IBM Data Processing Techniques

IBM Study Organization Plan

The Method Phase II

This manual discusses how to conduct the second phase of a system study, "Determining Systems Requirements". The modification of goal-directed activities in response to future conditions and the analysis of each activity in terms of input operations, outputs and resources is discussed. Presents techniques to aid in analyzing relationships between these elements and measuring levels of performance of new system designs. The Systems Requirements Specification (SRS), the documentary output from phase II, is described and examples shown.

Reprinted (May 1975)

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CHAPTER 1 - DETERMINING SYSTEMS REQUIREMENTS

This manual is a working guide for conducting business systems studies through the second phase of the Study Organization Plan, determining systems requirements.

PHASE II OBJECTIVES

In Phase II of a systems study, two questions must be answered:

- What is the system required to do?
- How is the system's performance to be evaluated?

In Phase I, the study team concentrates on gaining understanding and insight into a business as it presently exists and reacts to its environment. Now it is necessary to look beyond present relationships to find out what the system is logically required to do to meet future business goals and objectives.

A goal statement is valuable as a definition of purpose and intent; it acquires larger significance when it is related directly to the activities of a business. An activity is a series of logically related operations which support and fulfill a specific business goal. Since an activity is goal-directed in nature, it demonstrates a justification for existence; this characteristic is often absent in contemporary organizational alignments.

Activities are defined in Phase I and, along with the statement of present goals, are the base from which Phase II work is initiated. The goal statement and activity formulation are vital inputs to Phase II, because it is possible to analyze what is required of a system only if it is first known what useful purpose the system serves.

Systems requirements cannot be determined solely from an understanding of present conditions; future plans and growth have an equally important influence. To the present, judgments of the future must be added by forecasting the impact of new products and services, changes in mix, volume trends, design and process innovations, enactment of regulatory laws, and competitive products. In the conduct of this work, a study team hypothesizes, analyzes, synthesizes and simulates to establish true systems requirements reflecting both the present and the future.

The work of Phase II is documented in the Systems Requirements Specification, which describes systems requirements, activity by activity. The report shows operations that must be performed, inputs that must be accepted, outputs that must be produced, resources that must be employed, and factors for measuring performance of system designs.

The goal statement, the definition of activities, and time, cost and accuracy data for individual operations within an activity (and in summary) are principal inputs to the requirements specification. The Present Business Description furnishes a substantial share of the information for requirements specification but data about the future must still be secured. Often the goal statement and activity formulation are not sufficiently precise, or should be revised in light of study findings. Both are reappraised early in Phase II before definitive requirements specifications are established.

STUDY SCOPE

Phase II begins after the Phase I report is accepted by management and approval is given to continue. Phase II ends with management approval of the Systems Requirements Specification. Between these two points, the study team engages in the diverse tasks of requirements specification. These tasks include:

1. Analyzing, defining and modifying present and future objectives to produce a statement of true business goals.
2. Modifying existing activities or creating new activities to align with these redefined business goals; specifying activity scope and boundaries.
3. Analyzing each activity to establish required inputs, operations, outputs and resources.
4. Refining these requirements through several iterations.
5. Constructing measures of effectiveness for each activity.
6. Documenting requirements in the Systems Requirements Specification.

Requirement complexity varies from activity to activity. Since an activity by definition is relatively self-contained, complexity can be reduced by analyzing each one individually. Later, in Phase III, activities can be integrated, and any inconsistencies or incompatibilities worked out in systems design. Analysis by activity discloses certain overall constraints (technical or managerial) which may limit freedom of action. Recognition of these constraints is necessary for successful systems design. When requirements have been determined, acceptable and desirable performance levels are identified. This sets up a series of performance targets to be met in systems design.

Development of requirements may be a relatively straightforward process, or it may involve difficult and complex analysis. Interviews and data analysis provide satisfactory information for specifications in some instances; in others, a high level of technical competence in the use of management science techniques is required.

SYSTEMS REQUIREMENTS SPECIFICATION

The Systems Requirements Specification (SRS) is the output report from Phase II. It opens with a Summary section describing present and future business goals, general considerations of the overall system, and pertinent information on the several activities as they affect the unified business.

The rest of the SRS is a series of packets, one for each activity, each composed of three sections: General, Operations and Measurement. Figure 1 shows the structure of an SRS document.

The General section outlines activity goals and objectives, scope and boundaries, and other information such as policies and costs that are not examined in the more specialized sections.

The Operations section states what is required of an activity (what it must do) in terms of inputs it must accept, operations it must perform, outputs it must produce, and resources (personnel, equipment, facilities, inventories) it must use to support operations. These elements are summarized at the beginning of the section in an Activity Requirements Model.

The Measurement section specifies factors and rating scales for evaluating a system designed to perform the activity under a variety of conditions.

Taken together, these activity packets communicate a specification of system requirements that will be readily understood by management and useful to the study team in developing a workable and efficient systems design in Phase III.

VARIABILITY OF APPLICATION

The Study Organization Plan is designed for application to many industries (banking, manufacturing, insurance, etc.), to enterprises of different size (small, medium, and large multi-plant operations), and to studies with widely divergent objectives: completely creative design, mechanization of an existing system, or the continuing modification and improvement which all systems periodically undergo. For each of these situations, it is necessary to prepare a specification of system requirements, however brief.

For major, creative systems design, an SRS is necessary in its full meaning and context, since

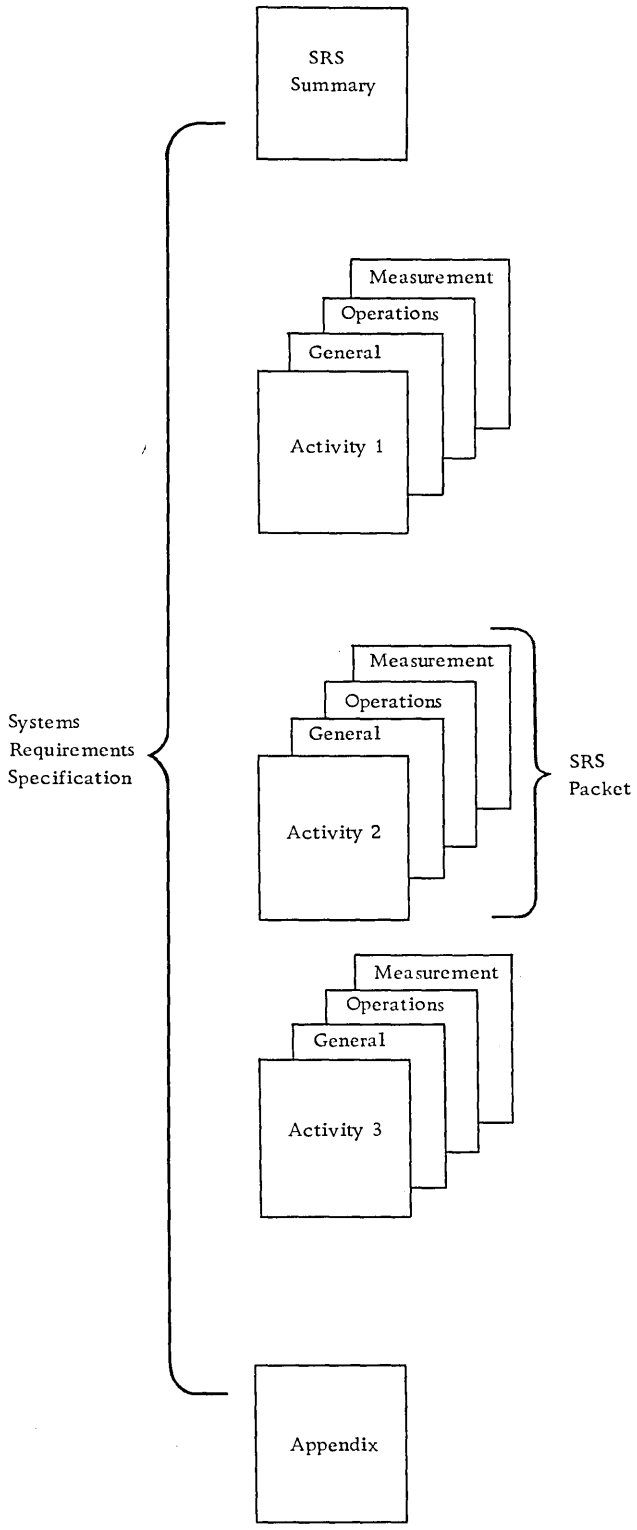

Figure 1.

new systems characteristics will significantly differ from the old. In improvement studies, the SRS points out areas of opportunity, thereby upgrading what may have started out to be a simple modification. Even in a straightforward mechanization, an SRS is valuable for bridging the gap between two essentially different types of systems, and establishes a base for more effective design. In each case, it is a matter of determining logical requirements rather than recognizing those that are accepted, inherited, or convenient.

The SRS is a definition of requirements at the problem level (in contrast to the solution description of Phase III). This problem definition is the firm documentation base that makes solution flexibility possible—and the base upon which new systems can be built as the business prospers and grows.

CHAPTER 2 - GOAL AND ACTIVITY ALIGNMENT

Goals of the present business were defined in Phase I, and activities formulated to meet these goals. In Phase II, goal and activity statements are reviewed and refined to accommodate changes that occur as a business plans for the future. The business goals directly considered are those within the scope of the study. After a decision has been reached on true goals of the present and future business, activity definitions are reshaped, and activity scope is realigned to conform to the new goal statement.

GOALS

In an established business, there is a pronounced emphasis on the demands and pressures of daily work, and often insufficient regard for future events. A billing date arrives and statements must go out; sales decline, and a promotional scheme must be devised to boost new orders; productive capacity is exceeded, and work must be subcontracted. Operating personnel have little time for considering the goals of a business; this is more properly the responsibility of persons who plan for operations in future time periods. Top managers or business owners decide what the goals should be. Product planners and systems analysts must know and understand these goals if systems designed to support the business are to be effective.

No matter how well the goals of an enterprise may have been thought through by management, they are seldom expressed in a form useful to the systems analyst. The problem in goal analysis is to change the usual broad, generalized statements into direct, specific definitions of what a business is attempting to do. Where goals exist only in the minds of management, they have to be extracted and formulated through interview and discussion. The more clearly and precisely goals are expressed, the more valid the specification of systems requirements will be.

Goals reveal purpose in a business; they state "what" a business is to do. In this respect, goals are ends rather than means. A sound goal statement shows not just present goals, but future goals that account for what a company strives for the next month, next year, and even the next decade. A business goal is stated in terms of:

- Products and services to be supplied.
- Maintenance of resources, both physical and informational.
- Bettering relationships and communications with consumers, suppliers, governments, shareowners, and the general public.

Goals are defined before activities. For a given goal, an activity (or activities) is designed to support the goal.

The degree of attention devoted to goals varies with the study. Precise goal definition, in a study aimed at creating a new system design for a large and complex business, is necessary to provide adequate direction for the study team; precision becomes less important in improvement or mechanization studies.

Future Business Goals

Much time elapses from the incubation of an idea to its practical implementation as a finished product or service. To maintain competitive advantage, a business must continually look ahead and plan for new products and services, often years before they are brought to the market. These ideas and plans of management determine future business goals.

The existence and availability of short and long range business plans provides the team with valuable input. A typical long range plan contains a wide range of data about future operations:

- Types of new products
- Development of new and present markets
- Possible changes in product mix
- Research and development projects
- Plant expansions and new site selection
- Projections of cash flow to finance corporate growth
- Projections on sales and manpower

In other cases these plans exist partially or even only as thoughts in the mind of managers, and the study team must draw them out in interviews.

In a large bank study, future planning documents revealed the imminent introduction of new services like "no check" payroll processing, retail credit servicing, automatic loans, and utility bill payment and collections. Individual interviews with bank officers also revealed that non-return of checks, customer accounts payable processing, and a community credit reference service were under consideration for the future. These services were also incorporated in the future goal statement.

One study team, facing up to the problem of poorly defined advance plans, asked each manager to make a list of future goals as he would express them on topics of new services, growth, etc., for the next ten years. The replies were correlated and the most appropriate and most frequently mentioned items were compiled into a composite report.

The study team used this report as a basis for discussion at a management meeting, where an acceptable future goal statement was finally devised.

Data Sources

Within a business, information about the future can be gathered from many different sources. The marketing manager is concerned with future plans on new products, distribution, and market penetration; engineering and research managers are sources for new product and technology data; the manufacturing manager controls plans for employment of new processes and materials that can affect current and future products.

Throughout Phase II, trend and projection data will be needed to establish numbers for future systems requirements. This information can also be usefully applied to goal definition, especially when long range plans have not been documented in detail.

The annual report furnishes clues to future goals. These excerpts came from the report of a large manufacturer:

- On expansion -

  An aggressive plan of expansion and acquisition has been continued by management while increasing available sales and manufacturing capacity, and, at the same time, allied fields with exceptionally good earning potentials have been entered.

- On distribution -

  Immediate and economical delivery is an especially strong competitive advantage of the company to both its commercial and industrial customers. Recognizing the trend of large industrial companies as well as the newer small technological concerns to locate their research and, in many cases, production facilities away from the traditional population centers, the company began systematically enlarging its market facilities with this in mind. Its branch warehouses from coast to coast are being improved with better inventories, automated billing and invoicing, and efficient stock control.

- On capacity -

  An additional 240,000 square feet of facility will be ready for occupancy this summer, freeing [additional] space presently needed for manufacturing and product development.

Internal projections are supplemented by forecasts from other sources. Trade associations predict industry trends; government bureaus and brokerage houses develop analyses by industry and commodity; research foundations and centers have information on product and other technological changes. Special studies on a variety of subjects may be of considerable value in determining futures: export markets, consumer attitudes, requirements for presently unsupplied goods and services, etc.

Figure 2 indicates trends of cosmetic item consumption and sales by type of retail outlet; trends projected from this data helped management decide on future compositions of product mix, and on where to concentrate marketing efforts. Sociological programs, developments and trends in such fields as urban renewal, prospective legislation on health and welfare, leisure time habits, and income by family groups can be analyzed for their effect on future conditions. A recent example of how legislation can have an impact on new services is found in the Retirement Act of 1962. Passage of this law permits brokerage houses and insurance companies to offer a new line of retirement plans to self-employed persons under special conditions outlined in the law.

Although an analyst can draw on a considerable amount of company, industry and government data for future goal formulation, this raw data must be related directly to the future operations of the particular business. Until such data is translated into a plan for facilities, manpower and materials, it is not particularly useful. The systems engineer, in analyzing this type of data, can only serve as a catalyst to management thinking. The ultimate decision on what goals are appropriate for the future of a business rests with management.

SALES GROWTH OF SELECTED COSMETICS ITEMS
(All sales figures expressed in thousands of dollars)

	1961 ($)	1960 ($)	1959 ($)	1958 ($)	1957 ($)	1956 ($)	1955 ($)	1954 ($)	1953 ($)	1952 ($)	1951 ($)
Rinses, Tints, Dyes	74,440	67,610	46,010	37,300	32,370	28,170	24,500	14,720	13,740	12,480	11,610
Spray Hair Fixatives	91,490	81,250	76,150	81,500	82,540	75,050	38,160	23,080	16,270	5,400	2,000
Shaving Cream-Aerosol	54,790	51,110	44,520	39,540	36,000	30,900	27,350	20,760	-	-	-
After-Shave Lotion	49,440	47,270	44,680	41,680	38,840	35,000	32,520	30,320	28,640	27,470	26,260
Liquid Facial Cleansers	29,640	29,030	26,900	26,610	26,120	25,060	21,640	8,500	4,800	-	-
Lipsticks	121,680	100,390	91,930	82,360	76,540	71,330	64,770	56,940	54,020	35,380	32,300
Mascara, Eyebrow Pencil, Eye Shadow	21,080	18,220	15,050	12,940	10,710	9,560	8,340	7,180	6,590	6,280	5,820
Toilet Water and Cologne	103,770	93,670	84,220	73,870	65,170	58,340	53,960	51,880	49,510	48,530	46,620

Selected Industry and Economic Statistics

	Retail Cosmetics Sales (000,000)	Population (000,000)	GNP (000,000,000)	Disposable Personal Income (000,000)
1961	$1,933.5	183.7	$518.7	$363.6
1960	1,784.0	180.7	503.4	349.4
1959	1,662.2	177.3	482.7	337.1
1958	1,523.7	174.1	444.5	317.9
1957	1,430.7	171.2	442.8	308.8
1956	1,321.0	168.2	419.2	292.9
1955	1,192.2	165.3	397.5	274.4
1954	1,086.8	162.4	363.1	256.9
1953	1,020.8	159.6	365.4	252.5
1952	1,004.0	157.0	347.0	238.7
1951	912.8	154.4	329.0	227.5
1950	840.1	151.7	284.6	207.7
Percentage Gain (1950-1961)	+130.2%	+ 21.1%	+ 82.3%	+ 75.1%
Ann. Compound Rate	7.9	1.8	5.6	5.2

Figure 2.

Example of Goal Synthesis

Modification of a preliminary goals and objectives statement can be shown in the study of the Commercial National Bank of Syracuse.* The initial statement emphasized present goals:

GOALS AND OBJECTIVES—PHASE I

1. Maintain and increase time and deposit balances to provide lending and investment ability consistent with customer needs and bank profit planning.
2. Increase speed, accuracy, and control of operations without incurring increased costs.
3. Improve customer service by reducing teller and loan processing time.
4. Pay interest rates and establish interest policies that are competitive with the banking industry, and as prescribed by Federal Reserve regulations.
5. Maintain loans outstanding at a figure consistent with and prescribed by bank policy through the extension of credit to qualified applicants.
6. Strengthen and maintain dealer relationships through continued good service, fair policies and practices, and competitive plans.
7. Serve the financing needs of the community and provide a profitable return to the bank on investments.
8. Make each customer a "total bank" customer.
9. Protect the quality of the loan portfolio and produce accurate and timely records for the customer.

* The names and locations of actual studies have been disguised.

10. Fulfill the borrowing requirements of present and potential individual and business customers, in order to provide a safe and profitable return to the bank.
11. Portray the bank's image by presenting positive identification factors to the public.

The Phase I goal statement was inclusive enough, but contained a mixture of performance, system, and business goals; many were tied to a general-purpose goal, profit. Early in Phase II, it was re-appraised and modified to read:

GOALS AND OBJECTIVES—PHASE II

1. Offer a balanced package of banking services to the community and surrounding areas which recognize customer needs, comply with federal, state and local regulations and laws, and are competitive in cost, accuracy and timeliness.
2. Maintain and increase time and demand deposit balances to provide lending and investment ability.
3. Maintain outstanding loan balances at a level consistent with established bank policy, and by accepting only qualified applicants.
4. Secure new and "total bank" account affiliations through promotional programs, and maintain the quality of bank-customer relationships and services.
5. Provide for the extension of bank services into newly developed suburban areas within the bank's established jurisdiction.
6. Explore and develop new banking financing practices and services for individual and business customers.
7. Strengthen and maintain community and employee relationships through continued good service, fair policies and practices, and forward planning.

The new statement not only brought the goals into sharper focus, but revealed how the bank would develop in the future.

ACTIVITIES

Activities are the means by which goals are accomplished. Already formulated in Phase I, they undergo modification in Phase II as future business goals are developed. Individual activities should correspond to individual goals in a fairly close one-to-one relationship, but there will be instances when a number of activities contribute to a single goal, or when a single activity will contribute to two or more goals.

Example of Activity Alignment

Returning to the Commercial National Bank of Syracuse, activities where originally identified as:

ACTIVITIES—PHASE I

1. Commercial checking accounts
2. Special checking accounts
3. Commercial loans
4. Mortgage loans
5. Foreign banking
6. Investments and stock transfer
7. Marketing, advertising and public relations
8. Correspondent banking
9. Legal and real estate
10. Savings accounts
11. Cashier and comptroller
12. Instalment loans

Early in Phase II they were reviewed with bank management and compared with the new goal statement. The new activity definition then appeared as:

ACTIVITY FORMULATION—PHASE II

1. Demand deposits
2. Time deposits
3. Instalment loans
4. Mortgage loans
5. Commercial loans
6. Marketing

Commercial and special checking accounts, having similar characteristics, were combined into the Demand Deposits activity. Demand and time deposits were maintained separately for legal reasons. Correspondent banking was absorbed into each of these activities by type of service (that is, demand deposit, time deposit). The three loan activities were, in effect, separate product lines, relatively self-contained, each one starting from and terminating in the outside environment. Advertising, public relations, international banking, legal and real estate activities were set aside from the immediate study for lack of transaction volume, although some of their operations were picked up in the selected activities. Each of the six activities included certain elements of the bank's functional cost centers (for example, all activities were entered through teller operations and employed central files).

Scope and Boundary

The alignment process yields broad activity definitions. These generalized statements must now be sharpened to provide a scope and boundary for each activity. For the wholly new activity, there is no other way to describe its content.

It is just as important to decide what is not contained in an activity as it is to decide what is included. Precise terminology is necessary to avoid the uncertainty of ambiguous function names. A clear, complete and understandable reference is needed to prevent confusion between adjacent activities on the part of the study team. The Scope and Boundary statement describes what is performed by an activity and what is not performed; the format of the description is secondary.

The Provide Demand activity statement from Butodale Electronics illustrates these points by treating activity scope in the following manner:

> This activity is concerned with accepting customer orders and preparing bids and quotations for potential customers. Requests and orders are received from Butodale salesmen or manufacturers' representatives, or are placed directly by the customer. They include orders for standard and custom-designed equipments and spare parts, but do not include requests for computation services. Standard equipments are processed routinely and the customer is furnished documents including price quotations, descriptive data, layouts, diagrams, and other information necessary to make the purchase decision.

The statement then goes on to mention special cases:

> Where the equipment is special, this activity includes management and engineering reviews, engineering design and layout, and the compilation of special cost data.
>
> After receipt of a formal order, the contract is edited and clarified for communication to engineering and manufacturing. Present volume of requests averages 15-20 weekly for standard products, and 3-4 for engineered products. This is expected to rise to a combined total of 25-30 weekly.

While it is not necessary to mention volumes in a scope statement, such information does show the activity size. The statement goes on to tell what is not included in this activity:

> Provide Demand does not include market forecasting, determination of plant schedules (this is actually worked out in conference with manufacturing when available capacity does not conform to customer requirements in regard to requested shipping dates), or the calculation of costs.

A final sentence summarizes the statement:

> The principal inputs, then, to this activity are customer orders or requests for quotation, and the principal outputs are quotations and specifications to the customer and communication of accepted orders to manufacturing.

An alternative method is simply to list the functions performed and the functions excluded. The study team for Custodian Life Insurance Company chose this technique, which is appropriate when functions are clear-cut and self-explanatory:

Functions performed by the New Business activity

- Review application and related forms
- Request medical and policyholder history
- Prepare processing documents
- Assemble application data
- Underwrite application
- Request additional information
- Prepare declination letter
- Calculate premiums
- Prepare policy
- Prepare internal records
- Prepare external records
- Provide new business statistics on current basis

Functions not performed by this activity

- Determine outside underwriting services
- Determine underwriting standards
- Set limits for policy size
- Initiate new plans of insurance
- Determine medical standards
- Determine premium rates or dividend schedules

Recognition of exclusions as well as inclusions avoids making unwarranted assumptions about an activity. An integrated material control activity, for example, usually includes production scheduling and control, inventory control, traffic and transportation, receiving and shipping, purchasing, and other operations related to overall material flow. Sometimes, however, the purchasing activity is independent or even reports to accounting. The inclusion-exclusion coverage should also point out presence or absence of functional work. In purchasing, traffic may be an identifiable function—or it may be performed by a buyer in addition to other duties.

Scope Verification

Activity scope statements are checked for completeness of coverage, independence, and practical working size. Content is compared with Phase I

Activity Sheets, to ensure completeness. Individual statements are compared as a unit against each of the others within the activity, and to other activities to check for conflicts and overlapping. This audit confirms that each activity is relatively independent and has few interactions with other activities.

Management Evaluation

A review by management of activity formulation serves two purposes:

- It advises management of the team's approach and progress.
- It allows management to make known any preferences about the sequence in which activities are to be analyzed.

Management may have several compelling reasons for assigning priority to activities for analysis and implementation, and their decisions establish the sequence of events for the study team. The total dollars in an activity frequently help decide which activity is selected for initial study: activities with a high potential for payoff will generally be accorded priority over others.

In some studies, activities having input from or output to the environment are analyzed first. In other studies, outputs from one activity serve as inputs to the following one. One output from a design engineering system, for example, can be a bill of materials; the content of the bill of materials establishes the input to the manufacturing planning system. Unless there is a strong reason for conducting the manufacturing study first, the engineering analysis takes precedence. Single-activity studies, of course, pose no sequencing problem.

Once management approval has been secured on activity definitions and priorities have been assigned, schedules can be drawn up for the balance of Phase II work.

CHAPTER 3 - REQUIRED INPUTS, OUTPUTS, OPERATIONS AND RESOURCES

The central theme in requirements specification is to determine what a system is required to do, activity by activity, in terms of:

- Outputs it must produce
- Inputs it must accept
- Operations it must perform
- Resources it must use

To define systems requirements, a study team moves away from present operations as they were described in Phase I and develops a specification from the position of what is logically necessary (or imposed) to fulfill the goals of an activity. Establishing logical requirements first, then adjusting to accommodate practical considerations, produces a more valid specification than one devised by building on present operations. Most activities contain many variable and interacting factors and conditions which make it difficult to arrive at a requirements specification in a single attempt; frequently several iterations are necessary to produce a satisfactory statement.

A study team first develops descriptive requirements for inputs, operations, outputs and resources. Then quantitative data (such as volume and time) are added to this description. Techniques such as correlation analysis, sampling, trend projection, forecasting and simulation are applied where necessary to increase precision of specifications.

DESCRIPTIVE REQUIREMENTS

Preparation of an Activity Requirements Model (Figure 3) in preliminary fashion has been found by many study teams to be a useful framework for analysis of requirements, even though the model will be subsequently revised.

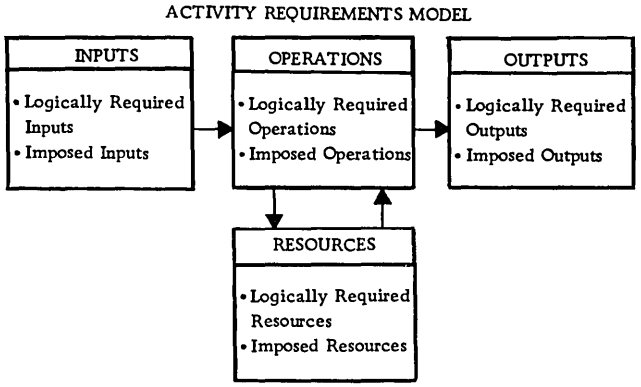

Figure 3.

Inputs or outputs are stated first since they are normally more closely associated with the goals and objectives of the activity than are operations or resources.

After specifying inputs or outputs, the study team progressively works through an activity to establish a logical sequence of operations required for activity performance.

The team may exercise any of several alternative approaches to arrive at an input, operation and output configuration, as diagrammed in Figure 4.

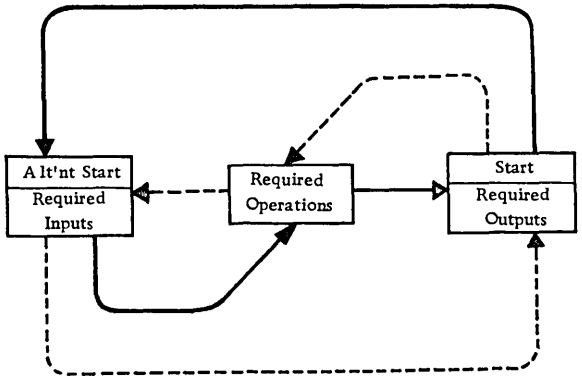

Figure 4.

Analysis of required resources results first in identification of those that are imposed; logically required resources emerge as relationships are clarified between inputs, operations and outputs.

Inputs and Outputs

Activity outputs are closely related to activity goals; they are often subject to constraints (the form of an invoice, the method and form of paying an employee, etc.) which make it easier to establish the activity's output requirements (though leaving less room for creativity in designing a new system). For these reasons, outputs are defined first by most study teams in analyzing an activity. Outputs from one activity that become inputs to another activity are defined in the form that is acceptable to the following activity. Once outputs are defined, the team is in a position to decide either what information (inputs) is required to produce the outputs (and, in turn, what operations are required to transform the inputs into outputs) or what operations must be performed to produce the output (and what information is therefore required).

Customer acceptance controls the form and content of many outputs—particularly in a business competing in services, such as banking. Legal and audit stipulations either affect outputs, or are

outputs in themselves (insurance and banking reports, small business administration reports, Social Security and income tax reports, etc.). Industry practice, as recognized by individual companies or as published by trade associations, also affects output formats. An output may be required by another activity within the business; it may also be required as feedback for repetitive processing or recycling of the activity.

Required inputs have many of the characteristics of required outputs and similarly may be imposed by the environment or other activities. In addition, some inputs are logically required to furnish information needed for outputs, and provide access to or maintain resources.

Determination of logically required inputs and outputs is illustrated in the Butodale study. Goals and objectives of the Provide Demand activity had been identified as:

- Sell custom-designed and standard computer equipments and accessories.
- Communicate individual specifications and requirements for special computer models.

The activity, according to the scope statement shown earlier, was concerned with accepting customer orders and preparing bids and quotations for potential customers.

What outputs were logically required to meet these objectives? The second goal suggested one: equipment specifications. The activity covered both custom-designed and standard units; therefore some customers ordered from a catalog, while others negotiated a specification and quotation through a series of conferences and letters with the engineering department. For the former, the order was acknowledged and a price and delivery schedule confirmed; for the latter, quotations of estimated price and delivery were prepared and supported by drawings and specifications outlining special equipment features and performance characteristics. Besides these outputs to the customer, the manufacturing department required customer order information to plan production schedules and determine shipping dates. A preliminary output specification was developed from this information:

OUTPUTS
Quotations
Acknowledgments
Bids
Letters of Transmittal
Prints and Drawings
Specifications
Audited Firm Orders
Communication of Firm Orders to Shop

The study team now had to decide whether to first establish inputs or the operations required to produce these outputs. Operations were extremely complex in engineering, sales, and manufacturing planning, so inputs were selected. What inputs were logically required? Certainly, firm orders were a prime input; and where a prospect was inquiring for information, his letter (or telephone call, wire, or any other suitable form) was also an input. The required inputs were described briefly:

INPUTS
Request for Quotation
Request to Bid
Formal Orders
Telephone Calls
Letters
Wires

With inputs and outputs defined, the operations were then identified—as they were logically required to transform these inputs into outputs, not necessarily as they were presently performed.

Operations Logic

If a team can define the cause-and-effect relationships which govern the transformation of inputs to outputs, they have established a sound basis for specifying required operations.

Actions don't just happen in a business; they are caused by some event or combination of conditions. Logic behind operations must be identified before an analyst can see the connection between events. This logic may take many forms:

- There may be a specific, identifiable cause or condition which determines the action. ("If the credit rating is OK, approve the order; if not, reject it.")
- It may be imposed as a directive. ("Response time on telephone calls may not exceed 18 seconds." Reason: a survey found that people intending to place an order hang up after this length of time when the ring is unanswered.)
- It is the only practical alternative to a situation or is an industry-wide practice (passbook for savings bank customers).
- It is the selection of a series of sequential operations, all of which have to be performed but not necessarily in a specific order (auditing an invoice).

Any or all of these are used in the development of requirements. Sometimes there is a direct

cause-and-effect relationship among events; at other times it is a process of selection, or combining practical alternatives.

Narrative form is often used to document simple operations. The following paragraph reveals the logic for determining an insurance premium rate:

> **Premium rate for a policy depends on the status of an applicant's health, age, occupation and sex. When these conditions are not covered in the appropriate instructions, rate is established by the underwriting department.**

Where decision logic becomes too complex for successful explanation in narrative form, a flow diagram can be used to demonstrate significant relationships among operations. Figure 5 is an example of a relatively straightforward decision logic net displayed in a flow diagram.

Decision tables can be used for documenting complex decision logic at both general and detail levels. They are particularly valuable as an analytical technique; this can be illustrated with an inventory example.

Inventory analysis contains many complex logical interactions in the handling of various transactions. For a typical manufacturing or retail inventory, four decision rules seem necessary to describe the four basic types of transactions: withdrawals from stock, receipts to stock, placement of new orders to replenish stock, and recounts to verify the balance on hand. The conditions and actions of these four transactions are recorded in tabular form in Figure 6. The first rule of the table reads:

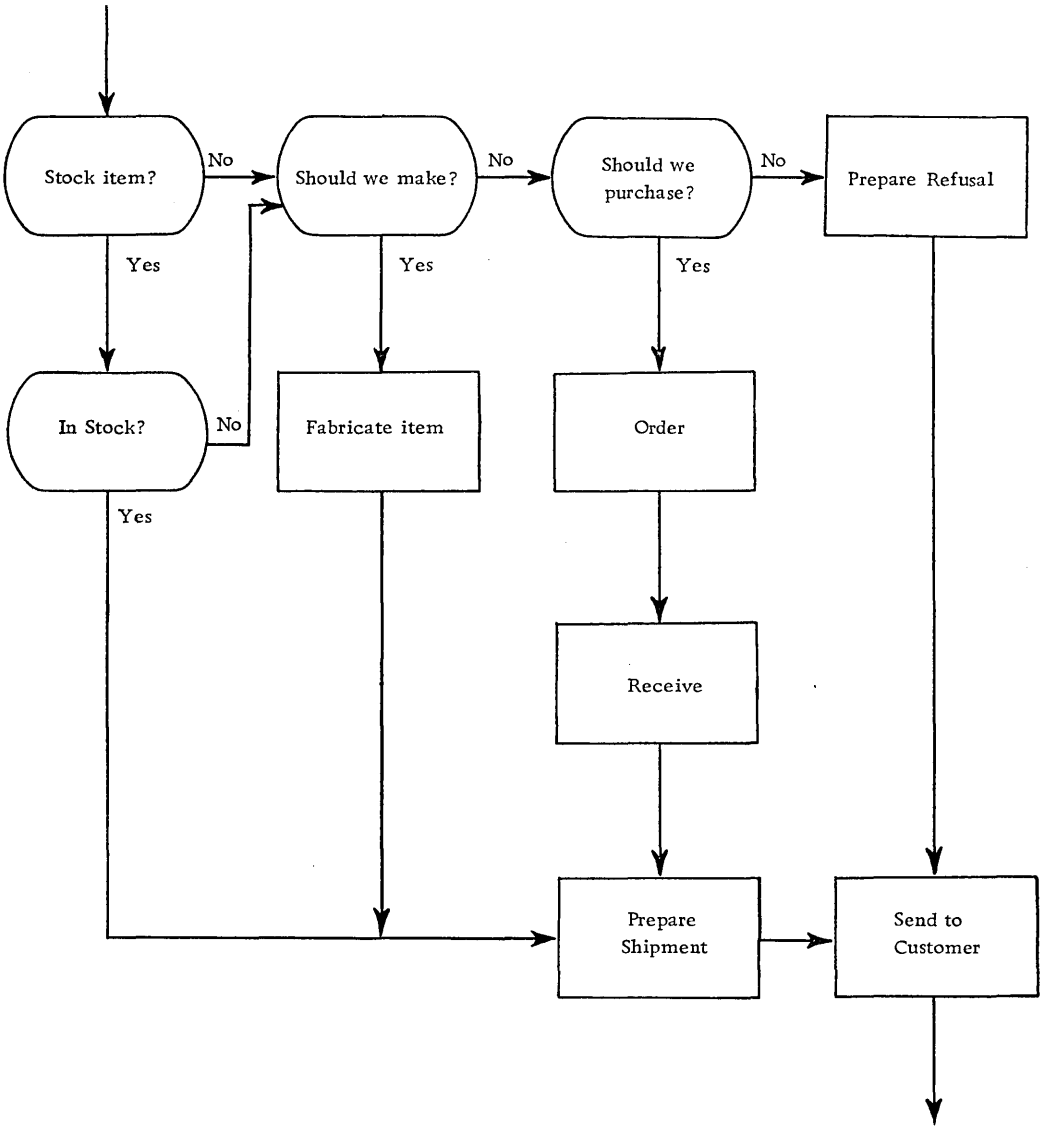

Figure 5.

TABLE: INVENTORY ANALYSIS

Type Trans	Withdrawal	Receipt	New Order	Re-Count
Trans Qty > Qty On Hand	No			
Trans Qty	≤Qty On Hand +Qty On Order -Ord Pt			>Ord Pt - Qty On Order
Qty On Hand	Less Trans Qty	Plus Trans Qty		= Trans Qty
Qty On Order		Less Trans Qty	Plus Trans Qty	
Go To	Next Trans	Next Trans	Next Trans	Next Trans

Figure 6.

If the type of transaction is a withdrawal,

and

the transaction quantity is not greater than the quantity on hand,

and

the transaction quantity is less than or equal to the quantity on hand plus the quantity on order less the order point

Then subtract the transaction quantity from the quantity on hand

and

go to the next transaction.

As the analyst checks these four rules, has he accounted for all possible situations? What happens if a withdrawal reduces the available balance below the order point? A new rule has to be added to cover this contingency, and another is needed to handle the case where a recount of stock shows a quantity less than the order point for that item. A final rule is added to provide for the situation where a withdrawal would make the on-hand balance negative. The analysis which once seemed complete has been expanded from four to seven rules (Figure 7). While the decision table did not make this analysis automatic, it presented the data in a form which promoted both organization and understanding of the logical structure.

Not all problems can be organized or structured so rigorously. Many times the analyst will work his way through an activity in step-by-step fashion, selecting operations and sequences as they seem

TABLE: INVENTORY ANALYSIS

Type Trans	Withdrawal	Withdrawal	Withdrawal	Receipt	New Order	Re-Count	Re-Count
Trans Qty > Qty on Hand	Yes	No	No				
Trans Qty		≤Qty On Hand +Qty On Order -Ord Pt	>Qty On Hand +Qty On Order -Ord Pt			≤Ord Pt -Qty On Order	>Ord Pt -Qty On Order
Qty on Hand	= 0	Less Trans Qty	Less Trans Qty	Plus Trans Qty		=Trans Qty	= Trans Qty
Qty on Order				Less Trans Qty	Plus Trans Qty		
Go To	Recount	Next Trans	Next Order	Next Trans	Next Trans	New Order	Next Trans

Figure 7.

to be logical or reasonable from his experience and background.

Operations

Required operations are those that are necessary to produce a required output, to accept an input, to maintain a resource, or to satisfy an activity goal. They may also be present to satisfy audit or legal requirements.

Operations are determined through observation, by hypothesizing operations logic from required inputs or outputs, or by experimentation. Observations of present operations always must be analyzed in terms of future rather than present circumstances. Experimentation involves the manipulation of a real-life situation under special test conditions or by appropriate simulation of actual operations.

Several types of relationship are generally evident among operations. There may be causal dependence: an operation is required because of the outcome of another operation. In a charge account activity, the recording of a sale and posting of the file are dependent upon the completion of a sale. Sequential dependence occurs when one operation must follow another. In an order processing activity, the order is received, a picking ticket is prepared, stock is selected, packaged and shipped, and an invoice is prepared. Stock cannot be shipped until selected and packaged; the selection process must follow the preparation of the picking ticket. This is a sequentially dependent set of operations. When operations are required at periodic or fixed intervals, a time dependence relationship is established. For example, a retail store may bill A-F customers on the 10th of the month, G-R customers on the 20th, and S-Z customers on the 30th; operations relating to charges for each group of customers must be performed at these times.

Certain operations in a series of sequential operations may be carried out in parallel with others, while many operations can be lap-phased (overlapped) to reduce total cycle time. Many retail businesses, for example, prepare a multiple-copy order for parallel processing by accounting (setting up the invoice and charge records), stockrooms (stock picking and packaging) and inventory control (reordering). Another example of lap-phasing is shown in processing a batch of 100 invoices; calculation of price times quantity is started for the first invoices in the batch while price lookup and posting is still going on for the bulk of the batch.

An effective approach in analysis of operations is to start with required outputs and attempt to reconstruct the logical sequence to the required inputs (or vice-versa). In this way, the transformation pattern or logic between inputs and outputs is clearly identified. Systems planners using this approach have found that they tend to identify only processing steps which are really necessary. Another approach is to decide how present system operations (displayed on Phase I Activity Sheets and detailed on Operation Sheets) need to be modified to accommodate the newly stated required outputs and inputs. Rarely, however, do radical yet profitable systems evolve from this approach.

In specifying required operations for the Provide Demand activity at Butodale, the study team used the scope and boundary statement as a base for postulating operations.

For standard orders, these operations were designated as logically required:

- Prepare a folder to assemble records relating to an individual order.
- Determine a delivery schedule.
- Edit the order in accordance with standard practices.
- Complete internal and external records.
- Enter the order on a shop schedule.

And, in addition, for special orders:

- Establish a design configuration as necessary to meet special customer requirements.
- Compile special costs and delivery data.
- Issue quotations and bids.

For the Activity Requirements Model, this statement of operations was documented as follows:

OPERATIONS
Prepare Quote Folder
Prepare Bid Sheet
Compile Cost and Price
Establish System Configuration on Layout Sheet
Set up Internal and External Records
Conduct Eng'g Edit and M'g'm't Review
Issue Quotations and Bids
Audit and Record Firm Orders
Describe and Enter Orders to Shop Schedule

After the logically required operations of an activity were developed through such an analysis, results were compared with Phase I Activity and Operations Sheets. This served as a check on the team's work to insure that requirements were not overlooked.

Resources

Resources are more likely to be subjected to constraints than operations. In the first pass at requirements, imposed resources are listed. Warehouses, teller windows, and branch offices, for example, are usually imposed even when a business is planning a major expansion or merger. However, to maximize their profitability, linear programming may be used to determine optimal location, size, number, etc. Likewise, the IBM Job Shop Simulator may be used to determine the effect of changes in location, grouping and utilization of imposed manufacturing resources such as machine tools and personnel.

The same situation exists for raw, in-process, and finished stock inventories. Inventories, per se, will usually be imposed, but their level (as the result of using different reordering rules) can be established by using an IBM Inventory Management Simulation program.

Personnel requirements are confined to skill and job descriptions. The number of individuals employed by a business probably will not change (with the exception of normal hiring to fill vacancies and newly created positions), but the types of positions and their work content may be altered considerably when the new system is installed. Therefore, personnel requirements carrying over to the new system are expressed in terms of what is presently known about position descriptions and costs.

Information resources (files) are described by name: the present name for those that already exist, a name that indicates content for those that do not. Some files are imposed, others are developed by reclassifying logically required information (presently considered as input) as a file.

As a general rule, resources are left relatively open in an SRS (except for those that are imposed), to permit greater freedom of design in Phase III.

Required resources for Provide Demand at Butodale were composed mainly of source files and personnel connected with the performance of the activity (job title only):

RESOURCES
Quotation Specialists - Engnrs.
Management - Typists - Clerks
Marketing Specialists
Calculating Facility
Cost File - Assignment Sheets
Price Catalog
Rate File
Installed Systems File
Contract Register
Customer Index
Project Index

Summary

The Activity Requirements Model for Provide Demand at Butodale is shown in Figure 8. Note that this activity did not exist as an entity except in the minds of the study team. The outputs, for example, were presently produced by many different departments. Quotations, acknowledgments and letters of transmittal were processed by the sales administration and engineering sales departments; bids by engineering sales and product engineering; prints and drawings by engineering services; firm orders by the sales administration and manufacturing administration departments. Operations were scattered throughout an equally wide variety of organizations.

The point here is that identification of required inputs, outputs, operations and resources is not just a simple, straightforward review of the existing system, organization or activity structure to shake out extraneous tasks and reports. It requires a careful analysis of logical necessities that are usually scattered through the business, and creative definition of the systems requirements that are necessary to meet activity goals.

Valid requirements specification takes more than one pass through an activity. Subsequent iterations can be made "in reverse" to check requirements accuracy, starting with inputs and proceeding through operations before outputs or resources are established. At the Commercial National Bank of Syracuse, the study team worked from inputs to operations to outputs for the Demand Deposit activity, since inputs arrived directly from the outside environment (customers). The goal statement and definition of activity scope and boundaries again served as the starting point for analysis. Inputs were specified as they were imposed (utility bill payments), and as they were logically required by the goal statement (deposits from customers). Operations were determined as they were necessary to process each of the inputs, and outputs were identified from the operations. During this analysis, the value of checking out requirements by reversing the analysis was graphically demonstrated. The operation "calculate service charges" was omitted on the first pass, because there was no direct indication that such an operation was logically required from the input statement. However, in working back from outputs, this operation was recognized from the general ledger entries on depositor statements.

QUANTITATIVE REQUIREMENTS

After the Descriptive model has been completed, rate, frequency and cost data are developed for inputs, outputs, operations and resources. Although

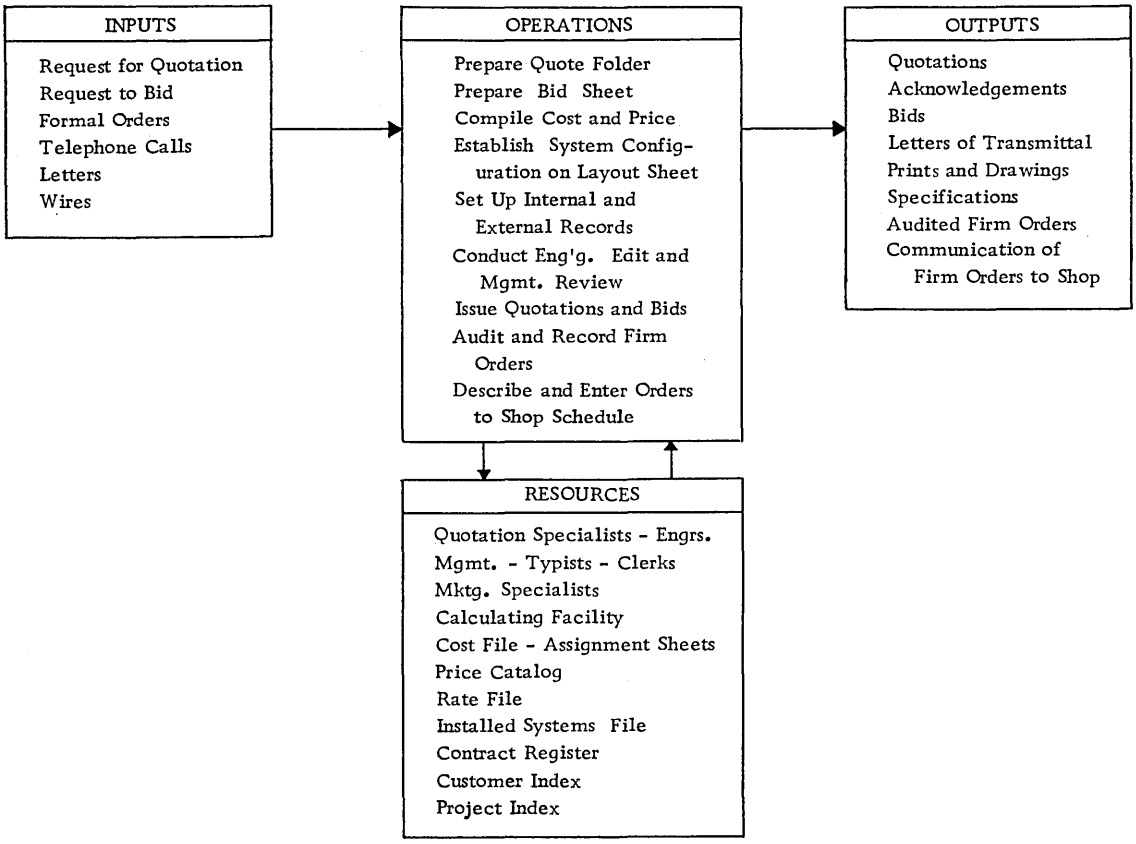

Figure 8.

the subject is treated independently here, in an actual study much of this task can be performed simultaneously with the building of the rough Activity Requirements Model.

Special documentation forms (included in the Phase II report) are used to show certain details for each input and output within an activity. A more detailed explanation of these and other SOP documentation forms appears in the IBM Reference Manual "SOP Documentation Techniques" (C20-8075).

Inputs and Outputs

Inputs and outputs are analyzed for peak and average volumes and rates, cyclic and periodic properties, trends and patterns—to the degree of detail that is significant. In classifying requirements, aggregation (putting like items together) and segregation (differentiating unlike items) are useful. If, for example, customer orders for specials, standards and spare parts are processed under entirely separate controls and have different cycles, then each parts category is treated individually.

Much Phase I data on peak and average volume can be used here, as long as it is expanded to reflect future requirements. Sales forecasts, operating budgets for advanced time periods, and management plans, secured earlier in Phase II goal analysis, are sources for this information. If forecasting data is not available, estimates of potential growth can be made from industry forecasts, or from present averages extended into the future. Sampling techniques are used whenever possible in trend projection to cut down the volume of data.

Figure 9 illustrates an Input Output Sheet as it has been filled out for the Provide Demand activity in Butodale Electronics. Pertinent information on inputs is located at the top, data on outputs below. The Input Output Sheet is a summary, not a detailed descriptive form; it shows pertinent characteristics of messages that must be accepted or produced by the system designed for the activity. Amplification of data, when useful, is placed in the Appendix. If, for example, format or content are fixed (imposed), a Message Sheet (MO8-4604) can be included, with a sample of the message, as Appendix support material. Summary data on traffic peaks, appearing in the Notes column of Figure 9, may be referenced to Appendix displays of traffic distributions and variations, if significant.

IBM — **Input Output Sheet**

NO.	NAME	RATE	MEDIA	SOURCE DESTINATION	NO OF FIELDS	NO OF CHAR	FORM	LOC	NOTES	Avg.	Peak
I 1	Request for		Wires Telephone								
	Quotation	50/W	Letters	Customer					Std. Systems	22	30
	(R-2000)								207-217	20	27
									Other	8	13
I 2	Request for								Peak Volume 12/W		
	Bid (R-2010)	10/W	Letters	Customer					10 Weeks a Year		
I 3	Customer	17/W	8½ X 11	Customer					Peak Volume 20/W		
	Orders (R-2020)		4 Part						6 Weeks a Year		
R 1	Quotations*	15/W	8½ X 11	Customer				X	Peak 29/W		
	(R-3000)		4 Part						10 Weeks a Year		
R 2	Acknowledgements	17/W		Customer			X	X	No Peaks		
	(R-3050)										
R 3	New Order	17/W		SHOP				X	Communicates Data		
	Schedule								on Firm Orders		
	(F-4080)										
R 4	Customer Order	17/W		SHOP OTHERS				X	Details of Firm		
	(R-2020)								Order as entered		
									to Contract register		

*Includes Letters, Drawings, Specifications, Layouts as necessary to supplement quotation.

DATE | R. L. Casey (ANALYST) | Demand (ACTIVITY) | Butodale (STUDY) | 1 (PAGE)

Figure 9.

IBM — **Required Operations Sheet**

NO.	OPERATION NAME	INPUT FACTORS	OUTPUT FACTORS	FREQUENCY OF EXECUTION	PROCESS SUMMARY
01	Classify incoming requests –	5	10	60/W	7 Look up
	All requests for bid or quotation are separated				3 Edit
	initially into 3 Groups: standard end items,				6 Relational
	standard systems and engineered products.				
02	Prepare Quote Folder (F.4050.1)	7	12	15/D	
	A folder is prepared for each request – to hold				2 Look up
	customer papers and documents generated within				4 Edit
	Butodale to fill the order.				3 Relational
03	Prepare Bid Sheet (R-3000)	15	20	45/W	10 Arithmetic
	A bid sheet is prepared for each request from price,				50 Logical
	cost, and installed systems files. Depending on the				30 Look Up
	type of request, each is processed somewhat				
	differently. A GPAC has approximately 13				
	major interconnected components available in				
	different groupings. Input-Output devices are				
	optional in 6 models. Although console and group				
	descriptions are standard, they may be modified				
	at customer request.				
04	Determine System Layout	27	38	12/W	
	A GPAC may have any one of several consoles,				60 Arithmetic
	and any one of several rack configurations.				32 Logical
					5 Edit
					15 Look Up

DATE | R. L. Casey (ANALYST) | Demand (ACTIVITY) | Butodale (STUDY) | 1 (PAGE)

Figure 10.

IBM Resource Sheet

NO.	NAME AND DESCRIPTION	AMOUNT	COST	NOTES
P1	Manager	1	$12,000/YR	
P2	Secretary	1	4,200/YR	MAIN OFFICE
P3	Underwriters	5	42,000/YR	
P4	Typists	2	7,600/YR	
P5	Agents	2	commission	SALES OFFICE
P6	Receptionists & Typists	27	92,600/YR	
P7	Doctor (uses his own office)	1	10,000/YR	
E1	Typewriters - Electric, 115 Volt	30	600/MO	
E2	Teletype - 10 LPM	(1)	175/MO	(1) 5 UNITS
				1 Sending
				4 Receiving
				Each is 3'X 3'
F1	Main Office - 161 Front St.	44'x 37'	200/MO	
F2	Sales Offices -	4 Offices;	880/MO	
	73 Clover St.	each is 24'x 58'		
	7476 Jones Ave.			
	35 Myrtle St.			
	1 River St.			
V1	Sales Records, monthly -	1200	15/YR	Monthly sales report
	Last 10 years			includes 8 fields
				repeated 120 times
				Plus totals.
V2	Stock Certificates	850	.25/UNIT	Each certificate is
				registered & insured.

DATE: | T. B. Flanagan (ANALYST) | Life Policy (ACTIVITY) | Life Insurance (STUDY) | 1 (PAGE)

BOB-4810-0

Figure 11.

IBM Resource Sheet

NO.	NAME AND DESCRIPTION	AMOUNT	COST	NOTES
V1	Inventory			
	Shop Stores	3120	1,450,000	All levels
	Finished Goods	850	1,210,000	caculated at
	Work in Process	350	3,370,000	Sales Volume of
	Indirect	5000	275,000	$22,700,000
				using decision
V2	Decision Rules			rules tested
				in simulation
	1. Forecast Review - 2 mos.			
	2. Order Points for			
	Shop Stores:			
	A. Items - 2 weeks			65% of total
	B. Items - 7 weeks			11% of total
	C. Items - 26 weeks			24% of total
	3. Service Level - 95%			
			*	
V3	Vendor Name File	850		
V4	Purchase Order File			13,500/year
V5	Project File (F-4070)	225		
V6	Back Order (Shortage) File	150		
V7	Eng'g. Release Notice File	550		
V8	Work Order File	8500		use 300/wk.
	(Order Records)			
V9	Requisition File			variable
V10	Operation Planning File	3750		
V11	Eng'g. Print File	4000		
V12	Receiving File			34,000/year
	*costs not identifiable			

DATE: | R. L. Casey (ANALYST) | Materials (ACTIVITY) | Butedale (STUDY) | 1 (PAGE)

BOB-4810-0

Figure 12.

Operations

In Phase I, operations were described as they are presently performed; in Phase II, operations are characterized by indicating what kind and number of input factors they must accept, what kind and number of output factors they must produce, and how often they must be performed. In most cases this numerical data is estimated from the same statistical projections used to establish volume and frequency of inputs and outputs.

An operation is further characterized by the nature and estimated number of the processes involved in its execution. This data is particularly useful in systems design. For example:

- How many arithmetic and logical processes must be performed?
- How many relations must be examined (comparison of one factor with another)?
- How many times will a resource be consulted for data (retrieval or lookup)?
- How many edit or audit functions will be necessary in the operation?

A Required Operations Sheet (MO8-4609) will be included in the SRS report, and it can be applied as a working paper in analysis. When completed, it contains a narrative description of what each required operation must do, along with the number of input and output data fields used in the operation, the number of times the operation will be executed within a selected time span, and a summary of the types of processes making up the operation. Flow diagrams and decision tables used for special analyses are placed in the Appendix. One Required Operations Sheet for Butodale's Provide Demand activity is shown in Figure 10.

Resources

Present and future physical and informational resources are described on a Resource Sheet (MO8-4610). Personnel, identified by occupational skill, are grouped wherever practical. Costs are projected from payroll registers and from the Phase I Present Business Description. Equipment is identified by name and type. Costs are projected on a consistent base. Wherever practical, equipments are grouped by function to compress the list. Facilities are listed by name, location, size and utility, with emphasis on those that may be affected by systems design. Figure 11 is an example of a Resource Sheet prepared for a small branch office of a bank.

File resources are identified, established and costed from the results of the required inputs analysis. File Sheets (MO8-4603) are used to describe the characteristics of each information file. Special attention should be placed on the characteristics of a file that may have been changed in requirements analysis:

- Size of the file in characters
- Retention rules
- Age of data
- Peak and average message volume
- Access requirements

Categories like "sequenced by", "labels", "storage medium" and "location" should be omitted unless imposed, since these characteristics will be developed in new systems design. The Resource Sheet shows only a descriptive file name, application and cost (if one can be compiled); the File Sheet provides the definitive information. For studies involving communications facilities, the network diagram is modified to show planned addition or deletion of trunk lines, terminals, etc., and the need for duplexing equipment, as these requirements are imposed or logically needed.

Finances become an important consideration in resource requirements analysis when a major change or expansion in an activity is contemplated (perhaps necessitating large outlays in capital equipment). Many companies have standard policies connected with the outlay of funds for new equipment purchases; these policies can be described in the Appendix and referenced by a note on the Resource Sheet.

An area often requiring special attention is physical inventory for retail and manufacturing concerns. Inventory may be described either as a dollar inventory value for one or more forecasted sales and production levels, or as a series of decision rules developed from simulation experiments. When the latter is the case, descriptions of the rules are included within Operations on a Required Operations Sheet, and are summarized with anticipated results on a Resource Sheet. Inventory rules include:

- Frequency of forecast
- Frequency of stock level review
- Required service level (safety stock requirements)
- Application of special inventory practices such as ABC item control, use of EOQ, etc.
- Type of order system (fixed order or fixed interval)

In the Butodale study, inventory was simulated (using a series of decision rules) at the forecasted sales level of $22,700,000 and results documented on a Resource Sheet (Figure 12). Inventory level also may be estimated from an analysis of inventories in relation to sales, if inventories have been adequately controlled in the past, by plotting

turnover ratio (sales over a time period, divided by average inventory over that time period) at different levels of demand (this relationship is shown in Figure 13 as it was compiled from historical data), then fitting a line or curve to the data. This provides a base upon which to estimate turnover (and therefore inventory) at various demand levels.

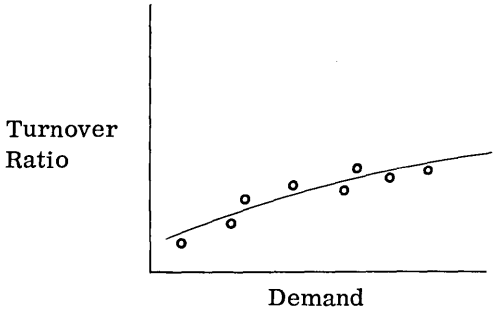

Figure 13.

Other methods of estimating size and content of a required inventory include:

- Computing inventory level at various levels of sales by summarizing average inventory level of all parts stocked.
- Comparing stock/sales ratios with those of others in the industry from analysis of balance sheets or published industry statistics.
- Classifying into raw, in-process, and finished stock by value, then computing average level.
- Analyzing high yearly value parts, models, or services in depth (taking advantage of "ABC" principles).

CONCLUSION

At this point, the study team has produced system input, operation, output and resource requirements for each of the activities within the scope of the study. The results may adequately state what the system is required to do, particularly in the case of improvement or mechanization studies. More likely there is a need to close down on certain of these requirements and sharpen them by one or more passes back through each activity, this time applying a slightly different approach (that is, if outputs were determined from inputs, now work in reverse) in an attempt to refine the requirements, and resolve any apparent conflicts or problems which arise when the activity is checked out as an integrated whole.

In certain advanced studies it may be desirable to call upon other sophisticated techniques of management science—especially if the study team is involved in creating a unique new design, or where relatively few constraints have been placed on their actions. For example, the IBM General Purpose Systems Simulator may be used to develop an understanding of true requirements through the simulation of the structure and action of complex, real-life situations. Vital information about maximum and average size of queues, response time and percent of use of selected resources may be obtained from each simulation run. The model must accurately reflect real conditions, and its output requires expert interpretation. There may be, however, no other way to secure this information at a reasonable cost.

In Phase III, it will be necessary to determine how well alternative systems configurations will perform; the measurement system for making this evaluation is devised during Phase II. Actually, the process of measurement development goes on continuously throughout the Phase II study. Measurement factors are the standards by which requirements are judged. When peak and average volumes, frequency of execution, rate, elapsed time, and other numerical data are being compiled for inclusion in the SRS working papers, value ranges are determined and recorded on a scale. Thus, if "record update time" has been identified as a significant measurement factor, and records are presently updated in an average of six and a maximum of eight days, a measurement scale can be plotted from zero to ten days.

The identification of measurement factors and the development of appropriate measurement scales are usually performed simultaneously with the formulation of input, output, operations and resource requirements.

MEASUREMENT

Some measures are direct and quantitative, and can be shown on numerical scales: the dollar cost of a system, the number of days from receipt of a customer order to product shipment, the average number of errors in preparing invoices, etc. Measures can also be indirect, or derived from combinations of factors: budget variance, return on investment, productive efficiency, inventory turnover, etc. A third group of measures consists of those that are qualitative or subjective: service effectiveness, customer goodwill, or product appearance. This latter class is difficult to measure; performance is usually expressed in abstract terms like "outstanding", "excellent", "fair", etc.

Study teams have found that a number of representative measures are needed for a balanced appraisal of systems performance. To achieve this coverage, eight to ten major measurement categories are selected initially (time, capacity, volume, etc.), then more precise factors are defined for each activity. "Time" is a major measurement category in an airlines study; it can be refined to such precise factors as "customer inquiry response time", "record update time", etc. A total of six to twelve of these specific factors is generally sufficient for comprehensive measurement of a single activity. The factors may be quite different from one activity to another.

Some major measurement categories and possible factors are:

1. Cost - operating, maintenance, unit.
2. Time - response (input, operations), access, elapsed, cycle, process, turnover.
3. Accuracy - frequency and number of errors, significance of errors.
4. Reliability - stability, durability, life.
5. Security - legal, safety, secrecy.
6. Quality - appearance, tolerance.
7. Flexibility - variability, sensitivity.
8. Capacity - average load, low load, peak load.
9. Efficiency - performance ratios.
10. Acceptance - customer, employee, managerial, shareowner.

This list shows many of the criteria by which a system's performance can be measured. In a study for a brokerage house, measurement criteria were first identified and described for the entire business as follows:

COLLINS, McCABE, AND COMPANY

System Selection Criteria

1. Execution Response Time - Customer service must be as good as or better than the present system.
2. Error Rate - Critical, since money errors are absorbed by the firm. Errors also affect customer and industry relations and must be the same as or lower than the present system.
3. Reliability - Affects the entire system, but especially input transactions and order execution. Includes ability to install new system with no service interruptions, and to conclude posting without fail before business operations of the next day.
4. Capacity - Management requires a system to operate at double present daily volume, while at the same time working efficiently under variable loads.
5. Cost - Comparable to present system. Value can be determined on a cost/customer service base.
6. Security - Certain procedures must meet industry regulations, audit practices, and account security.
7. Update Response Time - An important factor, but somewhat dependent on the type of account inquiries.
8. Inquiry Response Time - Again, this is a function of the class of inquiry, but it is important since inquiries result in trades.

Each of the descriptions gave an indication of values and importance to the business, but further work was required to segregate them into measurements for each activity and translate the measures into precise rating scales.

The measurement factors developed for Custodian Life show a different pattern:

CUSTODIAN LIFE INSURANCE COMPANY

New Business Activity

1. Volume Increase Capability - The new system must be capable of handling double the present volume, without overtime.
2. Accuracy - Defined as the degree of conformity and correctness in all documents and records. Measured by the total number of detected errors requiring reprocessing.
3. Processing Time - The number of days it takes to process a life insurance application from its receipt at home office to issuance of policy, by policy type.
4. Appearance - Prepared documents and reports will be judged for legibility, neatness and arrangement.
5. Personnel Cost - Annual salaries and employee benefits allocated to the operation of the activity.
6. Equipment and Supply Cost - Includes the costs of machine purchases and rentals, maintenance and parts charges, magnetic tapes and cards, and service fees.
7. Operational Efficiency and Control.- The degree to which operational efficiency is controlled by management. (Is the status of an application always known? Are schedules maintained on time? Can the system handle anticipated peaks? etc.)
8. Conformity to Practices - The extent to which company policies and practices are compiled with, and the degree to which the system provides statistical data for management information and action.

Some factors are spelled out only in general terms; others state exactly what performance level is required. A number of other factors, such as personnel training costs and flexibility to change, were considered earlier but were estimated because of lack of significance and difficulty of measurement.

RATING SCALES

A rating scale shows ranges of values for each measurement factor. Three sets of values are shown on the scale:

- Present operating point
- Acceptable performance range
- Desirable performance range

Operating points for the present system are secured from the Phase I report and from data gathered during Phase II. For example, in the brokerage house, present operating points for incoming customer orders were designated as:

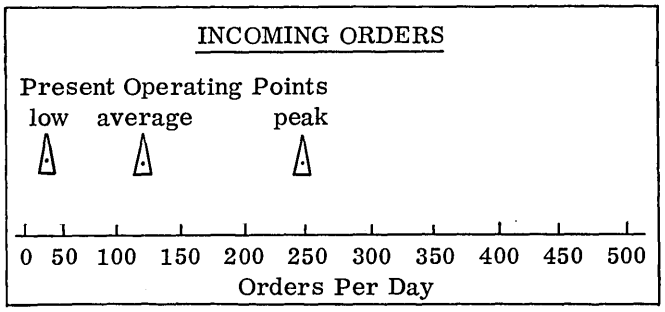

Figure 14.

An acceptable range covers the points at which activity performance satisfies future conditions. A desirable range is a statement of performance that will be more difficult to achieve through design, yet represents a more satisfactory level of attainment.

With values defined in this fashion, systems designers are able to propose a range of solutions in Phase III, as long as the cost vs. response speed trade-off, along with other considerations, can be resolved.

Sometimes targets can be approached from a different viewpoint. This is illustrated by the following measurement scale for an invoicing operation.

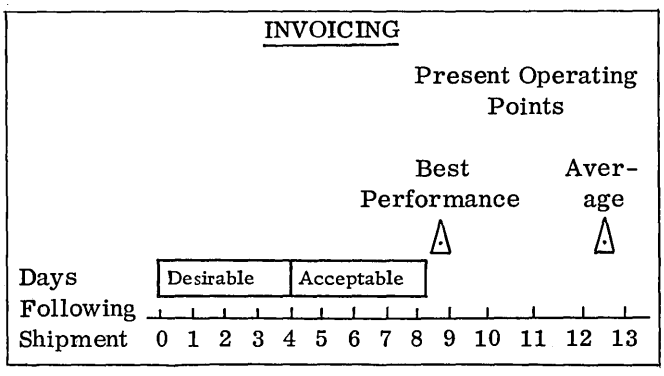

Figure 15.

Present performance is not acceptable, because much time (9 days, at least) elapses until shipping papers are forwarded to the billing section. However, what happens if a system can be designed to include the invoice with the shipment (without holding up the shipment)? This will not be resolved until systems design takes place, but at least the performance targets are extended to accommodate such a possibility.

There are other methods of displaying ranges of values for measurement factors. For example, values for elapsed time measurements can be shown in the form of cumulative curves:

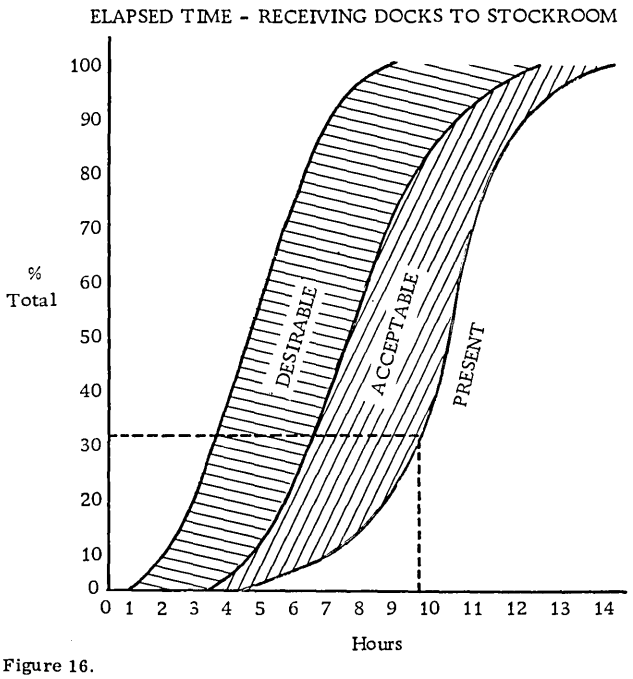

Figure 16.

The point on the present system curve defined by the dotted lines reads: "Thirty percent of the total number of items processed are handled in under ten hours."

Often, rating scales have significantly different ranges of values for quite similar measurement factors. In these cases, a separate scale is constructed for each one. Unwarranted complexity is introduced by attempting to display too many factors simultaneously, as in the linear graph in Figure 17.

The physical appearance of a printed document (invoice, policy, etc.) is an example of a qualitative factor. It can be measured on the same type of scale as those that are quantitative (Figure 18). Each point on a qualitative rating scale is supported by a narrative definition:

> "Good" means that the invoice is uniform in printing darkness, has no corrections, strikeovers or smudges, and can be read without difficulty. Line item entries should be in ascending part number sequence for easy reference, and the totals should be quickly identifiable.

If a study team can (in Phase III) produce a system operating within the high range of desirable performance in most factors, it can be assured design is at a near-optimum condition. If, however, trade-offs and other special considerations restrain performance of the design to acceptable ranges in a number of categories, the study team can be confident that system performance is still within satisfactory bounds—since acceptable performance levels were reviewed and approved by management.

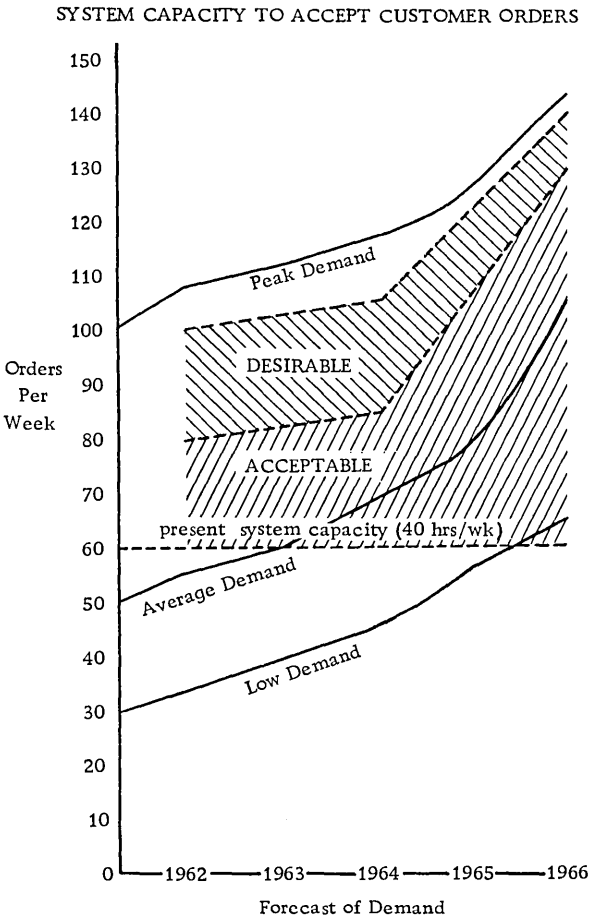

Figure 17.

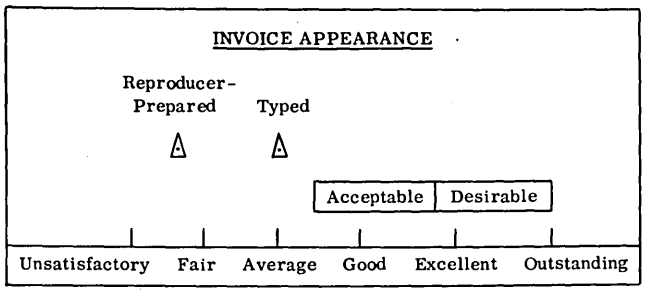

Figure 18.

SETTING VALUES FOR RATING SCALES

The study team is responsible for selecting measurement factors and constructing a rating scale for each one, but a final determination on acceptable and desirable values and ranges of value for each factor is accomplished jointly with management. Before measurement data is reviewed with management, requirements analysis must be fairly well along, and a substantial amount of information developed to support each rating scale. When the IBM Inventory Management Simulator is used, for example, the results of a number of simulations may be gathered to show how several management decision rules influenced inventory investment for various sales forecasts (in this case, of course, management would be interviewed before the simulation to determine the inventory policies to be tested).

Measurement Interviews

In the measurement review with management, a systems planner is not merely seeking information; he is now trying to discern how a manager feels about his business, what factors are important to him, and what he expects the business will gain from new system design. During these reviews, it is almost as important to develop an insight into feelings, opinions, biases, and the pressures on an individual as it is to form an objective appraisal on a subject. A manager may have strong opinions on certain topics; if they are controversial, or pertain to business policies which are not widely discussed, then it is important to find out how these beliefs affect system requirements.

To diagnose the real reasons behind management decisions and opinions, a systems planner not only has to be well prepared with factual data, but he must be adept at leading discussion on sensitive subjects and developing insight into the meaning behind statements made by the managers. What factors have a bearing on the subject: labor contracts? employee attitudes? satisfaction of a large and demanding customer? poor industry outlook? attitudes among consumers and suppliers? trade reciprocity? Many times it will be difficult to discover and interpret some of the deep-rooted problems which influence a management position; if they are not expressed openly, the study team has difficulty in deciding just what is desirable and acceptable in a business.

While these conditions have to be faced in most studies, the systems planner emphasizes the need for evaluation based on objective data first, then adjusts these decisions to accommodate subjective opinions and judgments when they must be recognized. This is an approach which affirms that there must initially be an order, a logic, and a magnitude to events; when this is defined, the results can be qualified by the experience, judgment and even intuition of management.

Documentation

After the measurement factors have been selected, each one is documented for the SRS report on a rating scale similar to those shown in this chapter. Definitions and explanations of the factors and their application are included in the SRS Appendix.

SUMMARY

Measurement of acceptable and desirable performance levels is rarely an absolute process. The study team must be aware of the need to measure early in Phase II, and be constantly seeking a series of factors which are particularly appropriate for the study and which adequately measure management objectives. Scales and values on the scales are evolved simultaneously with requirements analysis, but become usable measures only after they have been thoroughly reviewed with and approved by management. Once they have been worked into a cohesive framework, they form the basis for judging the validity of various systems designs.

CHAPTER 5 - COMPILING THE SRS REPORT

Except for preparing statements on policy and cost considerations covering all activities as a whole, requirements analysis is now complete. The remaining task is to draw data into a cohesive Systems Requirements Specification.

As has been mentioned, there is no established rule on how many iterations are necessary to develop a satisfactory statement of system requirements. One or two may be sufficient for mechanization or improvement studies; as variability increases and constraints are fewer, analysis is more complex and more iterations are required. Even in creative studies, however, a number of activities may be fairly straightforward and consist of but a single chain of decision logic. For example, in automated manufacturing planning, analysts must develop the logic chain between parts characteristics and operator or machine instructions. Complexity arises from the individual analysis of the many thousands of parts there may be in a product line.

To review, a Systems Requirements Specification documents Phase II results, activity by activity, under three major headings: General, Operations, and Measurement. An SRS Summary ties individual activity packets together.

GENERAL CONSIDERATIONS

A common procedure for preparing an SRS is to start with activity packets, then compile the Summary section.

A number of important considerations that materialized during Phase II, however, may not fall within any activity. These relate usually to policy statements and management decisions about implementation of the system, and are shown in a section of the Summary entitled "General Considerations". Included are such topics as rental or puchase of data processing facilities, financial limitations on overall system implementation and operating costs, location of equipment, and how the changeover is to be performed.

The statement of general considerations, noted below, is taken from the Custodian Life report:

> Cost
>
> The present total cost for each activity is a tentative upper cost limit for any new design applying to that activity. This includes personnel, equipment and facilities used to perform the work normally associated with data processing.
>
> Policies
>
> The standards used by the underwriters in determining the acceptability of an applicant are set up by the management of the company. These standards are the guideposts in the selection of risks, and must be adhered to in the underwriting decision.
>
> Custodian Life both leases and purchases data processing equipment; the plan most advantageous at the time is selected.
>
> Location
>
> Data processing is performed at the home office in Rockford, Ill. Any new system would utilize the facilities and resources at this location, rather than possible facilities at the general agencies.
>
> Conversion and Implementation
>
> Any proposed system will be run in parallel, and results compared in detail with the existing system output. The period of parallel operation will last only so long as needed to prove out the results of the new system but in no case will be less than one accounting period.
>
> It is important that any new system provide the status of an application at all times as it goes through the new-business processing.

The study team can show a tentative Phase III schedule for management's approval. The estimated start, elapsed time, and completion dates can be displayed on a Gantt chart similar to that shown in Figure 19.

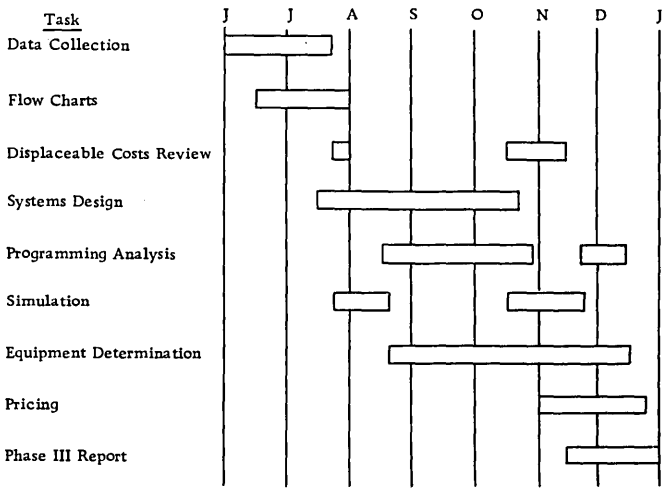

Figure 19.

ACTIVITY PACKET - GENERAL SECTION

The General section of each activity packet describes business goals and objectives as they relate to that activity, its scope and boundaries, and any applicable general considerations.

Goals and Objectives

Phase I business goal statements were refined and documented early in Phase II, in order to direct the requirements analysis properly. A full narrative goal definition for the entire business is included in the Summary section of the SRS; individual goals appropriate to single activities are pulled out and placed in the General section of each activity packet.

Activity Scope and Boundary

Activity definitions were resolved as the goal statement was prepared. Minor revisions may have been made to scope and boundary statements during Phase II analysis; therefore, the original statements are revised and entered in the General section in the form described in Chapter 2.

General Considerations

Most of the general considerations have impact on the entire business and therefore are contained in the SRS Summary section as described earlier. General considerations applying only to one activity are placed in the General section for that activity.

ACTIVITY PACKET - OPERATIONS SECTION

The Operations section specifies what each activity is required to do: what inputs must be accepted, what operations must be performed, what outputs must be produced, and what resources must be employed.

Activity Requirements Model

All four elements are described briefly in an Activity Requirements Model similar to that shown in Chapter 3. This model, used throughout Phase II as a working paper to portray activity elements, was subject to revision as changes occurred during analysis. Now these changes are introduced and the model produced in final form to show both imposed and logically determined requirements.

Required Inputs, Outputs, Operations and Resources

The Input Output Sheet, used earlier as a working paper, is now revised to summarize important features of required inputs and outputs emerging from requirements analysis.

The Required Operations Sheet describes transformations which convert inputs to outputs. In operations documentation, emphasis is placed on identifying the decision logic rather than describing the operation with a procedure statement. Any internal relationships, time dependencies, and required sequencing are noted in the description. Decision logic shown on decision tables and flow charts is consigned to the SRS Appendix. Special studies conducted to test operational variability, such as simulation runs, may be described there.

Resource Sheets show personnel, equipment, facilities, information, and physical inventories required by the activity. Resources may remain relatively unchanged if management imposes many constraints; under these circumstances the data is quite brief. More frequently, there will be important changes in resource requirements.

When positions and jobs of personnel are altered in content, the new work elements are outlined to show how they differ from previous job descriptions. Where the job title suggests the work content (computer programmer, transactions auditor, etc.), this is a sufficient explanation. Position guides for new and revised jobs are prepared in Phase III.

A map of an existing communications network might be placed in the SRS Appendix after it is revised to show network requirements resulting from Phase II traffic analysis.

ACTIVITY PACKET - MEASUREMENT SECTION

Measurement factors and scales for evaluating the effectiveness of alternative Phase III systems designs are shown in each activity packet's Measurement section. Factors are displayed graphically, similar to the examples of Chapter 4. Definitions of each factor are prepared and placed in the Appendix.

APPENDIX

The content, layout and forms of the SRS are aimed at stating systems requirements clearly, and briefly. Any analysis which cannot be readily condensed is consigned to the Appendix. The Appendix includes items such as simulation details,

extensive equipment lists, Message and File Sheets (where they are needed to describe imposed inputs, outputs and resources), definitions of measurement factors, and the like.

SUMMARY SECTION OF SRS

The Summary section integrates the activity packets and appraises the impact of the study on the entire business.

General considerations affecting more than one activity (for example, management policy, new systems cost and location) appear here. The statement of the overall goals for the business is located in this section.

Although activities are relatively independent in structure and content, outputs from some activities serve as inputs to others. There may be points of overlap, particularly in the use of common facilities. Interactivity relationship is described in this section.

A preface introduces the objectives and content of the report, and the sequence in which information is presented. The following paragraphs are excerpts from the Commercial National Bank of Syracuse SRS Introduction:

> This report, the Systems Requirements Specification, describes the present and future requirements for a business system at the Commercial National Bank of Syracuse, and establishes the measurements by which the performance of the new system is to be evaluated.
>
> Several changes have taken place since the Present Business Description report was published. The goal statement has been expanded to reflect the anticipated growth of this institution, and introduction of many new customer services. The activities (activities are sometimes referred to as subsystems) have been clarified both in definition and scope. Management also decided to include only those activities which have good growth potential and high transaction volumes in the new system. Consequently, five activities were selected and these five constitute the major sections of the requirements report.

The introduction continues by pointing out that management wanted the most advanced system design possible, and therefore had placed very few constraints on the study team. The team leader devoted several paragraphs to an explanation of why requirements analysis is critical to systems design, and what the difference was between an existing system and a required system. The main SRS report was then introduced.

REPORT STRUCTURE AND AUDIT

An SRS is organized as follows:

SYSTEMS REQUIREMENTS SPECIFICATION

- Summary Section
  - Introduction
  - Business Goals and Objectives
  - General Considerations
  - Activity Definitions and Interrelationships
- Activity #1
  - General Section
    - Goal and Objectives
    - Scope and Boundaries
    - General Considerations
  - Operations Section
    - Activity Requirements Model
    - Input Output Sheets
    - Required Operations Sheets
    - Resource Sheets
  - Measurement Section
    - Factors and Rating Scales
- Activity #2
  - etc.
- Appendix

Figure 20.

The completed SRS is audited in the same general manner as the Present Business Description (discussed in "Study Organization Plan: The Method, Phase I").

LOOKING AHEAD

After the report has been published and presented to management for review, the study team begins preparations for the creation of a new system. The methodology followed in designing a new system is described in the next manual, "Study Organization Plan: The Method, Phase III".

IBM SOP The Method Phase II

Printed in U.S.A. SF20-8137-0

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Data Processing Division
1133 Westchester Avenue, White Plains, New York 10604
(U.S.A. only)

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
(International)