242
RA02	0.11619	0.76506	0.41890	-0.27141	-0.02390
RA03	0.04468	0.94744	-0.07748	0.03145	-0.18953
RA04	-0.12641	0.94728	-0.07802	0.16530	-0.07410
RA05	0.29151	-0.74654	0.15711	0.25703	0.17677
RA06	-0.25945	0.38546	0.11853	0.63615	-0.30655
RA07	-0.28928	0.88806	-0.18156	-0.15228	0.07537
RA10	-0.14641	-0.79590	0.40526	0.16953	-0.02725
RA11	-0.34226	0.91782	0.08115	0.04365	0.00235
RA13	-0.18399	0.78369	-0.13000	-0.33714	0.27125
RA16	-0.16222	-0.31074	0.24785	-0.51586	0.52100
RA17	-0.45284	0.48650	0.39567	-0.00242	0.34350
RA81	0.37449	0.71773	0.18068	-0.25235	-0.41149
RA82	-0.08844	0.39364	0.15910	0.81159	-0.17506
RA83	-0.41961	0.84434	0.16764	0.04609	0.11727
RA84	-0.50983	0.64345	0.39767	-0.04922	0.31490
RA85	-0.24282	0.90914	0.28111	0.05291	-0.01845
PR81	0.19835	0.21847	-0.92841	0.01683	0.01236
PR82	0.97189	-0.07020	-0.09673	0.10234	0.08042
PR83	0.71964	0.03360	0.41648	-0.03402	0.15231
PR84	0.94032	0.00805	-0.29557	0.00086	-0.02493
PP81	0.95637	0.17520	-0.01274	0.14185	0.14557
PP82	0.95704	0.12727	0.13256	-0.11936	-0.06305
PP83	0.97853	0.15200	0.06940	-0.00311	0.03053

Table A-4c. Factor Analysis of Process and Product Characteristics: Final Communality Estimates

PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12
0.719991	0.767542	0.889995	0.606337	0.889736	0.729248	0.450045	0.581592	0.762626	0.887648	0.903562	0.891253
PR13	PR14	PP01	PP02	PP03	PP04	PP07	PP08	PP09	PP10	PP11	RA01
0.669885	0.500698	0.895629	0.948858	0.959640	0.942838	0.939714	0.956445	0.867309	0.929670	0.826385	0.747721
RA02	RA03	RA04	RA05	RA06	RA07	RA10	RA11	RA13	RA16	RA17	RA81
0.848534	0.942546	0.952223	0.764295	0.728598	0.934166	0.848611	0.968029	0.852170	0.721860	0.716310	0.921032
RA82	RA83	RA84	RA85	PR81	PR82	PR83	PR84	PP81	PP82	PP83	
0.877421	0.932966	0.933679	0.967668	0.949456	0.975803	0.716826	0.972246	0.986810	0.967917	0.986381	

Table A-5a. Factor Analysis of Development Team Background: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11	12
EIGENVALUES	59.434556	31.693876	14.532166	9.528660	7.998630	5.482735	4.401192	3.321116	1.840060	1.233380	1.086433	0.870430
PORTION	0.413	0.220	0.101	0.066	0.056	0.038	0.031	0.023	0.013	0.009	0.008	0.006
CUM PORTION	0.413	0.633	0.734	0.800	0.855	0.894	0.924	0.947	0.961	0.969	0.977	0.983
	13	14	15	16	17	18	19	20	21	22	23	24
EIGENVALUES	0.832064	0.550651	0.468227	0.262852	0.185787	0.117753	0.059431	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.006	0.004	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	0.989	0.992	0.996	0.997	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	25	26	27	28	29	30	31	32	33	34	35	36
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	37	38	39	40	41	42	43	44	45	46	47	48
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	49	50	51	52	53	54	55	56	57	58	59	60
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	61	62	63	64	65	66	67	68	69	70	71	72
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	73	74	75	76	77	78	79	80	81	82	83	84
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	85	86	87	88	89	90	91	92	93	94	95	96
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	97	98	99	100	101	102	103	104	105	106	107	108
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	109	110	111	112	113	114	115	116	117	118	119	120
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	121	122	123	124	125	126	127	128	129	130	131	132
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	133	134	135	136	137	138	139	140	141	142	143	144
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

5 FACTORS WILL BE RETAINED.

Table A-5b. Factor Analysis of Development Team Background: Factor Pattern (1 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
YP01	0.63986	0.57983	-0.35109	-0.07673	-0.10605
YP02	0.61952	0.61526	-0.37437	-6.30E-05	-0.08653
YP03	0.66139	0.57178	-0.35685	-0.03823	-0.11543
YP04	0.52780	0.70933	-0.33576	0.00685	-0.08916
YP05	0.34076	0.67862	-0.37838	0.45373	0.04872
YP06	0.70581	0.41362	-0.32094	0.18657	-0.16062
YP07	-0.23479	0.85647	-0.07056	0.37064	0.01035
YP08	0.46347	-0.47829	0.13474	-0.44992	-0.30435
YP09	-0.77532	0.48536	0.34371	0.01219	-0.04142
YP11	0.67703	0.58011	-0.22716	-0.25291	-0.06168
YP12	0.66204	0.64074	-0.25151	-0.15199	-0.04127
YP13	0.70072	0.58422	-0.23393	-0.20108	-0.08527
YP14	0.55808	0.74573	-0.20642	-0.15672	-0.04984
YP15	0.36355	0.74033	-0.29013	0.37537	0.09074
YP16	0.64587	0.49283	-0.18714	0.10299	-0.18140
YP17	-0.26207	0.88357	0.01037	0.28040	0.03651
YP18	0.40925	-0.44650	0.17506	-0.46035	-0.42637
YP19	-0.76908	0.49062	0.34297	-0.00626	-0.03140
YP21	0.55860	0.65723	-0.11826	-0.34146	0.02805
YP22	0.55007	0.69013	-0.16390	-0.27997	0.07641
YP23	0.57963	0.64408	-0.14682	-0.33614	0.03414
YP24	0.45030	0.76955	-0.12320	-0.27853	0.07926
YP25	0.33558	0.71675	-0.33896	0.14360	0.34497
YP26	0.58833	0.46289	-0.37418	-0.13013	0.19314
YP27	-0.20859	0.88706	-0.06892	0.11062	0.27569
YP28	0.33490	-0.51885	0.01145	-0.46066	-0.30367
YP29	-0.77475	0.49266	0.33428	-0.01918	-0.01185
YP31	0.65019	0.63119	-0.24193	-0.23513	-0.04631
YP32	0.63033	0.67725	-0.26960	-0.15547	-0.01421
YP33	0.67237	0.62601	-0.25358	-0.20461	-0.05534
YP34	0.53032	0.77105	-0.23610	-0.14414	-0.01785
YP35	0.36540	0.74495	-0.35145	0.33822	0.17192
YP36	0.68108	0.48216	-0.31882	0.05890	-0.04434
YP37	-0.24103	0.90578	-0.05142	0.25733	0.10842
YP38	0.41835	-0.50213	0.11365	-0.47682	-0.36391
YP39	-0.77392	0.49086	0.33891	-0.00332	-0.03091
YA01	0.80016	0.36228	-0.16830	0.05172	-0.17369
YA02	0.80288	0.36284	-0.19698	0.13211	-0.16402
YA03	0.83122	0.29657	-0.17355	0.14409	-0.18274
YA04	0.69960	0.49846	-0.12791	0.15739	-0.20959
YA05	0.60996	0.22273	-0.30802	0.57519	0.01342
YA06	0.77261	-0.07246	-0.13515	0.51494	-0.10843
YA07	0.28860	0.72917	0.17592	0.47894	-0.13009
YA08	0.40076	-0.58737	0.32384	-0.07986	-0.26246
YA09	-0.74168	0.49749	0.39954	-0.01352	-0.13262
YA11	0.84245	0.35465	0.01864	-0.19382	-0.07910
YA12	0.86411	0.38801	-0.00913	-0.08056	-0.11201
YA13	0.89702	0.31659	-0.00116	-0.05904	-0.13039
YA14	0.74632	0.55388	0.09347	-0.07670	-0.15766

Table A-5b. Factor Analysis of Development Team Background: Factor Pattern (2 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
YA15	0.64135	0.37163	-0.09457	0.48826	-0.19564
YA16	0.76991	0.05929	-0.05789	0.45752	-0.28961
YA17	-0.13975	0.77271	0.29881	0.38789	-0.28451
YA18	0.46461	-0.69166	0.07211	0.03080	-0.26973
YA19	-0.73412	0.50300	0.39957	-0.03341	-0.12366
YA21	0.70503	0.47392	0.15437	-0.33998	0.05217
YA22	0.72651	0.49821	0.10864	-0.28096	0.09389
YA23	0.75749	0.44231	0.10659	-0.29072	0.08416
YA24	0.59836	0.61998	0.19721	-0.28979	0.08306
YA25	0.66413	0.41586	-0.20963	0.18057	0.33885
YA26	0.79788	0.15830	-0.19683	0.05504	0.26828
YA27	-0.23486	0.83238	0.23256	0.08890	0.15488
YA28	0.47594	-0.65794	-0.02998	-0.27860	-0.14296
YA29	-0.74035	0.50541	0.39074	-0.04710	-0.10334
YA31	0.84600	0.43654	-0.00611	-0.17347	-0.07599
YA32	0.86422	0.44650	-0.03946	-0.08218	-0.05552
YA33	0.89441	0.37943	-0.02808	-0.08187	-0.08318
YA34	0.74250	0.60912	0.06851	-0.08116	-0.09734
YA35	0.71033	0.37013	-0.21467	0.46966	0.04066
YA36	0.85924	0.04682	-0.13654	0.41003	-0.07189
YA37	-0.23288	0.84292	0.25541	0.34203	-0.09581
YA38	0.48060	-0.70274	0.13884	-0.09576	-0.24594
YA39	-0.73944	0.50303	0.39568	-0.03097	-0.12169
YE01	0.79484	-0.06837	0.33334	0.05502	0.32477
YE02	0.81388	-0.10783	0.30315	0.11374	0.31518
YE03	0.78003	-0.15842	0.30335	0.16745	0.30634
YE04	0.61666	0.15584	0.55262	0.17336	0.20402
YE05	0.71293	-0.25564	0.11535	0.44402	0.25529
YE06	0.57100	-0.42958	0.23003	0.51010	0.20770
YE07	-0.53122	0.42416	0.56263	0.24639	-0.01608
YE08	0.16713	-0.55985	0.27259	0.39950	0.05561
YE09	-0.75833	0.47725	0.38042	-0.03146	-0.14436
YE11	0.66119	-0.18994	0.52746	-0.15830	0.32012
YE12	0.69580	-0.18399	0.54112	-0.07400	0.27997
YE13	0.71250	-0.25317	0.52410	0.00117	0.26475
YE14	0.53023	-0.04907	0.71353	-0.09604	0.27136
YE15	0.66944	-0.08852	0.30468	0.40969	-0.08736
YE16	0.59070	-0.35842	0.17884	0.59126	-0.06955
YE17	-0.36402	0.49138	0.65054	0.24409	-0.20292
YE18	0.16684	-0.57838	-0.10241	0.55102	-0.03893
YE19	-0.75276	0.47989	0.37428	-0.04709	-0.14163
YE21	0.63303	-0.02752	0.52730	-0.24541	0.43107
YE22	0.64802	-0.04249	0.51688	-0.21306	0.45796
YE23	0.64720	-0.03209	0.49664	-0.19294	0.48719
YE24	0.48937	0.10688	0.65474	-0.25364	0.45108
YE25	0.62824	-0.04158	0.29215	0.10076	0.44181
YE26	0.52930	-0.02273	0.30968	0.26443	0.59035
YE27	-0.43810	0.49297	0.58838	-0.00773	0.16835
YE28	-0.16118	0.15474	-0.19147	0.56818	0.65073

Table A-5b. Factor Analysis of Development Team Background: Factor Pattern (3 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
YE29	-0.75820	0.48698	0.36487	-0.06523	-0.10616
YE31	0.71759	-0.10063	0.50933	-0.14712	0.38123
YE32	0.75414	-0.11212	0.49286	-0.07272	0.37074
YE33	0.76918	-0.14359	0.47572	-0.03059	0.37129
YE34	0.58258	0.07982	0.69524	-0.08598	0.34874
YE35	0.73939	-0.14031	0.26835	0.34686	0.21247
YE36	0.63615	-0.33858	0.21702	0.50706	0.24462
YE37	-0.46059	0.49843	0.63717	0.15652	-0.01004
YE38	0.11474	-0.51844	0.03690	0.58757	0.15742
YE39	-0.75810	0.48153	0.37359	-0.04921	-0.13184
RK01	-0.81210	0.24660	-0.02229	0.02451	0.08401
RK02	-0.81088	0.31389	-0.00667	-0.04299	0.12023
RK03	-0.81324	0.34260	-0.03812	-0.05856	0.12420
RK04	-0.76621	0.19133	-0.14395	-0.08305	0.16201
RK05	-0.65992	0.55433	0.01084	-0.33027	0.14877
RK06	-0.67210	0.57017	-0.07316	-0.25044	0.21495
RK07	0.06801	-0.09963	-0.59545	-0.45157	0.38254
RK08	-0.44337	0.44974	-0.34014	0.05752	0.38184
RK09	0.70971	-0.49392	-0.43596	-0.00519	0.14013
RK11	-0.72843	-0.16301	-0.25834	0.37472	0.14127
RK12	-0.77927	-0.11131	-0.29478	0.20311	0.30027
RK13	-0.81227	-0.07314	-0.27666	0.15849	0.32598
RK14	-0.58582	-0.30134	-0.42560	0.17169	0.41808
RK15	-0.46319	0.02178	-0.17642	-0.29534	0.53592
RK16	-0.61328	0.13161	-0.14364	-0.28801	0.52481
RK17	0.06369	-0.30647	-0.46458	-0.25646	0.61678
RK18	-0.61744	0.39120	0.02877	-0.10904	0.25309
RK19	0.71796	-0.48472	-0.41133	0.00670	0.15803
RK21	-0.67744	-0.26816	-0.34637	0.16195	0.05185
RK22	-0.71807	-0.18706	-0.33619	0.10357	0.04796
RK23	-0.73556	-0.16692	-0.32466	0.10358	0.04813
RK24	-0.56119	-0.35010	-0.44443	0.07338	0.10886
RK25	-0.71035	0.25633	-0.16619	-0.21570	0.04544
RK26	-0.71342	0.34066	-0.11190	-0.15554	0.07805
RK27	0.21245	-0.37249	-0.57220	-0.25212	0.23192
RK28	-0.53533	0.60343	0.18143	0.08606	0.15656
RK29	0.74250	-0.49716	-0.37547	-0.02642	0.13323
RK31	-0.86027	-0.10329	-0.26803	0.23073	0.07433
RK32	-0.89466	-0.01315	-0.26141	0.11991	0.14654
RK33	-0.90743	0.02626	-0.26224	0.09512	0.16159
RK34	-0.76349	-0.21705	-0.42457	0.08180	0.24592
RK35	-0.74755	0.32143	-0.14093	-0.33752	0.32200
RK36	-0.76057	0.39200	-0.12771	-0.26499	0.32611
RK37	0.12861	-0.33219	-0.63639	-0.35301	0.51469
RK38	-0.58362	0.49489	-0.08708	-0.00867	0.29022
RK39	0.72665	-0.49208	-0.40790	-0.00923	0.14475

Table A-5c. Factor Analysis of Development Team Background: Final Communality Estimates

YP01	YP02	YP03	YP04	YP05	YP06	YP07	YP08	YP09	YP11	YP12	YP13
0.886023	0.909993	0.906500	0.902457	0.928059	0.832851	0.931127	0.756778	0.956696	0.914266	0.940037	0.934742
YP14	YP15	YP16	YP17	YP18	YP19	YP21	YP22	YP23	YP24	YP25	YP26
0.937216	0.913558	0.738561	0.929440	0.791201	0.950844	0.875359	0.889946	0.886528	0.894012	0.880859	0.754648
YP27	YP28	YP29	YP31	YP32	YP33	YP34	YP35	YP36	YP37	YP38	YP39
0.923374	0.685915	0.955202	0.937096	0.953038	0.953204	0.952588	0.955944	0.803427	0.959150	0.799850	0.955720
YA01	YA02	YA03	YA04	YA05	YA06	YA07	YA08	YA09	YA11	YA12	YA13
0.832668	0.859435	0.863150	0.822958	0.847555	0.897368	0.892240	0.685743	0.974980	0.879672	0.916350	0.925353
YA14	YA15	YA16	YA17	YA18	YA19	YA21	YA22	YA23	YA24	YA25	YA26
0.903245	0.835055	0.892827	0.937299	0.773166	0.967998	0.863801	0.875578	0.872397	0.872187	0.807881	0.775419
YA27	YA28	YA29	YA31	YA32	YA33	YA34	YA35	YA36	YA37	YA38	YA39
0.833996	0.758358	0.969132	0.942176	0.957627	0.958341	0.943092	0.909878	0.932419	0.956140	0.813754	0.972136
YE01	YE02	YE03	YE04	YE05	YE06	YE07	YE08	YE09	YE11	YE12	YE13
0.856055	0.878201	0.847453	0.781622	0.849253	0.866835	0.839625	0.578364	0.969391	0.879009	0.894657	0.916528
YE14	YE15	YE16	YE17	YE18	YE19	YE21	YE22	YE23	YE24	YE25	YE26
0.875543	0.724289	0.863803	0.897920	0.677989	0.959307	0.925577	0.944024	0.941126	0.947396	0.687106	0.743083
YE27	YE28	YE29	YE31	YE32	YE33	YE34	YE35	YE36	YE37	YE38	YE39
0.809534	0.832865	0.960670	0.951464	0.966949	0.977364	0.958141	0.803856	0.883365	0.891158	0.653328	0.965950
RK01	RK02	RK03	RK04	RK05	RK06	RK07	RK08	RK09	RK11	RK12	RK13
0.728471	0.772397	0.799035	0.677548	0.874110	0.891082	0.719366	0.663642	0.957361	0.784298	0.837962	0.873061
RK14	RK15	RK16	RK17	RK18	RK19	RK21	RK22	RK23	RK24	RK25	RK26
0.819394	0.620577	0.772432	0.759993	0.611054	0.944630	0.679733	0.676667	0.687367	0.652260	0.646520	0.667825
RK27	RK28	RK29	RK31	RK32	RK33	RK34	RK35	RK36	RK37	RK38	RK39
0.628646	0.715537	0.957900	0.881330	0.904772	0.928038	0.877461	0.899622	0.924996	0.921409	0.671419	0.957585

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Table A-6a. Factor Analysis of Resource Model Parameters: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11
EIGENVALUES	17.264845	10.181945	9.332785	7.504366	4.671458	4.220036	3.567814	3.229747	2.712048	2.428738	1.589455
PORTION	0.237	0.139	0.128	0.103	0.064	0.058	0.049	0.044	0.037	0.033	0.022
CUM PORTION	0.237	0.376	0.504	0.607	0.671	0.728	0.777	0.822	0.859	0.892	0.914

	12	13	14	15	16	17	18	19	20	21	22
EIGENVALUES	1.467409	1.190751	1.002526	0.739438	0.638142	0.541002	0.498288	0.219206	0.000000	0.000000	0.000000
PORTION	0.020	0.016	0.014	0.010	0.009	0.007	0.007	0.003	0.000	0.000	0.000
CUM PORTION	0.934	0.950	0.964	0.974	0.983	0.990	0.997	1.000	1.000	1.000	1.000

	23	24	25	26	27	28	29	30	31	32	33
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	34	35	36	37	38	39	40	41	42	43	44
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	45	46	47	48	49	50	51	52	53	54	55
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	56	57	58	59	60	61	62	63	64	65	66
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	67	68	69	70	71	72	73
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000

6 FACTORS WILL BE RETAINED.

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Table A-6b. Factor Analysis of Resource Model Parameters: Factor Pattern (1 of 2)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
PS01	-0.61582	0.26829	-0.03936	0.26185	0.32170	0.05601
PS02	-0.01038	0.83143	-0.41250	0.01660	0.02291	-0.06206
PS03	0.49962	0.49380	-0.32180	-0.20295	-0.24840	-0.09918
PS04	0.52563	0.39395	-0.24186	-0.24202	-0.32153	-0.22429
PS05	0.38736	-0.50024	0.23426	0.16200	-0.45284	-0.12031
PS06	0.53462	0.07867	-0.05556	0.19879	-0.52349	-0.42061
PS07	-0.40564	-0.45821	0.22794	-0.19082	0.55030	0.17687
PS08	0.37815	-0.72110	0.30397	-0.06264	-0.16204	-0.14392
PS09	0.71974	0.24194	-0.29685	0.04746	-0.35611	-0.30495
PS10	0.33044	-0.76711	0.25899	0.25959	0.00665	0.05661
PS11	0.02256	-0.61659	-0.28599	-0.61562	-0.15530	-0.07510
PS12	0.13339	-0.54769	0.16506	0.45610	-0.12939	0.07829
PS13	0.37860	-0.41536	0.45113	0.50592	0.16904	0.08498
PS14	-0.12911	-0.20368	-0.28223	0.64928	-0.20537	0.10893
PS15	-0.16783	-0.17115	-0.13869	0.68371	-0.16205	0.12693
PS16	-0.16635	-0.20393	-0.10264	0.53700	-0.22878	-0.05662
WF02	-0.16583	-0.42916	0.66222	-0.11209	-0.01045	-0.08804
WF03	[illegible]	0.34502	0.46329	-0.36080	0.21058	-0.48814
WF04	-0.10742	0.64625	0.37111	0.45790	0.09748	0.07961
WF05	-0.15576	0.53660	0.08235	0.43707	-0.09256	0.46833
WF06	0.27975	0.35174	0.23424	0.39039	-0.01148	0.34130
WF07	0.21854	0.68047	0.24035	0.28122	0.01056	-0.13083
WF08	-0.05848	0.58587	0.15963	0.36913	0.04072	0.38361
WF09	0.19729	-0.04911	0.17681	-0.20765	0.37461	0.40044
WF11	0.16583	0.42916	-0.66222	0.11209	0.01045	0.08804
WF12	0.18187	-0.56660	0.23756	0.42803	0.37276	0.02546
WF13	0.34153	-0.20579	-0.04038	0.49022	-0.33687	0.27405
WF14	0.66705	-0.00733	-0.12604	-0.08619	-0.34357	0.35428
WF15	0.68462	-0.11296	-0.13262	0.06175	0.02233	0.34564
WF16	0.66110	-0.05702	-0.02588	0.01397	-0.15569	0.44569
WF18	0.54655	0.05019	-0.18568	0.18042	-0.29443	0.47124
WF19	0.29819	0.14155	0.67074	0.14046	-0.36414	-0.32117
WF20	0.54558	0.03735	0.12320	0.01940	0.30212	-0.03720
WF21	0.46371	0.04087	-0.27935	-0.26810	0.01452	0.45333
WF22	0.72033	0.25475	-0.25511	-0.27252	-0.24259	0.25677
WF23	0.67785	-0.27045	0.13383	0.47056	-0.01351	0.00068
WF31	-0.23910	-0.30273	-0.76127	0.27901	0.16197	-0.24188
WF32	0.27509	0.33490	0.72503	-0.34759	-0.17972	0.21393
WF34	0.11957	0.34788	0.46708	-0.36273	0.22969	-0.48108
WF35	-0.03564	0.49336	0.27762	-0.13538	-0.06241	0.01026
WF36	0.29310	0.33155	0.71864	-0.35705	-0.19610	0.18099
WF37	0.27435	0.33509	0.72517	-0.34673	-0.17791	0.21553
WF39	-0.01750	-0.08748	-0.46137	0.58820	0.42851	-0.14290
WF40	-0.31462	-0.31303	-0.47431	-0.37000	-0.32741	-0.15551
WF41	-0.32756	0.31265	-0.19909	0.15815	0.08797	0.37320
WF42	0.24171	0.10033	0.37350	0.29334	0.52310	0.03305
WF43	-0.29068	-0.09593	0.23572	0.69531	-0.12511	-0.04354
WF44	-0.61797	-0.10241	0.22264	0.38720	-0.02727	-0.21662
WF45	0.22937	-0.02038	-0.45536	-0.16421	-0.29732	0.04197

Table A-6b. Factor Analysis of Resource Model Parameters:
Factor Pattern (2 of 2)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
WF46	-0.11554	0.32741	-0.78468	0.19978	-0.08865	0.09022
WF47	-0.06666	-0.13330	0.69086	-0.27207	0.09111	0.24012
WF50	-0.06562	0.09533	-0.34028	0.51651	0.15035	-0.47044
WF51	0.87338	0.00374	-0.25471	-0.05942	0.25451	-0.09910
WF52	0.87496	0.01467	-0.25877	-0.08343	0.24524	-0.07846
WF54	0.22149	0.64833	-0.07284	0.14927	0.16163	-0.07017
WF55	0.71951	0.24216	-0.23727	0.04738	-0.35628	-0.30485
WF61	0.01744	-0.66082	-0.12851	-0.40355	-0.10977	0.05205
WF62	-0.10061	0.64742	-0.01546	0.31346	0.20429	0.01534
WF63	0.30452	0.21410	0.56663	0.44051	-0.32373	-0.26320
WF66	0.41012	0.05876	0.67743	0.12512	-0.32931	-0.32512
WF67	0.66596	-0.18796	-0.05903	-0.23642	0.26952	0.22026
WF68	0.92344	-0.04708	0.05573	0.13700	0.12413	-0.15626
WF69	0.87596	-0.05297	-0.11363	0.04512	0.35730	-0.15387
WF70	0.83688	-0.05688	-0.08930	0.05186	0.32799	-0.14704
WF71	0.54346	-0.15445	-0.09777	-0.31956	0.18243	0.42871
WF72	0.90980	-0.01123	0.03917	0.09245	0.21587	-0.23093
WF73	0.84004	0.03470	-0.09639	-0.07490	0.42976	-0.15942
WF74	0.87207	0.01231	-0.08463	-0.08021	0.40727	-0.12031
WF75	0.67979	-0.27021	0.13303	0.46254	-0.01379	0.01068
WF76	0.92603	0.09703	-0.20648	0.00047	0.19421	-0.09758
WF81	0.05482	0.68539	0.52443	0.22373	0.14587	0.05197
WF82	0.85463	-0.02863	-0.02184	0.21353	-0.19561	0.29074
PS81	0.33044	-0.76711	0.25899	0.25959	0.00665	0.05661

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Table A-6c. Factor Analysis of Resource Model Parameters:
Final Communality Estimates

PS01	PS02	PS03	PS04	PS05	PS06	PS07	PS08	PS09	PS10	PS11	PS12	PS13
0.627955	0.866198	0.709743	0.7022[illegible]4	0.700940	0.785572	0.796984	0.806279	0.886736	0.835362	0.871221	0.575899	0.811133
PS14	PS15	PS16	WF0[illegible]	WF03	WF04	WF05	WF06	WF07	WF08	WF09	WF11	WF12
0.613411	0.586530	0.423707	0.670645	0.761499	0.792407	0.737923	0.525873	0.664878	0.657220	0.416400	0 670645	0.733361
WF13	WF14	WF15	WF16	WF18	WF19	WF20	WF21	WF22	WF23	WF31	WF32	WF34
0.589524	0.711876	0.622822	0.664052	0.677020	0.814318	0.407271	0.572328	0.847889	0.772141	0.890931	0.912380	0.769245
WF35	WF36	WF37	WF39	WF40	WF41	WF42	WF43	WF44	WF45	WF46	WF47	WF50
0.344080	0.910971	0.911760	0.770846	0.690216	0.416708	0.568765	0.650263	0.639537	0.377506	0.792173	0.639472	0.649834
WF51	WF52	WF54	WF55	WF61	WF62	WF63	WF66	WF67	WF68	WF69	WF70	WF71
0.905807	0.905993	0.528020	0.886814	0.632247	0.569735	0.827764	0.861[illegible]59	0.659364	0.916660	0.936362	0.947488	0.647960
WF72	WF73	WF74	WF75	WF76	WF81	WF82	PS81					
0.937878	0.931879	0.954593	0.767076	0.956811	0.821820	0.899849	0.835362					

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Table A-7a. Factor Analysis of Additional Detail: Factor Loadings

	1	2	3	4	5	6	7	8	9	10	11	12
EIGENVALUES	68.763092	13.299239	11.069012	8.296697	6.809343	5.414136	4.167956	3.897744	3.138966	2.868020	2.172525	1.700233
PORTION	0.502	0.097	0.081	0.061	0.050	0.040	0.030	0.028	0.023	0.021	0.016	0.012
CUM PORTION	0.502	0.599	0.680	0.740	0.790	0.830	0.860	0.888	0.911	0.932	0.948	0.961

	13	14	15	16	17	18	19	20	21	22	23	24
EIGENVALUES	1.578837	1.180475	0.914864	0.738425	0.425104	0.339138	0.226194	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.012	0.009	0.007	0.005	0.003	0.002	0.002	0.000	0.000	0.000	0.000	0.000
CUM PORTION	0.972	0.981	0.987	0.993	0.996	0.998	1.000	1.000	1.000	1.000	1.000	1.000

	25	26	27	28	29	30	31	32	33	34	35	36
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	37	38	39	40	41	42	43	44	45	46	47	48
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	49	50	51	52	53	54	55	56	57	58	59	60
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	61	62	63	64	65	66	67	68	69	70	71	72
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	73	74	75	76	77	78	79	80	81	82	83	84
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	85	86	87	88	89	90	91	92	93	94	95	96
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	97	98	99	100	101	102	103	104	105	106	107	108
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	109	110	111	112	113	114	115	116	117	118	119	120
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	121	122	123	124	125	126	127	128	129	130	131	132
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	133	134	135	136	137
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000

6 FACTORS WILL BE RETAINED.

Table A-7b. Factor Analysis of Additional Detail: Factor Pattern (1 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
SW01	0.89042	0.41971	-0.01154	0.11289	-0.02896	-0.08264
SW02	0.79280	-0.09251	-0.56477	0.09405	-0.00583	0.04490
SW03	0.87081	-0.28887	-0.11361	-0.22864	0.08804	0.08046
SW04	0.53657	-0.49079	0.32321	0.55599	0.09012	-0.11483
SW05	0.96546	0.08126	0.02460	0.21624	0.02106	-0.07400
SW06	0.90770	0.35223	0.03949	-0.03894	0.09722	0.09623
SW07	0.69390	-0.09746	-0.60264	0.24872	0.00773	-0.03455
SW08	0.86141	-0.19632	-0.02389	-0.36053	0.03979	0.07970
SW09	0.52086	-0.35538	0.33929	0.65626	-0.05923	-0.08223
SW10	0.96656	0.01137	0.11404	0.20342	0.04009	0.03335
SW11	0.58795	-0.01966	0.33831	-0.62514	0.22897	-0.14275
SW12	0.40113	0.36836	-0.74004	0.26351	0.25204	-0.01932
SW13	0.66523	0.17741	0.01726	-0.30765	0.29275	-0.32421
SW14	0.31634	0.36423	0.61829	0.48306	0.03747	0.02110
SW15	0.47281	0.39026	0.59983	0.37320	0.11024	-0.03598
SW16	0.88002	0.29479	-0.29904	0.01254	0.03304	-0.17654
SW17	0.49453	-0.20118	-0.08669	-0.01691	-0.46741	0.39279
SW18	0.56749	-0.57975	-0.00868	0.01644	-0.15803	0.14908
SW19	0.47437	-0.60663	0.20130	-0.16755	0.47825	-0.11672
SW20	0.95757	0.03873	-0.22000	-0.02522	0.06885	-0.12120
SW21	0.92176	0.27941	0.07717	-0.19761	0.06905	0.05879
SW22	0.74133	-0.33258	-0.41565	0.13416	-0.08564	-0.08870
SW23	0.82983	-0.28119	0.04706	-0.34491	-0.00158	0.06479
SW24	0.34524	-0.67133	0.20268	0.50774	0.09444	-0.19430
SW25	0.97884	-0.14317	0.06972	0.01426	0.06702	-0.03262
SW26	0.93395	0.28566	0.00902	-0.16804	0.06625	0.01098
SW27	0.76734	-0.32215	-0.42638	0.13324	-0.12603	-0.03781
SW28	0.85064	-0.30244	0.04187	-0.32644	0.00274	0.04959
SW29	0.42813	-0.54565	0.35639	0.54781	0.13916	-0.17402
SW30	0.98630	-0.07513	0.07646	0.04127	0.07506	-0.04856
SW31	0.60823	-0.12615	0.32640	-0.57074	0.27535	-0.08011
SW32	0.40113	0.36836	-0.74004	0.26351	0.25204	-0.01932
SW33	0.55087	0.05692	0.32710	-0.38514	0.21941	-0.36103
SW34	0.33600	0.38599	0.58215	0.49876	0.03786	0.02311
SW35	0.46918	0.37134	0.61124	0.36998	0.10178	-0.03358
SW36	0.89641	0.28783	-0.20393	-0.04200	0.04430	-0.21490
SW37	0.49984	-0.21516	-0.08654	-0.01054	-0.48739	0.39796
SW38	0.54357	-0.59369	0.02105	-0.00220	-0.12518	0.12413
SW39	0.47555	-0.60525	0.20167	-0.17143	0.47808	-0.11549
SW40	0.96525	0.01503	-0.12921	-0.07645	0.08771	-0.15404
SW41	0.90515	0.30607	0.00174	-0.19567	0.16444	0.03287
SW42	0.71742	-0.31089	-0.48394	0.14916	-0.11913	-0.06930
SW43	0.83649	-0.31942	-0.01770	-0.33578	-0.00421	0.04815
SW44	0.39173	-0.67141	0.22855	0.50010	0.01488	-0.15993
SW45	0.97842	-0.14932	0.00683	0.02546	0.09266	-0.04042
SW46	0.92319	0.30095	-0.07755	-0.14417	0.12147	-0.06986
SW47	0.75937	-0.31620	-0.45198	0.12957	-0.23342	0.05362
SW48	0.83657	-0.39609	0.02109	-0.29423	-0.01622	0.03719
SW49	0.50783	-0.54210	0.38796	0.47303	0.14193	-0.14168

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Table A-7b. Factor Analysis of Additional Detail: Factor Pattern (2 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
SW50	0.98753	-0.05473	0.01864	0.02529	0.09759	-0.08054
SW51	0.90862	0.20535	-0.06601	-0.22922	0.21792	0.06072
SW52	0.75049	-0.40309	-0.37528	0.12646	-0.11378	-0.06689
SW53	0.82172	-0.34885	0.12140	-0.37282	-0.01934	0.05085
SW54	0.40170	-0.61206	0.28495	0.54914	0.07064	-0.15732
SW55	0.96045	-0.20482	0.02490	0.02139	0.14612	-0.02190
SW56	0.94381	0.25802	0.02671	-0.11194	-0.00695	-0.01280
SW57	0.74533	-0.07691	-0.54622	0.14108	-0.14041	-0.02936
SW58	0.84534	-0.17977	-0.08271	-0.39951	-0.01570	0.12423
SW59	0.64416	-0.43035	0.32612	0.48425	-0.10228	-0.09992
SW60	0.97637	0.12704	-0.02307	-0.08322	-0.03181	-0.00457
SW61	0.93799	0.24550	0.06322	-0.10418	-0.00486	-0.00726
SW62	0.75346	-0.09477	-0.50706	0.13063	-0.22165	0.00999
SW63	0.83065	-0.18283	-0.04721	-0.43195	-0.03865	0.12861
SW64	0.61983	-0.08260	0.16005	-0.19870	-0.42699	-0.01050
SW65	0.95464	0.16588	-0.00808	-0.13390	-0.02787	-0.00402
SW66	0.82338	0.39524	0.28411	0.09936	-0.17345	-0.11150
SW67	0.67255	-0.15357	-0.38623	0.20583	-0.36507	-0.03399
SW68	0.87410	-0.14819	0.01081	-0.24593	-0.29185	0.08854
SW69	0.50893	-0.01440	0.18659	-0.04062	-0.50176	-0.07616
SW70	0.87697	0.30968	0.20462	0.07856	-0.21677	-0.11076
SW71	0.30492	0.05694	0.21814	-0.29050	-0.19800	0.36680
SW72	0.39591	-0.25954	0.05946	0.16545	0.20958	0.38916
SW73	0.48984	-0.00147	0.12144	-0.06157	-0.17974	-0.33909
SW74	-0.21263	0.06195	-0.05886	0.20512	0.06595	0.20305
SW75	0.31424	-0.24984	0.22479	-0.15612	-0.12540	0.19916
SW76	-0.07549	0.50164	0.16810	-0.05588	-0.57887	-0.23035
SW77	-0.15903	0.42288	0.18117	-0.07777	-0.51341	0.01444
SW78	-0.20550	0.43821	0.25236	-0.04019	-0.02626	0.44219
SW79	0.37522	0.42712	0.27685	-0.17964	-0.57402	-0.27721
SW80	0.23716	0.44802	0.16735	-0.21020	-0.55627	-0.45138
SW81	0.13105	-0.50005	-0.16777	0.10626	0.32611	0.15897
SW82	-0.12718	-0.35765	-0.01289	0.09320	0.22874	0.66504
SW83	0.49425	-0.50780	0.05184	-0.08355	0.35289	0.15019
SW84	0.56245	-0.43453	-0.05600	-0.14264	0.23759	-0.31911
SW85	0.19826	-0.24526	0.14313	0.05016	-0.01992	-0.41784
SW86	0.16176	0.01198	-0.17655	-0.02764	0.04936	-0.65176
SW87	0.62168	-0.25893	0.06020	-0.19608	0.21347	-0.29646
SW88	0.43846	0.05333	-0.09608	-0.32223	-0.00128	-0.59093
SW89	0.12928	-0.01697	-0.20408	-0.31935	0.11368	0.32635
SW90	0.23079	0.19662	0.37918	0.22785	-0.33785	-0.14993
MS01	0.51842	0.46098	0.52935	0.23993	0.16947	0.03683
MS02	0.97548	0.01198	0.07649	0.07305	0.14670	-0.06054
MS03	0.71448	0.16418	0.25531	-0.18396	0.39337	0.07664
MS04	0.49511	0.26109	-0.55717	0.34295	0.11179	0.00211
MS05	0.46759	0.22638	0.39571	-0.06355	0.30431	0.44113
MS06	0.78056	0.30331	0.06961	0.03426	0.38231	0.25567
MS07	0.45692	0.19810	0.13965	-0.26129	0.23724	-0.29925
MS08	0.40704	0.44419	-0.66262	0.30374	0.23863	-0.01105

Table A-7b. Factor Analysis of Additional Detail:
Factor Pattern (3 of 3)

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6
MS09	0.12425	0.35637	0.42886	0.12569	0.25637	0.03740
MS10	0.51513	0.55638	-0.43259	0.24973	0.35629	-0.05916
MS11	0.61458	0.44725	0.47153	0.13192	0.18532	0.04924
MS12	0.90619	0.15466	0.22127	0.10743	-0.08580	0.03839
MS13	0.45500	0.15215	0.16677	-0.22771	0.20250	0.27095
MS14	0.35857	0.37495	-0.58165	0.41208	0.06321	-0.01068
MS15	0.33254	0.21040	0.39425	0.05827	0.26577	0.58504
MS16	0.59906	0.41398	-0.02824	0.19230	0.28460	0.47045
MS17	0.19937	0.27546	0.17591	-0.22128	0.10425	-0.25884
MS18	0.39144	0.45108	-0.66506	0.31877	0.22759	-0.01216
MS19	0.07027	0.35347	0.42859	0.14843	0.22905	0.07409
MS20	0.43726	0.60084	-0.44441	0.29504	0.31784	-0.03688
MS21	0.82525	0.13096	0.08246	0.08137	-0.28460	0.15452
MS22	0.70135	0.05767	0.09242	0.34346	-0.29179	0.33146
MS23	0.97676	-0.00744	-0.09176	-0.07872	0.11135	-0.00892
MS24	0.95242	0.24350	-0.05241	-0.00971	0.07633	0.04293
MS25	0.96571	0.09250	-0.00893	0.03094	-0.07366	0.09572
MS26	0.87840	0.18188	0.19346	0.06701	-0.18264	-0.08940
MS27	0.87140	0.18534	0.23662	0.10439	-0.19801	-0.07132
MS28	0.90657	0.14770	0.19919	0.06717	-0.15267	-0.03116
ES01	0.96303	0.09081	0.06890	0.21381	0.03602	-0.05394
ES02	0.96050	0.03783	0.03833	0.22228	0.05799	-0.00156
ES03	0.91655	0.34760	-0.04393	0.05848	0.09671	0.01924
ES04	0.88650	-0.20886	-0.07380	-0.26977	-0.01836	0.12482
ES08	0.98601	-0.07750	0.08409	0.04949	0.07089	-0.04245
ES09	0.96628	0.19861	-0.06104	-0.12751	0.03222	0.01222
ES10	0.84447	-0.30691	0.06420	-0.33445	0.00623	0.04653
ES05	0.86217	-0.08731	0.04672	-0.02141	-0.37655	0.22347
ES06	0.97582	0.12922	-0.02427	-0.08200	-0.02059	-0.00228
ES07	0.96095	0.08276	-0.01927	0.03717	-0.09784	0.10703
ES14	0.91331	0.09424	0.05767	0.01674	-0.32128	0.09262
ES15	0.83546	0.10549	0.17874	0.12430	-0.32942	0.16630
ES16	0.90529	-0.09630	-0.08356	-0.18493	-0.04834	0.29076
ES17	0.76724	-0.06857	-0.05138	0.06517	-0.44109	0.27277
ES18	0.82451	0.04177	0.03863	0.14840	-0.46760	0.04004
ES19	-0.14518	0.05724	-0.04954	-0.07192	0.03166	-0.09214
ES11	0.92319	0.30095	-0.07755	-0.14417	0.12147	-0.06986
ES12	0.75937	-0.31620	-0.45198	0.12957	-0.23342	0.05362
ES13	0.68418	-0.56182	0.31309	0.27323	0.10642	-0.09911

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Table A-7c. Factor Analysis of Additional Detail:
Final Communality Estimates

SW01	SW02	SW03	SW04	SW05	SW06	SW07	SW08	SW09	SW10	SW11	SW12	SW13
0.989548	0.966949	0.921162	0.963677	0.992003	0.969776	0.917288	0.919064	0.990079	0.991463	0.924130	0.977597	0.759769
SW14	SW15	SW16	SW17	SW18	SW19	SW20	SW21	SW22	SW23	SW24	SW25	SW26
0.850212	0.888389	0.983168	0.665593	0.705692	0.903974	0.986901	0.980943	0.866141	0.893071	0.915428	0.989250	0.986699
SW27	SW28	SW29	SW30	SW31	SW32	SW33	SW34	SW35	SW36	SW37	SW38	SW39
0.909459	0.925837	0.957790	0.993981	0.900374	0.977597	0.740515	0.851507	0.880011	0.977886	0.699660	0.679462	0.904439
SW40	SW41	SW42	SW43	SW44	SW45	SW46	SW47	SW48	SW49	SW50	SW51	SW52
0.985901	0.979394	0.886797	0.917134	0.932379	0.990520	0.989289	0.955061	0.945410	0.966254	0.995208	0.975821	0.899957
SW53	SW54	SW55	SW56	SW57	SW58	SW59	SW60	SW61	SW62	SW63	SW64	SW65
0.953623	0.948462	0.987318	0.970805	0.900267	0.929055	0.961436	0.977937	0.955023	0.900094	0.930251	0.638534	0.957647
SW66	SW67	SW68	SW69	SW70	SW71	SW72	SW73	SW74	SW75	SW76	SW77	SW78
0.967271	0.801881	0.939624	0.553251	0.972269	0.401939	0.450384	0.405776	0.140167	0.291462	0.678099	0.506792	0.495785
SW79	SW80	SW81	SW82	SW83	SW84	SW85	SW86	SW87	SW88	SW89	SW90	MS01
0.838483	0.842333	0.438283	0.647550	0.658905	0.686930	0.297453	0.485473	0.629059	0.657350	0.280054	0.424238	0.849111
MS02	MS03	MS04	MS05	MS06	MS07	MS08	MS09	MS10	MS11	MS12	MS13	MS14
0.988071	0.797076	0.753861	0.717705	0.918820	0.481627	0.951378	0.409277	0.954860	0.854256	0.914442	0.424267	0.781394
MS15	MS16	MS17	MS18	MS19	MS20	MS21	MS22	MS23	MS24	MS25	MS26	MS27
0.726578	0.870348	0.273404	0.952559	0.393549	0.939138	0.816481	0.816728	0.981219	0.976905	0.956782	0.887946	0.904867
MS28	ES01	ES02	ES03	ES04	ES08	ES09	ES10	ES05	ES06	ES07	ES14	ES15
0.912154	0.990337	0.984564	0.975958	0.923642	0.994560	0.994309	0.925509	0.945331	0.976658	0.953060	0.958421	0.892690
ES16	ES17	ES18	ES19	ES11	ES12	ES13						
0.956881	0.869203	0.925321	0.041469	0.989289	0.955061	0.977566						

APPENDIX B - FACTOR ANALYSIS OF CLASS FACTORS

Table B-1 reproduces the output of the factor analysis of the 38 class factors defined in Section 4.2. Appendix A (Volume 1) reproduces the analyses that generated the class factors analyzed in Table B-1. The elements of Table B-1 are explained in Section 3.2 and Appendix A of this volume.

Table B-1a. Factor Analysis of Combined Factors: Factor Weights

	1	2	3	4	5	6	7	8	9	10
EIGENVALUES	5.911264	5.487984	4.550632	4.254443	4.194758	3.146996	2.401181	1.811425	1.610531	1.213957
PORTION	0.156	0.144	0.120	0.112	0.110	0.083	0.063	0.048	0.042	0.032
CUM PORTION	0.156	0.300	0.420	0.532	0.642	0.725	0.788	0.836	0.878	0.910

	11	12	13	14	15	16	17	18	19	20
EIGENVALUES	0.835570	0.667346	0.531131	0.419778	0.292650	0.229489	0.203478	0.148694	0.088686	0.000000
PORTION	0.022	0.018	0.014	0.011	0.008	0.006	0.005	0.004	0.002	0.000
CUM PORTION	0.932	0.950	0.964	0.975	0.982	0.988	0.994	0.998	1.000	1.000

	21	22	23	24	25	26	27	28	29	30
EIGENVALUES	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	31	32	33	34	35	36	37	38
EIGENVALUES	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000	-0.000000
PORTION	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
CUM PORTION	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

5 FACTORS WILL BE RETAINED.

Table B-1b. Factor Analysis of Combined Factors: Factor Pattern

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
FACTOR01	0.52285	0.26370	0.67622	0.03723	0.27397
FACTOR02	-0.26059	-0.66952	0.50424	-0.32244	-0.21491
FACTOR03	0.24802	-0.11163	0.14442	0.27318	-0.39755
FACTOR04	0.41423	-0.58681	-0.26881	0.43864	0.10694
FACTOR05	-0.54011	0.11351	0.18267	0.50881	0.08660
FACTOR06	0.50109	0.26758	0.59665	0.07297	0.53007
FACTOR07	0.29582	-0.64160	-0.08156	-0.24065	0.18455
FACTOR08	0.59995	0.09942	-0.61325	0.08940	0.02487
FACTOR09	0.10876	-0.21753	0.23417	-0.48902	-0.16168
FACTOR10	-0.27069	-0.53930	0.00341	0.26422	0.44597
FACTOR11	-0.29748	0.34452	-0.33968	-0.26665	0.51252
FACTOR12	-0.62211	0.54171	0.25693	0.18694	-0.36947
FACTOR13	0.66525	0.23500	0.23459	0.04142	-0.48441
FACTOR14	-0.15095	-0.59517	0.52406	0.03006	-0.13209
FACTOR15	-0.13210	0.13325	-0.01291	-0.86321	0.08713
FACTOR16	0.05193	-0.24752	-0.07515	-0.09413	-0.46749
FACTOR17	0.78629	0.31877	0.06382	-0.12762	0.41118
FACTOR18	-0.02034	-0.55847	0.57667	-0.34274	0.15770
FACTOR19	-0.39009	0.44489	0.09843	-0.49906	0.34039
FACTOR20	-0.27002	-0.11478	-0.29101	0.06731	0.61136
FACTOR21	-0.05685	0.10824	-0.29772	-0.62068	-0.36220
FACTOR22	0.02929	0.31362	0.52305	0.29759	0.40098
FACTOR23	0.31896	-0.45408	-0.28293	-0.12935	0.35867
FACTOR24	0.43632	0.17131	-0.15666	0.03021	0.11100
FACTOR25	-0.30279	0.36012	-0.51270	0.17209	0.29857
FACTOR26	-0.62888	-0.39728	-0.01826	0.07902	0.25327
FACTOR27	-0.59662	0.47041	0.36108	0.04974	-0.36119
FACTOR28	-0.12332	-0.20473	0.39847	-0.03494	0.58107
FACTOR29	0.46965	0.34384	-0.27268	-0.07494	-0.21364
FACTOR30	0.43686	0.26729	0.56388	0.23318	-0.04229
FACTOR31	-0.05800	0.58038	-0.07950	0.14295	0.48051
FACTOR32	-0.03584	-0.21477	-0.14431	0.74838	-0.00690
FACTOR33	-0.61269	0.64236	0.30592	-0.08706	-0.09825
FACTOR34	-0.09994	0.01597	-0.03295	0.55736	-0.45521
FACTOR35	-0.47965	-0.09759	-0.35256	0.42779	0.25558
FACTOR36	-0.04542	-0.27088	0.15070	0.43581	-0.23286
FACTOR37	0.49185	0.43573	0.24857	0.34876	0.12448
FACTOR38	-0.16354	-0.29895	0.47864	0.09323	0.33205

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Table B-1c. Factor Analysis of Combined Factors: Communalities

FINAL COMMUNALITY ESTIMATES:

FACTOR01	FACTOR02	FACTOR03	FACTOR04	FACTOR05	FACTOR06	FACTOR07	FACTOR08	FACTOR09	FACTOR10	FACTOR11	FACTOR12	FACTOR13
0.876626	0.920582	0.327504	0.792038	0.604361	0.964970	0.597777	0.754509	0.379267	0.632835	0.656348	0.917928	0.789195
FACTOR14	FACTOR15	FACTOR16	FACTOR17	FACTOR18	FACTOR19	FACTOR20	FACTOR21	FACTOR22	FACTOR23	FACTOR24	FACTOR25	FACTOR26
0.670004	0.788091	0.297016	0.909303	0.787183	0.724709	0.549068	0.620022	0.622128	0.533350	0.257498	0.602986	0.624053
FACTOR27	FACTOR28	FACTOR29	FACTOR30	FACTOR31	FACTOR32	FACTOR33	FACTOR34	FACTOR35	FACTOR36	FACTOR37	FACTOR38	
0.840548	0.554760	0.464408	0.636420	0.597858	0.628355	0.898831	0.529195	0.612205	0.342303	0.630687	0.464158	

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