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MANAGEMENT SYSTEMS RESEARCH STUDY (NS6-2036)

SEMI-ANNUAL STATUS REPORT

February-August 1975

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Introduction

The status report which follows describes the accomplishments and activities supported by NASA-Ames Grant 2036 (principal investigator A. V. Bruno) during the period February-August 1975. The members of the project team include M. K. Bohman, J. L. Hall, J. K. Leidecker, Z. L. Vancura, N. F. Pohl, and S. W. Blandin.

Purpose

The research activities described on the following pages have as a common purpose, the investigation of procurement activities at the NASA-Ames Research Center. The procurement process because of its traditional complexity encompasses a rather broad set of functional activities within NASA-Ames. The level of complexity and its far-reaching implications necessitated the partitioning of the research effort into the following activities:

Section 1. Simulation of the Procurement Cycle

Section 2. Construction of a Performance Evaluation Model

Section 3. Examination of Employee Development Procedures and Review of Evaluation Criteria for Divisional and Individual Performance Evaluation.

Section 4. Determination of the Influences and Apparent Impact of Contract Type and Structure

Section 5. Development of a Management Control System for Planning and Controlling Manpower Requirements

Each of these research tracks will now be discussed in greater detail.

Note: All tables, exhibits, and figures referenced below have not been included in the body of this interim report. Copies of the omitted materials will be sent upon request. In addition, these materials will be included in the final report for this project.

Section 1

Simulation of the Procurement Cycle

Section 1

Simulation of the Procurement Cycle

I. Overview

This project is concerned with developing a Monte Carlo simulation of the
procurement cycle at ARC. At this point the flow of PR's has been simu-
lated up to log-in, volume/time indices have been developed to assess PR
inflow fluctuation, day-by-day PR arrivals have been simulated, and the
progress of PR's of a certain category are being monitored during the pro-
curement cycle. In the future, efforts will be made to improve and
consolidate the contents of the special R&D flow simulation, as well as to
develop similar models for the other branches of the Procurement Division.
It is expected that the output generated by the finalized versions of these
models will be helpful in evaluating the overall performances of the indi-
vidual branches within Procurement. This effort should also help locate
the existing strengths and weaknesses (processing inefficiencies or under-
staffed conditions) in Procurement operations. When alternative procurement
policies are under consideration this simulation could be used to test and
compare them to help determine the optimal choice.

II. Activities Report

A. Accomplishments to date

(1) The processing and routing of purchase requests by the
Procurement Control Unit has been simulated up to the
point when the requests are logged in by Procurement.
(Ref NASA 1A below)

(2) The sorting of purchase requests reaching Procurement
and their identification with individual categories has
been simulated on the basis of a dual branch system.
(Ref NASA 1B below)

(3) Volume/time indices have been developed to measure the
observed fluctuations in the flow of incoming purchase
requests during a year.
(Ref NASA 1C below)

(4) A simulation model has been developed to generate the
number of purchase requests entering Procurement, day
by day.
(Ref NASA 2 below)

(5) For the category of commercial orders in excess of $10,000
that have to be formally advertised, a simulation model
has been developed to monitor their progress during the
procurement cycle.
(Ref NASA 3 below)

NASA 1A

The basis for NASA 1A simulation is a flow chart shown in
EXHIBIT 1-1. This chart schematically describes what happens
to a purchase request submitted to the Procurement Control
Unit by some originating department. The attributes of each
purchase request are being checked on a number of points. The
purchase request is then either returned to the originator, if
deficiencies have been detected, or sent to another department,
if applicable, or forwarded to the Procurement Division for
further processing.

A number of control activities appear on the flow chart. For
the purpose of designing a computer simulation model, I have
separated these activities by nodes that are described in EXHIBIT 1-2.
Each individual activity is then identified in terms of its begin-
ning and ending nodes as shown in EXHIBIT 1-3.

The flow chart in EXHIBIT 1-1 also contains probabilistic estimates.
For example, the probability that a randomly selected purchase
request is for capital equipment has been judged to be 0.05; the
probability that funds are not available for a purchase is shown
as 0.02; etc. These probabilities are associated with the node
designations from EXHIBIT 1-2 and summarized in EXHIBIT 1-4.

The first part of the computer program shown in EXHIBIT 1-5 processes
the purchase requests received by the Procurement Control Unit,
in chronological order, and routes each of them through a sequence
of nodes. Any number of incoming purchase requests may be pro-
cessed. The output describes the path for each individual
purchase request by listing the sequence of node designations
it has reached. A sample output is provided in EXHIBIT 1-6.

NASA 1B

The classification scheme used in the sorting model pertains
to the purchase requests previously examined and passed on by
the Procurement Control Unit to enter Procurement. The basis
for this classification system is a chart shown in EXHIBIT 1-7.
This chart establishes order categories using a dual branching
system. For example, the first fork in the chart separates all
modifications to the existing purchase orders from new procure-
ment; the second fork splits all new procurement, in turn, into
a group of grants and consortia, and another stratum containing
all other purchase orders, etc.

As a result, 20 distinct categories have been established.
Any purchase request entering the system should fall within
one (and only one) category. Each category has been assigned
a number, shown on the right-hand column on the chart, that
extends the node designation system of the previously discussed
routing model. These models may be processed sequentially.

The branching points are denoted on the chart by circled
numbers. At each branching point a pair of probability
values is shown. Those are subjectively estimated, condi-
tional probabilities. For example, nearly 90% of all incoming
purchase requests are judged to be for new procurement; a
little more than 40% of large commercial orders are to be
formally advertised; etc. Past experience has been used, in
part, to aid in assessing the probabilities.

The second part of the program shown in EXHIBIT 1-5 sorts the
purchase requests entering the Procurement Division and
assigns them to one of the 20 existing categories. Any
number of consecutive purchase requests may be processed.
For each incoming purchase request, the output lists the
sequence of branching points through which it has been
sorted and its category number. A sample output is repro-
duced in EXHIBIT 1-8.

NASA 1C

Since it is known that the intensity of order inflow varies not
only from category to category, but also from month to month
within each classification, it is desirable to measure, and
account for, these fluctuations explicitly in a model. For
this purpose, volume/time indices have been developed.

Information in regard to the actual volume of purchase requests
received by Procurement during the period July, 1969, thru
February, 1975, has been retrieved from available NASA files.
These data are shown in EXHIBIT 1-9. No break-down by categories
seems to be available at this time.

In the absence of any marked trend in either direction, and
on the assumption that no significant differences exist in
the relative volume fluctuations among various categories,
the index values for the individual months have been calculated
and applied to all categories alike. The results are summarized
in EXHIBIT 1-10. The remarkable gap occurring between the June
and July index levels is apparently due to the replacement of
the old budget by a new one at the beginning of a fiscal year.

NASA 2

As stated above, this model simulates the volume of purchase
requests entering the Procurement Division. The model design
calls for the resolution of a number of issues:

> Should the volume be simulated daily,
> weekly, or on some other basis?

> How many categories should be included
> in the model?

What are the characteristics of the
random process that generates purchase
requests?

What specific techniques and procedures
should be used to duplicate the output
of this process?

I have decided to carry out the simulation on a daily basis since
probably too much information would be lost by using a longer
period of time. A business day, rather than a calendar day,
has been chosen as the smallest unit for measuring time. Saturdays,
Sundays, and holidays do not affect the normal working of the system,
and are left out of consideration.

Of the total 20 classifications established in NASA 1B, I have
selected 6 most important categories and lumped together the
remaining 14 to form a seventh group. The criteria used in
judging the relative importance of an individual category involve
its historial volume and its estimated annual dollar value. The
seven "new" categories are used in this model. Their description
and identification with the designations used in NASA 1B is pro-
vided in EXHIBIT 1-11. It may be observed that some of the cate-
gories that have been excluded in the current model involve as
few as 5 purchase requests per year.

The character of the random process generating purchase requests
may be considered to be Poisson.* The critical requirement of
independence appears to be reasonably satisfied by the actual
process characteristics: the individual requests are originated
in different departments and submitted as needs arise. If we
substitute a business day for the unit of space, a number of
incoming purchase requests for the number of "successes", and
an expected flow stream for the process intensity, we can use
Poisson probabilities for the purpose of simulation.

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*Generally, the Poisson process produces a number of "successes" in
consecutive units of space in accordance with an explicit probability
rule. The Poisson probability of achieving r "successes" per unit of
space is defined as

$$\frac{e^{-m} m^r}{r!} ,$$

where m is a parameter measuring the intensity of the process per unit
of space. One of the important characteristics of the Poisson process
is that the probability rule remains unchanged throughout the duration
of the process. This carries with it the implication that the number
of successes achieved in any unit of space does not depend on the out-
comes previously recorded.

This feature has been actually incorporated in the model construction in a modified form. Since the expected number of incoming purchase requests is not time invariant and the volume also varies with various categories, a matrix of Poisson parameters, instead of a single one, has been used to design the input structure. The simulating procedure itself uses the usual Monte Carlo technique.

In many studies based on the use of Poisson probabilities, the usual procedure is to approximate the function by some other theoretical distribution that is "faster" or more convenience to work with; if this is done, inaccuracies are often introduced, successively accumulated, and carried over into the simulated results. The computer program prepared for the model actually calculates all cumulative Poisson probabilities needed to simulate a value and iterates this cycle 1757 times to produce the annual output (7) categories X 251 business days per year = 1757 iterations).

The listing of the computer program appears in EXHIBIT 1-12, and sample output covering the period of forty (40) business days is shown in EXHIBIT 1-13.

NASA 3

There is a strong conceptual affinity between the processing of orders during the procurement cycle and many inventory control and manufacturing operations. The movement of unfinished products on an assembly line may serve as an example. A generalized description of the process involves a mass of objects moving at some variable speed along a line and successively passing a set of distinct points until the last element of the set is reached. In the procurement cycle, the objects are the purchase requests, the points are the milestones, and the speed of the movement is given by the time needed to complete a particular activity between a pair of consecutive milestones; the last element of the set of points corresponds to an award. The problem is to describe the state of the system by simulating the changing volume of orders reaching individual milestones.

The preliminary design of the model uses only one category of purchase requests for the sake of simplicity. Category No. 6 (32.1 in the classification model) has been chosen to experiment with because its composition appears to be fairly homogeneous. This category includes commercial orders in excess of $10,000 that have to be formally advertised.

The volume flow is monitored in the model on a daily basis to insure detailed reporting of the progress of work accomplished toward the award stage.

The consecutive milestones are identified in the model as follows:

Milestone	Identification
M0	Purchase request received by Procurement
M1	Information available to support request
M2	Solicitation issued
M3	Proposals received
M4	Proposals evaluated
M5	Contract awarded

This description is in line with the current practice at NASA-ARC. Because of the need to identify the beginning of each activity in the cycle, milestone zero has been included.

The time required to advance a purchase request or order from a given milestone to the next is subjectively estimated. The movement between milestones 2 and 3 is assumed to require a fixed number of days as the prospective sellers usually face a firm deadline for submitting proposals. The time needed to complete other activities in the cycle is represented by Normally distributed random variables. Standardized Normal deviates are generated internally by a subroutine based on the algorithm by Box and Muller.*

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*Box and Muller: A Note on the Generation of Random Normal Deviates, Annals of Mathematical Statistics, Volume XXIX (1958), pages 610-611.

The following parameter values are currently used in the model:

| Estimated parameter | Between milestone | | | | |
	0 and 1	1 and 2	2 and 3	3 and 4	4 and 5
Mean	10	7	35	4	7
St. deviation	1.0	0.7	0	0.4	0.7

A part of the input needed to process the order flow depends on the daily number of purchase requests entering Procurement. This information, which is obtained from the previously discussed NASA 2 model, is stored on a file and subsequently retrieved to register the volume temporarily accumulated at milestone zero.

In simulating the system behavior, it is important to distinguish between two smoothly connected time phases covering the output span. The first phase starts with the system initiation. The number of purchase requests in the system is set to zero at the beginning of day one, and some time must be allowed to pass for the memory of the starting conditions to be forgotten. The second phase pertains to a going system. With the approach of this phase, a dynamic equilibrium begins to emerge. Accordingly, the model design allows one year to elapse before the transition to actual simulation takes place. (The situation is comparable to starting a car and driving it in low gear before it attains a reasonable speed.)

The output provides the following information for any desired period of time:

     (1)   the acquisition status at the beginning of a given business day;

     (2)   the cumulative number of awards at the beginning of a given business day;

     (3)   the number of purchase requests or orders that have advanced to the next milestone during a given business day;

     (4)   the number of contracts awarded during a given business day.

An output sample covering a period of five (5) days is shown in EXHIBIT 1-14. As explained above, the acquisition status and the movements of purchase requests through the system are shown after the pre-simulation phase has been completed. Accordingly, the actual simulation starts with business day 252 when the number of cumulative awards is reset to zero.

The figures shown in EXHIBIT 1-14 are to be interpreted as follows:

At the beginning of day 252, there are 38 purchase requests or orders in the system. Seven of them have reached milestone zero, but not yet milestone one; two of them have reached milestone one, but not yet milestone two; twenty-three of them have reached milestone two, but not yet milestone three, etc. In reporting the acquisition status, the figures give a distribution of requests and orders among different milestones. Similar information is given at the beginning of business days 253 thru 256. The purchase orders that have reached milestone five represent awards. The number of awards is being cumulated in the column headed M5. It may be seen that a total of four contracts have been awarded as of the beginning of day 256.

The intra-day movements of purchase requests and orders are simulated to determine the acquisition status at the beginning of the next day. For example, during day 252 two purchase requests have reached milestone zero and two have advanced from milestone zero to milestone one; as a result, there are still seven purchase requests at milestone zero at the beginning of day 253 (i.e., 7+2-2=7); during day 254, three purchase requests have advanced from milestone zero to milestone one and two from milestone one to milestone two; therefore, there are five requests at milestone one at the beginning of day 255 (i.e., 4+3-2=5), and so on.

A contract award takes place when a purchase order completes the movement between milestones four and five. No contracts have been awarded during day 252, two during the next day, and one during each of the three following days.

B. Work-in-Progress

The work in progress involves the development of a model whose purpose is to simulate the processing of purchase requests and orders in the Research and Development Branch of the Procurement Division. (Ref NASA 11 below)

The central concept underlying the structure of this model is one of the system of flows described in the last paragraph on page 5 of this report. This concept is applied to the processing of all order categories handled by the Research and Development Branch.

The numbering of individual categories has been tied in the model to a recently developed general classification system for the Procurement Division as a whole. This system divides all incoming purchase requests into two major groups, new procurements and modifications, and each of these groups, in turn, into a number of subgroups that are further stratified by the estimated dollar value of the purchase requests and/or by the type of processing required. This classification scheme is shown in EXHIBIT 1-17.

As it appears from the examination of the columns headed R & D, S & C, and SUPPLY in EXHIBIT 1-17, each Procurement Division Branch processes fewer than the 24 categories listed. The Research and Development Branch does not handle categories 1,2,3,13,14,15,and 23, and these numbers have been, therefore, left out of consideration in the model. The remaining categories, that do apply to Research and Development operations, are numbered in the model exactly the same way as EXHIBIT 1-17. (i.e., 4,5,6,etc.). This should faciliate a contemplated future integration of NASA 11 with models monitoring the operations of the other branches.

The volume flow is simulated by the model on a daily or weekly basis, as desired. This option should increase the flexibility in using the model as a tool of administrative control. If more accurate and detailed forecast of the progress of the work toward the award stage is desired, a day-by-day simulation should be used, as it usually is in short-term projections. If rough estimates are adequate for some purposes of control, weekly output may be preferred. In choosing between the two options one must not lose sight of the fact that the computer might need a considerably greater amount of time to simulate, say, a year of operations if daily, rather than weekly, summaries are to be produced and printed. In the remaining portion of the description of the NASA 11 model it will be assumed that the model user desires weekly reports of the acquisition status and the volume flow.

The milestones successively reached by purchase requests or orders are identified in the model as follows:

Milestone	Identification
M0	Purchase request received by R & D
M1	Information available to support request
M2	Solicitation issued
M3	Proposals received
M4	Proposals evaluated
M5	Negotiations completed
M6	Contract awarded

These seven milestones are applicable to most of the categories processed by the Research and Development Branch. There are a few categories, however, with fewer milestones. For example, milestone 2 logically does not apply to new and modified grant requests and in those instances where only a funding action is required (categories 12, 24, and 22). In such cases where a milestone is not applicable, it is simply ignored in the model, but the general identification scheme shown above has been preserved to insure a uniform processing format.

The model design calls for information processing in two sequential time phases, pre-simulation and actual simulation. As explained on page 7 of this report, the pre-simulation phase is needed to initiate the flow system and develop it to the point where it becomes a going system with a dynamic equilibrium. From that time on, actual simulation carries on.

Both time phases require the following input:

(1) an estimate of the annual number of purchase requests to be received by the R & D Branch, broken down by categories;

(2) a forecast of time needed to advance a purchase request or order from milestone to milestone, broken down by categories;

(3) estimates that make it possible to quantify the degree of uncertainty associated with the forecast in (2).

The numerical input values currently entered in the model are shown below. It should be pointed out that these data represent very crude, temporary estimates that shall be revised to make the simulation results meaningful.

Estimated Annual Number of PR'S to enter the R & D Branch

Category*	Estimate
4	300
5	25
6	1
7	1
8	10
9	30
10	2
11	1
12	50
16	1
17	1200
18	25
19	4
20	1
21	1
22	50
24	30
TOTAL	1732

*The identification of individual categories with numbers is shown in EXHIBIT 1-17.

Expected Time Needed to Advance a Purchase Request
or Order from Milestone to Milestone
(All estimates in calendar days)

	Between		milestone			
Category	0 and 1	1 and 2	2 and 3	3 and 4	4 and 5	5 and 6
4	5	7	35	7	2	2
5	5	14	35	35	7	7
6	5	21	63	35	14	7
7	5	42	63	35	21	7
8	5	7	35	7	2	2
9	5	14	35	63	7	7
10	5	21	63	63	14	7
11	5	42	63	63	21	7
12	5	N/A	N/A	14	7	7
16	5	7	35	7	2	2
17	5	7	35	7	2	2
18	5	7	35	7	2	2
19	5	14	35	35	7	7
20	5	21	63	35	14	7
21	5	42	63	35	21	7
22	5	N/A	N/A	N/A	N/A	2
24	5	N/A	N/A	14	7	7

To quantify the uncertainty about the estimates, the time needed
to complete an activity in the cycle is considered to be Normally
distributed. This assumption has been retained from the NASA 3
model because there are no objectively verifiable data to consult,
and there does not seem to be any more acceptable assumption to
replace it. The degree of uncertainty is measured by the standard
deviation of the Normal distribution. Its values have been
tentatively estimated as follows:

Estimates of Standard Deviation Values

(All estimates in calendar days)

Category	Between milestone 0 and 1	1 and 2	2 and 3	3 and 4	4 and 5	5 and 6
4	1.5	2.1	0	2.1	0.6	0.6
5	1.5	4.2	0	10.5	2.1	2.1
6	1.5	6.3	0	10.5	4.2	2.1
7	1.5	12.6	0	10.5	6.3	2.1
8	1.5	2.1	0	2.1	0.6	0.6
9	1.5	4.2	0	18.9	2.1	2.1
10	1.5	6.3	0	18.9	4.2	2.1
11	1.5	12.6	0	18.9	6.3	2.1
12	1.5	N/A	N/A	4.2	2.1	2.1
16	1.5	2.1	0	2.1	0.6	0.6
17	1.5	2.1	0	2.1	0.6	0.6
18	1.5	2.1	0	2.1	0.6	0.6
19	1.5	4.2	0	10.5	2.1	2.1
20	1.5	6.3	0	10.5	4.2	2.1
21	1.5	12.6	0	10.5	6.3	2.1
22	1.5	N/A	N/A	N/A	N/A	0.6
24	1.5	N/A	N/A	4.2	2.1	2.1

The flow from milestone 2 to milestone 3 is assumed to require a known number of calendar days since the prospective sellers are bound to meet a pre-determined deadline for submitting proposals. Therefore, the standard deviation in the corresponding column has been set equal to zero for those categories where milestone 3 applies.

The procedure used in the model to process the input involves a number of repetitive weekly cycles or iterations. Each cycle includes the following operations:

(1) produce the acquisition status at the beginning of the cycle;

(2) determine the number of incoming purchase requests;

(3) sort these requests into individual categories;

(4) for each request, determine the time needed to reach successive milestones up to and including the award stage;

(5) store the information obtained in (4)
     for future use;

(6) if there are other purchase requests
     or orders in the system, determine which
     transfers should be effected during the
     current week and make appropriate changes
     in a flow table;

(7) produce the end-of-cycle acquisition status.

The exponential probability distribution has been used to help
determine the size of the volume flow entering the Research
and Development Branch. To ascertain the number of incoming
purchase requests during a week, exponential random variates
measure the time elapsed from the receipt of the last request
to the next, and a running count of the volume influx is kept
until the end of the week. The method is consistent with the
discussion on page 4 of this report where the incoming purchase
requests have been identified as Poisson arrivals. Exponentially
distributed random variables ob late the need for calculating
Poisson probabilities.

The time required to advance a purchase request or order from a
milestone to the next is determined with the aid of a subroutine
generating standardized Normal deviates. The technique used is
conceptually identical with the one discussed on page 6 of this
report.

The model output produces two interrelated tables for each week
of pre-simulation and simulation. The first table reports the
most recent acquisition status and the second shows the flows
of purchase requests and orders that have taken place during the
current week. The computer program is listed in EXHIBIT 16.

A sample computer printout covering one year of pre-simulation
is attached in EXHIBIT1-18. Another printout simulating one year
of a going system is shown in EXHIBIT 1-19.

The initial acquisition status table in the pre-simulation period
appears on the first page of EXHIBIT 1-18. It shows no purchase
requests or orders in the system. The system initiation begins
in the first week when purchase requests start coming in.

The flow table for week one, displayed on the next page, reports
what has happened during the week:

(a) a total of 28 purchase requests have been
     received by the Research and Development
     Branch;

(b) 18 of these requests are in category 17,
     4 in category 4, 2 in category 9, etc.;

        (c)   of the 28 requests received, only 2 have
                 advanced to the next milestone, one in
                 category 5 and the other in category 17;

        (d)   no purchase requests have advanced beyond
                 milestone one.

Several blank entries may be observed in the flow table. For
example, for category 12 the numbers in columns labeled TO M1
and TO M2 are missing. As previously mentioned, milestones 1
and 2 are not applicable in this instance, and a purchase request
reaching milestone zero shall eventually advance directly to
milestone 3.

The acquisition status table as of the end of the first week is
presented on the same page. It shows the distribution of
purchase requests and orders in the system after all flows of
the week have been accounted for. The total number of purchase
requests and orders in the system is reported and broken down
by category designations. The progress of work toward the award
stage is likewise being tracked in the table.

An examination of the figures shows how a flow table relates two
successive acquisition status tables. For example, 17 purchase
requests are reported at milestone zero for category 17 in the
acquisition status at the end of week 1. This figure has been
obtained by adding the corresponding number reported in the
immediately preceding acquisition status table to the volume
inflow to milestone zero during the first week, and subtracting
the number transferred in that week to the next milestone (i.e.,
17=0+18-1). That relationship holds throughout the pre-simulation
and simulation period.

With the passage of time, the volume of requests and orders in the
system increases and their distribution among the milestones
achieves a reasonable degree of stability, although the flow and
acquisition figures keep fluctuating. When this happens, there
is an indication that pre-simulation might have accomplished its
purpose. To be on the safe side, I deliberately extended the
pre-simulation phase to cover an entire year. At the end of
the 52nd week of pre-simulation, there are 274 purchase requests
or orders in the system, as shown in the acquisition status
table, end of week 52, in EXHIBIT 1-18.

As the transition to actual simulation takes place, the number
of awards is reset to zero for all categories (see column M6,
acquisition status table, end of week 0, in EXHIBIT 1-19), but
all other entries in the table are left intact to preserve the
properties of a going system. Many more simulation runs would
be needed to obtain meaningful statistical information about the
behavior of the system.

Section 2

Performance Evaluation Model

Section 2

Performance Evaluation Model

Overview

This project is concerned with the development of a performance
evaluation model for assessing a buyer's performance as well as for
candidate selection, performance correction, training, compensation,
promotion, discipline, and transfer. The basic Walsh PEM model serves
as a prototype in this project. Several changes are contemplated includ-
ing an increase in the number of categories, a choice of indices over
ranks, and the need to explicitly include quality indices in the PEM.
The revised PEM should provide a planning tool to aid buyers in esti-
mating PO milestone and completion dates, should provide buyers and
supervisors with information for workload scheduling, and should provide
both groups with a means of establishing clearly stated behavioral goals.

Need for a Work Scheduling System

The problem, as defined in the original research proposal, called
for the development of a computer-based, quantitatively-oriented Work
Scheduling System (WSS). The intended purpose of such a system was to
facilitate manpower planning and to determine appropriate staffing
levels for the Procurement Division.

The main consequence of inadequate planning is the inability to
maintain a constant workload throughout the year. In the absence of
a plan which has been coordinated with the technical staff, there is
an inevitable work overload at the end of the fiscal year and a slack
period at its beginning. Professor Vancura (Simulation Tract) has docu-
mented the existence of the seasonality in processing PR's at ARC.
Heavy workloads appear to occur during the months of February, May,
July (heaviest), August, and September with "slacks" occuring in the
remaining months (especially June). *

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*See Appendix 2-A, "No. of PR's Logged in Procurement" and
"Volume/Time Indices."

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In various interviews with procurement personnel, it appears that, while overloading is a very real problem, the so-called "slack" periods actually result in only less of an overload. That is, there seems to be unanimous agreement in Procurement that the Division is simply overloaded, i.e., understaffed. A report by the Chief of the Procurement Division documents this understaffing problem from an operating management perspective.[*] Importantly, this report does not identify the implementation of a WSS as a possible approach to the problem solution but rather concentrates on the expansion of the procurement personnel workforce. Such an approach (which may, in part, ultimately be necessary) will alleviate some of the pressures due to the chronic understaffing and work overload but will do little or nothing toward mitigating seasonal variability. Without an appropriate work scheduling system, apparent **overloads** (and underloads) will continue to occur.

A natural consequence of work overload is that certain activities tend to get slighted. For the Procurement Division, as a whole, there is some evidence that the quality of procurement actions may be suffering as a direct consequence of work overload.[**]

Three recent organizational changes, however, may be contributing to the supposed work overload: (1) the creation of the APO's, (2) the increase in size and activity of the review unit, and (3) the inclusion of contract administration into a **contracting** officer's responsibility. A detailed investigation of these changes is beyond the scope of this research tract; and the changes are identified here only as a by-product and for future managerial consideration.

Implementing a Work Scheduling System

The operational feasibility of a work scheduling system rests on four factors:

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[*]Lloyd Walsh, "Study of Staffing Problems within the Procurement Division together with Proposed Solutions", April 9, 1975.

[**]Ibid., Section II A.

(1) a management mechanism whereby a defined administrative unit has organizational authority to hold technical and procurement staffs, alike, responsible for the fulfillment of an advanced procurement plan;

(2) the ability to plan with sufficient lead time to make indicated adjustments in staffing feasible;

(3) a management tracking system which facilitates the monitoring and control of the procurement process; and

(4) valid work measurement standards to allow the translation of workload forecasts into manpower requirements.

Advanced Procurement Planning. There is, in fact, no mechanism at ARC, formal or informal, which periodically allows or requests contract load forecasts from the Technical Divisions. Also, the **contracting** officers are dependent upon the technical staff during the initial period and review stages of each contract action. If the technical staff does not keep to a reasonable timetable for initiating and reviewing procurement packages, there is little recourse for the Procurement Division. The lack of an organizational unit and/or mechanism which can demand, of both technical and procurement personnel, the development of a workload forecast and adherence to a work schedule, precludes the operalization of a work scheduling model at ARC.

We recommend the creation of the necessary organization structure to implement a work scheduling model. The necessary organizational restructuring envisioned here is comprehensive in nature and would involve several divisional units outside of Procurement. In this respect, a plan developed by the National Institute of Health under a grant from the Department of Health, Education, and Welfare, could serve as a prototype model for ARC. The NIH plan, still in the experimental stages, is designed to promote mutual planning between procurement and technical staffs. A paradigm of managerial control used in this study is shown in Figure 2-1.Two benefits of this type of plan

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*"Special Studies of Measurement Problems", Measuring Research and Grants Administration Programs--Special Report #3, Volume I, October, 1973.

are (1) the explicit consideration of the exact goals and objectives (missions) of the entire organization and (2) the built-in feedback loops which tie actual performance back to planning. Because the Santa Clara Research Group has restricted its first-year efforts to dealing only with the structure and activities of Procurement in so far as the Division can be viewed as a total system, the development of an organizational restructuring plan is beyond the scope of the present research. If further research should reveal that the creation of a central procurement policy and review section is not possible, at the present time, there may, nevertheless, be an opportunity to implement an informal planning system by utilizing the Assistant Procurement Officers to collect estimates of the number and types of contracts that would accompany anticipated research projects.

Long-Range Procurement Manpower Planning. A usual problem in manpower planning is that it often results in insufficient lead time, particularly when complex jobs requiring advanced training are involved. A recent comprehensive nationwide study by Arthur D. Little, Inc. (March 28, 1975), however, reveals that most government procurement agencies believe that manpower planning could be performed as much as two years in advance if the technical staff indicated the relative probability of gaining authorization for specific projects at the time when the preliminary budget plan for the project is drawn.

Management Tracking System Planning. A necessary appendage to a procurement work scheduling model is a purchase request tracking system that monitors the progress of specific contract actions and measures conformance to the overall procurement plan. Mr. Al Platt, under the direction of Chief Lloyd Walsh, has been able to initiate an automated tracking system for contracts in excess of $10,000 (representing about 2,000 of the 15,000 contracts processed by the Procurement Division in a year).

Professor M. K. Bohman's research effort, here, on management information systems deals directly with the design of an automated data base and expanded tracking system which should give the necessary visibility to the procurement process.

Procurement Work Standards Planning. The quality of manpower forecasts is dependent upon the validity of the calculations used to translate contract load into manpower requirements (node #4 in the NIH paradigm of Figure 1). Although all three procurement processing branch supervisors at ARC have some "rules of thumb" by which a **contracting** officer's work is judged, there is, at present, no single objective quantifiable system.

A Work Measurement Model

Because of these findings and conclusions, the orientation of this research tract was shifted away from the development of a work scheduling system and toward the development of a Work Measurement Model (WMM). (Such a model is seen as one of the necessary prerequisites to the development of a work shceduling system.)

From March through May of this year, the thrust of this research effort was on the development of alternative approaches to work measurement. There are two basic approaches to work measurement: regression analysis and time-and-motion analysis. Regression analysis generally utilizes multiple linearly related independent variables to statistically predict the level of a single dependent variable. The dependent variable may be either expected output from performing task A or, less commonly, and only for mechanistic tasks, the major determinant of output from performing task A, i.e., input variable X. Thus, given knowledge about the parameters of selected dependent variables, regression analysis might be used to predict either (1) the number of purchase requests a **contracting** officer could be expected to process during a specified period of time, or (2) the number of purchase requests that can be expected to

enter a **contracting** officer's queue during a specified time period. The selection of appropriate independent variables is, of course, critical. To date, regression analysis applied to government procurement activities has utilized variables such as (1) total tons shipped and/or received, (2) number of "line items" processed, (3) total tons in storage, (4) total paid drill strength, and (5) number of items processed during previous year. The use of such variables can result in accurate procurement manpower requirements only where procurement deals mainly with large quantities of standardized items. This is <u>not</u> the case with research installations such as ARC.

Time-and-motion (T & M) studies are traditionally associated with production and the planning, control, and training of personnel whose jobs can be clearly defined in terms of basic physical body movements. More recently however, there has been a renewed interest in the basic philosophy of the approach of T & M with emphasis now shifting away from physical motion and toward the development of standardized times for non-physical activities. **Figure 2-2** contains a hierarchical listing of work-units. These work-units form the basis for activity measurements along a time dimension.

Several governmental agencies are currently attempting to develop procurement manpower standards on the basis of fourth-order and higher work measurement units. In fact, the current Chief of the Procurement Division at ARC, Mr. Lloyd Walsh, is currently implementing some of the necessary data collection techniques to implement such a work measurement system. The Walsh model is quite unique and can be described as follows:[x]

The Performance Evaluation Model (PEM) is a three-dimensional measurement tool for assessing a buyer's performance. The three dimensions of measurement are (1) workload, (2) ability to complete all necessary procurement actions within a normal time, and (3) the ability to predict PO completion dates.

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*The model is currently only partially implemented at ARC.

Workload. PO's are categorized by attribute (e.g., dollar amount and type of award procedure) and each category assigned a point value indicative of the relative amount of "effort" required to guide it through the procurement process. A buyer's workload is calculated by multiplying the number of PO's processed per period by the appropriate PO category point values and summing across categories. The higher a buyer's point total, the heavier the workload. A Workload Report is produced **monthly** which shows each buyer's total workload points. The **monthly** figures are averaged to produce a yearly workload report for all buyers.

Longer than Normal Time. The actual time required to see a PO through the procurement cycle (completion is defined as contract awarded) is recorded and compared to "normal time". Normal time is defined in terms of the historical mean average completion time for each PO category. Negative variances are awarded demerit points--one demerit for each one day of time longer than normal. The lower a buyer's demerit point total, the better. Obviously, zero demerit point totals are possible. A Longer Than Normal Report is produced monthly. A yearly report is also produced which recaps monthly totals and includes a monthly average.

Number of Delays. A buyer must assign each PO an expected completion date. Some PO's also have several (up to a maximum of six) expected milestone dates. The six key milestones in the procurement cycle are identified as: (1) purchase request receipt date, (2) purchase request acceptance date, (3) proposal receipt date, (4) proposal evaluation date, (5) negotiation completion date, and (6) date of award. The accuracy in prediction of expected milestones and completion dates is monitored through the monthly Delay Report. Each required delay in or postponement of an expected milestone and/or completion date is awarded one demerit point. Again, the lower a buyer's demerit point total, the better.

The PEM includes a Buyer Proficiency Report, issued once a year, which is designed to indicate the relative effectiveness of a buyer. Effectiveness is defined in terms of the three measures of performance evaluation described above. Specifically, each buyer is ranked on each of the three measurement criteria: (1) workload, (2) ability to complete all necessary procurement actions within a normal time, and (3) ability to predict PO completion dates. The ranks are added to produce a total buyer proficiency (BP) score. The BP scores are then ranked to produce a relative measure of proficiency. An example of this procedure is provided in a memo from Mr. Walsh to all NASA Procurement Chiefs (dated, February 26, 1975):

> The system uses an averaging process and then relates those averages to other buyers in the division. This places each buyer in a relative position to all other buyers for each area of concern (workload - longer than normal - delays). This approach to ranking allows for balancing of high averages with low averages in certain areas of a given buyer. For example, if a buyer in a group of 18 had the heaviest workload, the greatest quantity of delays, and placed sixth in longer than normal time, his overall proficiency rating would be 25 (Workload: 1 + Delays: 18 + Longer Than Normal: 6 = 25). This would place the buyer above average. The story told in this rating review is logical. One could presume that the buyer with the heaviest workload would have the highest quantity of delays because of scheduling difficulties and the greater potential for priority shifts.

> A tally sheet identifying each buyer is used to support this report. Each area of concern is included under the buyer's name and the appropriate area factoring number is inserted under the corresponding month. Workload is measured at the close of each quarter and the other two areas are measured at the close of each month. All areas are then averaged. Placement or relative position of each buyer is then added to the tally sheet. Ties are given identical scores and numbers corresponding to the quantity of ties are skipped in establishing the next place. For example, if three buyers tie for first place, each would be given a one point score. The next in line would be given a four point score. The placement of the three areas are then added together to form the buyer proficiency rating. A separate summary sheet showing the proficiency ratings is then prepared. This sheet is then noted with any special information which has significant impact on the rating conclusion such as indications of only part-time employment.

Buyer	Average Workload	Pos.	Average LTN	Pos.	Average Delay	Pos.	Tot. Pos.	Effec. Rank	12/31/73 Rank
1	26.0	11	1.9	6	3.3	2	19	7	9
2	38.3	9	0.1	1	4.4	4	14	3	5
3	53.3	4	0.4	3	8.7	6	13	2	4
4	45.0	6	1.3	5	9.2	7	18	5	2
5	39.7	8	4.9	11	12.2	8	27	11	11
6	54.0	3	2.8	9	18.4	9	21	9	5
7	82.7	2	2.0	8	23.1	10	20	8	8
8	43.7	7	1.9	6	7.6	5	18	5	5
9	47.3	5	0.2	2	1.3	1	8	1	1
10	37.3	10	0.8	4	3.9	3	17	4	3
11	99.3	1	4.3	10	38.8	11	22	10	10

The months of June and July of this year were spent in analyzing this model. The thrust of the model is toward "performance evaluation" rather than "work measurement". From an overall analysis (principally, by interviews) of the Procurement Division and ARC in general, it became apparent that there was a definite need for a performance evaluation mod 1.

The Model Perspective

There are subtle but important differences among the concepts of work scheduling, work measurement, and performance evaluation. Work scheduling involves the creation of an organization structure with authority and responsibility for holding the Technical Divisions and the Procurement Division, alike, responsible for the creation and execution of an overall procurement plan including a detailed activities schedule.

Work measurement, by contrast, is a subset of work scheduling and is concerned only with the translation of workload forecasts from the Technical Division into manpower staffing requirements for the Procurement Division.

Performance evaluation, on the other hand, is normative in nature while work measurement is basically descriptive. And, where work measurement is seen as a subset of work scheduling, performance evaluation has no necessary relationship to work scheduling. The purposes of performance evaluation or performance appraisal include candidate selection, performance correction, training, compensation, promotion, discipline, transfer, etc. In essence, performance evaluation is the appraisal of the contribution of an individual employee to the effective administration of management processes. Thus, the whole thrust of a performance evaluation model would be quite different from a model appropriate to work measurement or work scheduling. And, it is from this unique perspective that any performance evaluation model must be judged.

MODEL CRITIQUE

There were several underlying assumptions in the Walsh model that needed to be investigated. The month of August, 1975, has been directed toward this effort. The following are comments and observations relevant to the analysis of the PEM:

Workload Report

There are two crucial variables in this weighted average approach to workload measurement: the initial definition of PO category types, and the point values (weights) assigned to each category. Mr. Walsh identified only six PO categories. Professor Vancura initially identified twenty categories for simulation purposes but remarked that these categories appear too heterogeneous in terms of average completion times to provide accurate results.

Point values must be subjectively determined and, in general, agreed to--a difficult but not impossible task.

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The Walsh model currently operational at ARC is designed to monitor pre-award activities (this excludes contract administration, termination, and disputes) and uses the following point scale:

Type of Action	Work load - Units
Order against Federal Schedule Contract or through other agency	1
New procurement other than above	
under $25k	4
$25k - $50k	5
$50k - $100k	6
$100k - $1m	12
over $1m	20

This scale does not, of course, consider differences between Research and Development, or Supply, etc. requirements, nor does it consider the type of contract.

Also, an issue raised by Professor Vancura is the possibility of the need to construct seasonal workload averages, e.g., monthly indices of the Procurement Division's workload.

Longer than Normal Report

In addition to the question of category homogeneity along the time dimension, of crucial importance would seem to be the assignment of one demerit point for each one day of delay regardless of PO category. Apparently, a balancing procedure is thought to exist: some buyers would work on many short-term PO's with the chance of several running longer than normal by no more than a day or two vs. those buyers working on only a few long-term contracts with only one or two going longer than normal but going over by several days.

Several typical ARC situations would need to be used to test this aspect of the model. The emphasis on negative rewards for negative variances and only the absence of negative rewards for positive variances needs to be examined. Behaviorally, this policy would seem questionable as it appears

to encourage a buyer to reach standards but does nothing to motivate him to do any better.

Delay Report

Of crucial importance also is the assigning of one demerit for each negative time change regardless of the amount (number of days) of time involved. Again, there seem to be an assumption concerning some inherent balancing mechanism: those buyers with numerous short-term PO's will have a few with time delays while buyers with only a few long-term PO's may have several delays on each project. This assumption would, of course, need to be tested.

Three additional points worth noting and in need of testing are the assumptions that (1) delays are equally bad regardless of PO type, (2) delays on milestones are equally as bad as delays in completion, and (3) estimations that are longer than actual are good, i.e., no negative demerits are assigned for "positive" variances.

Buyer Proficiency Report

A buyer's BP rating is based on the assumption that each of the three work measurement criteria are equally important. Is this true?

Also, the use of a single aggregate figure tends to wash out criteria differences. For example, a buyer with an extremely light workload would probably have few delays and few longer than normal times. Supposing that his rankings on the three criteria were 18, 1, and 1 out of a total of 18 buyers, clearly his score of 20 is good yet his workload may be unacceptably low. Perhaps minimum standards would have to be established for each category to preclude the coverup of category extremes in a single aggregate summary measure of performance.

A more general criticism of the ranking approach is that always someone is last although he may be showing great improvement and someone

is first although he may be showing an actual decline in performance. Perhaps a behaviorally more attractive approach would be to construct an index of performance thus emphasizing a buyer's changes in performance over time and only secondarily a buyer's relative standing among buyers.

MODEL CHANGES

The month of September, 1975, is being used to design and test (through interviews with procurement supervisors) modifications in the Walsh model. To date, the following changes have been proposed and are currently being evaluated:

Number of Categories

From the feedback from extensive interviews with procurement personnel, it is believed necessary to utilize at least 24 separate categories in classifying purchase orders. This is a four-fold increase in the number of categories over the Walsh model; but the increase is deemed necessary if workload units are to be equitably assigned. Figure 3 shows the proposed set of categories and the milestones appropriate to each category.

Ranks and Indices

From a motivational perspective, it is not clear that a ranking of contracting officers' performance is appropriate. Rankings show no necessary relationship to changes in the absolute level of performance. In place of, or perhaps in addition to a ranking system, an indexing system is proposed. Such a system reports a contracting officer's performance in relation to some base period, e.g., the first quarter of 1975. Thus, a rating of 110 would indicate that a contracting officer did 10% "more" than his performance during his base period.

Purchase Order Quality

It is believed necessary to explicitly include quality indices in the Performance Evaluation Model . Clearly, those PO's which are "sent back"

to a **contracting** officer to be "cleaned-up" affect the number of PO's he is able to complete during a time period. Thus, indirect measures of quality are included in the original version of the model. However, because of the complex nature of the rules and procedures regarding what actually constitutes a correct procedure in converting a PR to a PO, it appears that, operationally, a "good" job is quite subjectively defined. An overemphasis on quantity with no corresponding concern for quality is not only detrimental to the mission of the Procurement Division but may also lead to serious practical (operational) problems. Thus, some measure of "quality" is deemed necessary in developing an appropriate Performance Evaluation Model. This may take the form of incorporating PO ratings (given by the review officers) into the model; but, more likely, overall quality will be inferred by the number of re-worked PO's an officer must complete during a time period.

Data Base

Of particular concern in terms of schedule feasibility is the fact that the model requires a collection of historical data in order to specify "standard times" for the completion of procurement activities between various milestones for the Longer than Normal Report. Thus, implementation of the model may necessarily be stalled until some data base is collected via the proposed expanded tracking system.

Model Purpose

From a managerial perspective, perhaps the most important consequence of the development of a Performance Evaluation Model is that it cannot easily be used to "show" Division under- or over-staffing. Indirectly, and over the long run, it may be possible to infer understaffing by monitoring aggregated individual performance indices and noting a downward trend. But, the basic purpose of the model is to facilitate, through the use of "objective" measurements, individual performance appraisal.

Section 3

Examination of Employee Development Procedures

Section 3

Examination of Employee Development Procedures

Overview

This project concentrates on the impact of the human variable on the effectiveness of the procurement division. In this context it is concerned with employee development, motivation, performance, and morale. The comments and recommendations which emerge are the consequence of extensive interviews of Procurement personnel, review of NASA documents, and the observations of the researchers. The content of the report is concerned with the cradle-to-grave concept, the contract review process, the weekly tracking system, training, meetings and communication, job performance information, and career planning.

Introduction

This is an interim report on the investigation of Employee Development, and related areas such as motivation, performance, and morale, at the NASA-AMES Procurement Division.

The comments and recommendations presented in this report are based on extensive interviews of Procurement personnel, reviews of NASA documents, and observations of the researchers. Thirty-eight employees of the Procurement Division, representing all sections/offices of Procurement, volunteered to interviews by the researchers. Each interview lasted approximately one hour. The general format followed in the interviews is outlined in Appendix 3-A.

This report is informational. The researchers expect that it will serve as a basis for further discussion (including discussion between the researchers - Hall and Leidecker - and Procurement management) as well as an impetus for direct action.

All the points made in this report reflect observation by the researchers, recurring comments in the interviews and the researchers' analysis. Therefore the researchers believe it important that Procurement management consider and/or investigate the points and communicate its decisions and reasoning to all Procurement personnel.

Outline of the Report.   The content of the report is divided into five broad areas:

* General Comments - this area consists of points concerning:

> The Cradle-to-Grave concept;
> the Contract review process;
> the Weekly Tracking System; including the format
> of that process; and some general points as to
> morale problems.

* Training

* Meetings and Communication

* Job Performance Information and Career Planning

* Summary - This section focuses on selected points in the report
> that the researchers think deserve primary attention.

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FINDINGS

A. GENERAL COMMENTS

1. **Cradle-to-Grave Concept.**

   Cradle-to-grave concept has the support of most personnel, but some aspects may need further consideration if concept is to give optimum returns:

   a. Emphasis perceived by personnel is on getting contracts out; relatively little attention is given to administration of the contract. Contract administration tends to receive attention only when big problems occur.

   b. Administrative work is seen as time consuming, although often routine (e.g., involving change orders). Use of low level G.S. personnel for some administrative duties, such as contract close-outs, may strengthen cradle-to-grave operation.

2. **Contract Review Process.**

   Overall, there seems to be a positive response toward the contract review process. However, personnel expressed some strong concerns about the purpose of the review process. The purpose is still not clear. Personnel aren't sure whether the review process will be used for constructive coaching or for discipline/chastisement. Work needs to be done:

   a. To clarify the purpose(s) of the review

   b. To explain its usage

   c. To improve the process itself (see 3-A.3)

3. **Format of Contract Review Process.**

   There is substantial concern with the format of the review process:

   a. Complaints that the review process is done in "piece-meal" fashion, thereby taking up unnecessary amounts of time.

   b. Current review process is causing bottlenecks (see (a)). Process may result in 5 to 6 typing repeats, reviews by all parties, then a final typing.

   c. Although there is a favorable response to the rigor/quality added by the review process, there is concern that required corrections are often "nit-picking" exercises.

      (1) Some personnel believe that a "zero-defect" assumption is present. If so, is it appropriate? Communication with personnel could improve morale.

      (2) Can some minor review points be made as "teaching points" for future work rather than requiring correction on the contract in question?

d. Complaints that some memos from Review are critical but do not provide specific direction for improvement.

e. Indications that some verbal feedback from Review, supplementing written memos, would improve morale. Isolated comments regarding Branch Chief reviews indicate, however, that verbal reviews alone may cause confusion because employees forget instructions or because verbal instructions are misinterpreted more easily than written instructions.

4. Weekly Tracking System.

Resistance to the weekly tracking system still exists. Causes of resistance cited:

a. Some people still see it as demeaning: i.e., record keeping/clerical work is beneath their status.

b. Purpose of system is not clear: how will information be used?

c. Takes time away from "job": better understanding of how system contributes to "job" is needed.

d. Format of reporting needs improvement.

5. Other Comments - "Morale"

a. Need for more recognition of work accomplished. There is a general tendency to stress need for improvement without giving recognition to work accomplished by personnel.

b. Recurring comments concerning amount of work and size of backlog. More effort toward recognition of work accomplished (see (a)), and toward WPPR (see D. 5) could help this morale problem.

c. Some concern expressed that the use of senior-level Procurement personnel as APO's may not be making optimal use of the abilities these employees possess. This concern suggests two questions that may need attention:

(1) Is the APO role defined as effectively as possible?

(2) Do other Procurement personnel have a satisfactory understanding of the APO role?

d. Isolated comments identifying the status of Procurement as an important cause of morale and output problems; e.g., belief that technical personnel have more access to training programs than do procurement personnel.

e. Room available as lunch-lounge would be appreciated.

B. TRAINING

1. A general improvement in the understanding of current regulations, new interpretations, and changes would improve performance and morale.

2. There is some indication that Branch Chiefs do not feel they have sufficient time to accept responsibility for identifying training needs and developing appropriate programs. If so then alternate approaches must be considered:

    a. Establishment of a committee to determine "standard interpretations" to the Regulations in questionable areas. Such a committee would also be given responsibility of keeping personnel informed as to new regulations, interpretations, and problem areas.

    b. It may be useful to have the Policy and Review Office develop a list of recurring problem areas (inappropriate application or interpretation of regulations, etc.) as a basis for determining training needs.

    c. APO's are frequently used as resource people by Branch personnel. Thus APO's might also develop a list of recurring problem areas.
    ✻ (Note: such approaches could be used to complement, rather than substitute for, training efforts by the Branch Chiefs.)

3. To keep personnel current, it is necessary that appropriate publications be circulated to all levels. It was indicated that often, due to time pressures, circulation below the level of Branch Chief was infrequent.

4. Various formal procurement training programs are available from sources outside NASA-AMES (e.g., Army, Navy, Air Force, Civil Service). Personnel should identify these opportunities for NASA-AMES employees.

5. Training for Small Purchases Agents needs to be formalized. There should be an in-house program taught by in-house instructors on:

    a. regulations

    b. form usage

    c. anticipated/expected problem areas.

6. A commodity buying assignment may be helpful in training new people in small purchases. This may be the best way to give experience to personnel.

7. Some comments that requestors (technical personnel) do not understand procurement system, making work for procurement personnel more difficult and time-consuming. Identification of specific weaknesses in this area, and effective communication to technical personnel, could improve performance and morale in Procurement.

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C. MEETINGS AND COMMUNICATION

1. Branch Meetings.

   Generally good reaction to meetings at Branch level. Improvements can be made by:

   a. Scheduling meetings rather than calling them at very short notice.

   b. More frequent meetings: every two weeks, or more frequently suggested.

   c. Objective of meeting should focus on regulation interpretation and work-related problems. Problem-oriented training could be initiated here.

2. General Staff Meetings. The effectiveness of General Staff meetings could be increased substantially if these meetings:

   a. Are of short duration and well-organized.

   b. Include all personnel, including clerical staff.

   c. Rely on agenda published in advance whenever possible.

   d. Are informational, not evaluative. Minimize or eliminate negative feedback at this level.

   e. Eliminate specific, narrow comments relating to one branch or one individual.

   f. Are open to all comments from personnel.

3. Some comments that there is a tendency to implement concepts before/ without a general discussion of possible problem areas (re: implementation) as seen by personnel.

4. There is a general feeling the Procurement management tends to keep ideas "close to vest" until implementing. Personnel express a desire to know what's happening, whether the "news" is good or bad.

D. JOB PERFORMANCE INFORMATION/CAREER PLANNING

1. Feedback - personnel generally desire more feedback as to work accomplishments from supervisors.

2. Supervisors often seem too busy to assist employees with work-related problems. If this is an accepted fact, then <u>alternate</u>, <u>known</u>, <u>formal</u> sources should be identified.

3. Employees indicate they need and desire more complete answers as to their promotional possibilities. Their comments suggest that there is only rudimentary attention to career development. Discussions as to employee work objectives and career counselling is desired.

4. Little use is made of the formal appraisal system. Employees are typically given "satisfactory" ratings without any specific counselling being provided.

5. <u>Work Planning and Progress Review (WPPR)</u> -

   a. Most employees were impressed by objectives of a WPPR system but were not familiar with its usage at AMES or in Procurement.

   b. WPPR, or some formalized performance feedback system, should be used more extensively at NASA-AMES Procurement. Such a program also should be linked to some basic career counselling/work improvement objectives.

   c. Aspects to consider:

      (1) Majority of employees indicated that the objective of WPPR is important to them, but is not being implemented.

      (2) Supervisors represent a key aspect of a program of this nature. They must support the program, and be prepared (know how) to administer it.

      (3) <u>Implementation</u>. There might be advantages to establishing a control group (one branch) and implementing WPPR in this group. The program should be explained to all participants. Possibly advisors (Hall & Leidecker) would be useful to the Branch Chief implementing the program.

SUMMARY

1. <u>Focus on Selected Findings</u>.

   The researchers believe that the Procurement Division's performance level could be improved substantially if attention initially is focused on three aspects of this report.

   <u>First</u>, the researchers see a direct link between training and performance level. There is a need for more training if performance is to improve. (There is some danger that the time needed for training efforts is viewed by some personnel as detracting from performance.) Particularly important is the need to expend more effort to <u>identify</u> specific training needs. The identification of specific training needs will also guard against ineffective "training for the sake of training".

   Personnel in Policy and Review (Office of Staff Specialists) and the APO's because of their duties and activities, should be very useful in identifying specific training area needs. Branch Chiefs should also be involved.

   <u>Second</u>, Branch Section meetings should be used more extensively to provide problem-solving information to employees. The Branch meeting can be an important tool in the training effort, especially once specific training needs are identified.

   <u>Third</u>, the researchers believe that substantial benefit can be obtained through effective use of the Work Planning and Progress Review (WPPR) program.

   <u>Such a program, if used properly, can:</u>

   a. Contribute to the identification of on-going training needs.

   b. Provide Procurement personnel with desired feedback and recognition (thereby improving the communication process).

   c. Contribute substantially to performance improvements.

2. <u>Future Direction</u>.

   The effective use of a WPPR Program requires a good understanding of the program by <u>all levels</u> of Procurement personnel. As noted earlier in this report, very few members of the Procurement Division are aware of, or understand, the nature of such a program.

   Therefore Procurement Management should consider whether, and to what extend, Procurement personnel need training in the <u>purpose</u> and <u>use</u> of a WPPR program in order for the Procurement Division to realize the benefits described above.

Section 4

Determination of Influences and Apparent
Impact of Contract Type and Structure

Section 4

Determination of Influences and Apparent
Impact of Contract Type and Structure

I. Overview

This project is concerned with the investigation of important factors relating to the selection of contract type and structure in various contracting situations. Data were collected from 150 NASA-ARC contract files and arrayed across an extensive set of contract situational variables; partial data from 24 other large NASA contract files were solicited for comparative purposes. Preliminary results suggest that certain managerial variables are more important than others; if these variables are controllable, they could be used in a predictive model which would assist procurement personnel in selecting the most efficient contract type/structure. In addition to the activities described above, inputs to a management information system are being assembled in conjunction with the development of an on-going data base.

II. A. Accomplishments to Date

1. Assessment of NASA/ARC Procurement Environment
   a. Familiarization with Legal and Administrative Constraints.
      Through literature review and personal interviews with NASA-ARC procurement personnel the legal and administrative environment influencing contract type selection generally has been determined. The principal document governing this environment is the NASA Procurement Regulation which describes the formal advertising and negotiation methods of procurement as well as the contract types available to NASA-ARC. In addition to statements of general policy and criteria for both methods and all contract types, this regulation also describes Determinations and Findings which are required to support all negotiated procurements and contract type selection. This regulation is an interpretation and elaboration upon Chapter 137 of Title 10 of the United States Code which is the basic law applicable to procurements by NASA.

Additional documents reviewed which relate to the legal and administrative environment include the following:

a.   NASA Procurement Regulation Directive No. 74-9 of December 23, 1974.

b.   NASA Incentive Contracting Guide, October 1969, NASA Publication NHB 5104,3A.

c.   Report of the Commission on Government Procurement, December 1972, U.S. G.P.O. Stock Number 5255-00002.

2.   Data Collection and Analysis

a.   Contract Type Identification. Through an examination of procurement records it has been determined that the procurement methods and contract types used by NASA-ARC from January 1, 1973 through March 10, 1975 included the following:

Procurement Method:

Formal Advertising	156
Negotiation	1167
Total Number of Contracts	1323

Contract Type; other than firm fixed price:

Cost plus fixed fee (CPFF)	123
Cost plus incentive fee (CPIF)	1
Cost plus award fee (CPAF)	4
Time and Materials (T & M)	12
TOTAL	140

Thus, although 88% of the contracts were negotiated, only 11% were of the cost reimbursement type, and 9% of the total

were CPFF. The sample sizes for CPIF (1) and CPAF (4) are too small for valid statistical inference on an empirical basis. As a result, most of the empirical analysis must be concentrated on CPFF and FFP type contracts, with apriori judgemental or inductive hypotheses concerning criteria for other contract types. These hypotheses must then be tested against contracts to be let in the future.

b.   Interviews with Procurement Personnel. Intensive interviews were conducted with several procurement personnel to ascertain their perspective as to the important factors in the procurement process. Procurement personnel were asked to describe typical procurement activity from a "cradle-to-grave" point of view.

c.   Procurement Situation Definition. An on-site examination of completed contract files was conducted at NASA-ARC on April 16 and 17, 1975. This on-site examination helped to identify a set of variables which were deemed to be important in defining a procurement situation. A revisit to procurement personnel described in 2b above led to several deletions, additions, and restructuring of variables. The resultant list of variables is contained in Exhibit 1, "Procurement Analysis Coding Sheet."

d.   Initial Data Collection. Subsequent to developing the "Procurement Analysis Coding Sheet," a data file was created which consisted of the data elements

arrayed across 100 randomly selected ARC contracts. This activity commenced on June 1, 1975 and was completed by June 21, 1975. Table **4-1 contains a** summary description of the 100 contracts.

e. Subsequent Data Collection. The 100 randomly selected contracts provided a data base which was to be used for both univariate and multivariate analyses. However, only 16 of the 100 contracts were of the cost reimbursement type, prompting a second effort to collect exclusively cost-type contracts to insure sufficient numbers of both types for comparison purposes. The second ARC data collec-- tion was completed on August 20, 1975. Table **4-2 con-** tains combined sample (N = 150) statistics including means, standard deviations, skewness and minimum/maxi- mum of a selected set of variables.

During the data base construction phase of the research pro- ject, collateral efforts were being made to solicit comparable data from other non-ARC sources. To date, only one effort has been successful.

Twenty-four contracts with significant cost overruns were acquired from a NASA Headquarters file which contained data from all NASA installations.

f. Preliminary Inferences from Data Analysis. Step-wise multiple regression analysis was used to identify the most important variables in explaining variation in actual contract costs. This exploratory analysis was

conducted to determine the extent to which analyses

performed on the NASA data base (described in 2e above)

were different from those performed on the ARC data

base (described in 2d above).

The results are summarized in Table 4-3. **As can be seen from**

Table 4-3, the results are sufficiently mixed so as to make in-

terpretation difficult. Although the P.R. cost estimate appears

to be an important factor in explaining variation in actual

contract cost, it should be noted that this situation occurs

only when negotiated contract price has been excluded as an

independent variable in the regression analysis. In addition,

the degree of R & D sought and the $ value and number of modi-

fications variables appear to be of sufficient importance to

justify closer examination. The $ value and number of modifi-

cations variables are <u>most</u> important in the NASA Analyses.

The reader should bear in mind that the ARC Analysis is per-

formed on contracts which are mostly firm fixed price (86%)

and that the NASA Analysis is concerned with contracts which

have substantial cost overruns. The conclusion reached in

this exploratory stage is that efforts should be made to

gain better representation for non-FFP contracts and that

farther analyses should be performed.

II. B. Work in Progress

1. Future Multivariate Regression Analyses. As described in 2f

above, it appears that multivariate regression analyses should

be performed as follows:

a. Regression Analysis on expanded data base (N = 150);

the additional 50 contracts representing non-FFP

contracts.

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b.   Regression Analysis on partitioned data base. These

analyses would include separate analyses on only

FFP contracts and separate analyses on non-FFP con-

tracts, the results to be compared.

2.   <u>Data Refinements.</u> These will include a critical examination

of the reasonableness and internal consistency of input data

prepatory to building a predictive model (described in III C

below).

3.   <u>Further Data Collection.</u> Solicitation of data for comparison

purposes will continue. Several sources of additional data

are potentially available but at this time are not confirmed.

C.   <u>Description of Problems Encountered</u>

The major problems to date concern both the lack of variation

in contract types and availability of coded data elements from

contract files. As noted in II A2 above, 88% of the cost reim-

bursement contracts let in the past two years were of the CPFF

type. The sample sizes for CPIF(1) and CPAF(4) are too small

for valid statistical inference on an empirical basis.

In addition, the condition of the historical data file is such

that it is extremely time consuming and expensive to generate

even a partial data base.

III.   <u>Proposed Research</u>

A.   <u>Ongoing and Projected Research</u>

1.   Although the legal environment for procurement and contracting

at ARC is well established by existing regulations and direc-

tions, more information is needed concerning local organiza-

tional and administrative procedures. In particular, the cri-

teria or method used for assigning procurement requests to individual contract teams is needed. It is expected that procedural descriptions will come from the research efforts in tracks 2 and 3.

Of more importance, perhaps, is information concerning the degree and type of pre-procurement communication and planning on the part of requestors and technical monitors. It appears that many contractual and D & F decisions are at least tentatively made prior to formal submission of the purchase request to the procurement division.

2. Ongoing research with respect to Procurement Situation, Method and Contract Type involves continued refinement of the data element list and the design of an appropriate summary data sheet format coded for computer input. Such appropriately coded information could be useful not only with respect to procurement method and contract type selection prior to contract award, but could also serve as the input to a dynamic, summary Management Information System for top management in the Procurement Division. It would be factual, computer based, and capable of status reporting individual contracts as well as comparison with aggregated indicators on previous similar contracts. In the later sense, it could serve as a useful control or selective management tool for control purposes. It is contemplated that this summary data sheet, appropriately coded for computer processing will be integrated into the management information system that is being developed in this project. Other aspects of this input to the MIS will be discussed in III A8 below.

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3. Projected research includes the investigation of alternative or additional methods of contract proposal, evaluation, and administration. For example, most procurement work statements do not appear to address incremental or marginal efforts or costs. Particularly for large contracts in which the work to be performed is not well defined it may be useful to request a potential contractor to propose or indicate the degree or extent of accomplishment expected for various contract amounts, e.g., what do you expect to accomplish if the contract is funded at $90,000 to $100,000 or $110,000? Conversely, what is your estimated cost at different levels of effort or output? Such incremental proposals might enable NASA-ARC personnel to evaluate at what level the marginal benefit is equal to or exceeds the marginal cost. With three or more such data points a partial "cost-effectiveness" curve could be constructed. The evaluation of this information might be highly subjective, but most helpful in determining optimal-seeking funding or accomplishment levels.

4. Projected research includes the coding refinement of data elements. As has been described above, the dollar value and number of modifications appear to be of sufficient importance in determining final contract cost as to justify closer scrutiny. Efforts have been launched to reconstitute these two variables into component variables such that "legimate" contract modifications for scope and/or engineering changes can be distinguished from those changes which, in effect, are solely for the purpose of adjusting negotiated contract

cost to agree with actual costs after the fact. It is important to note that of the non-FFP contracts in the original sample of 100 contracts, none had variation between actual cost and final negotiated contract prices.

5.   Ongoing Procurement Process Analysis. An ongoing portion of the project relates to the creation and maintenance of procurement process activity logs by selected procurement personnel. This effort is an attempt to capture dynamic aspects of the procurement process relative to:

> Procurement decision making and contract milestones
>
> Information flows
>
> Important external factors treated exogeneously by traditional procurement procedures

6.   Contract Type Selection Model. One of the original purposes of this phase of the total research project was to assist procurement personnel in the selection of an optimal contracting approach and structure in a given procurement situation. Despite the paucity of usable data for this purpose, it is still possible to construct a contract type selection model which attempts to predict the "best" contract type given a specific set of contract environment variables. The type of mathematical procedure for the construction of this model is multiple linear discriminant analysis. Linear discriminant analysis is an appropriate technique when the criterion variable is expressed categorically (two or more contract types to choose from) and where the predictor variables are at least interval scaled (cost data, degree

of R & D sought, etc. will be acceptable here). The application of discriminant analysis usually has four main objectives:

a.   Testing whether significant differences exist among the average "score" profiles of two or more apriori defined groups, assuming group covariation and dispersion are equal and the distributions are multinormal.

b.   Determining which variables account most for such intergroup differences in average profile.

c.   Finding linear combinations of the predictor variables that enable the analyst to represent the groups by maximizing among-group relative to within-group separation.

d.   Establishing procedures for predicting group membership.

It is this last objective which has special appeal for this project in that it addresses the problem which confronts contracting officers as they contemplate the need to select a particular contract type from a set of possible contract types.

7.   An Analysis of the Relationship Between Estimated and Actual cost will continue to be made. Although data limitations prevent extensive testing in this phase of the research project, preliminary findings seem to suggest that actual cost, performance and schedule attained in any contract is a random variable. It is hypothesized that the probability

distribution of this random variable may be described as a beta distribution.

The beta distribution is a two parameter (a and b) continuous distribution where the mean or expected value of the random variable is the parameter a divided by the parameter b. Parameters of the Beta distribution can be estimated apriori for various types of procurements based upon most likely, pessimistic and optimistic cost and performance estimates. As in PERT networks, the node (a - 1 / b - 2) can be considered most likely (i.e., target cost or performance value) and the end points can be considered as the most pessimistic and optimistic values, respectively. These estimates may then be tested against available data with respect to actual cost and performance attainment to accept or reject the hypothesis at some confidence interval. If the Beta hypothesis is rejected, alternate probability density functions may be examined for goodness-of-fit or a simple histogram or frequency polygon may be employed.

The fundamental purpose of the research is to determine if there is an open, systematic, verifiable and objective approach to the determination of contract types and the establishment of share proportions if incentive contracts are selected. A subsidiary purpose is to provide guidance as to the circumstances under which the use of incentive contracts is appropriate and in the best interests of the purchaser.

The significance of the research relates to or stems from the fairly long history of the use of cost reimbursement and

incentive contracts which has been surrounded by much controversy. If a more tractable method of determining when and how incentive provisions should be used, much of the controversy might be resolved. The end result could well be more efficient contracting both for the buyer and the seller.

8.   Procurement Cost Monitor.   Means to monitor procurement cost deviation from expected might be developed through the combined use of traditionally available information and an operational management information system. The data to be used would include:

P.R. Cost Estimate

Negotiated Contract Price

Total Dollar Value of Modifications

Total Dollar Value of Modifications for Scope and Engineering Changes

Actual Contract Price

Adjusted Negotiated Contract Price (Adjusted only for scope and engineering changes - excludes modifications for change orders)

It is anticipated that a combination of historic precedent and managerial judgement might be applied to a series of ratios $\left(\text{e.g., } \dfrac{\text{Total \$ Value of Mods.}}{\text{Negotiated Contract Price}}\right)$ significant deviations from expected would be reported to management.

Section 5

Development of a Management Control System for
Planning and Controlling Manpower Requirements

Section 5

Development of a Management Control System for
Planning and Controlling Manpower Requirements

I. **Overview**

   This project has focused on the development of a management control
system for use in planning manpower requirements, in communicating the results
of operations and also the subsequent coordination of tracking contracts and
PO's. The control standard to be used will be a standard based on estimated
past performance. The classification for various milestones performance
will be similar to that developed by Langley Research Center. As more
accurate information is accumulated, the original estimated standards and
the standard labor hours will be modified. In addition to the creation and
use of standards for management controls a data base will be created to pro-
vide information for various status reports (e.g., milestones missed, man-
power planning requirements, buyer proficiency reports, etc.).

II. **Activities Report**

A. Accomplishments to date

   1. A general investigation of various types of managerial control
      systems in use has been made through a search of the literature in
      the field to determine if an existing system could be used at ARC.
      There is a paucity of material available concerning administrative
      feedback in the public sector, and the information available seems
      to offer the author's conclusion and not empirical evidence. The
      effectiveness of feedback in the administration of public sector
      subordinates seems to be based mainly on assumptions. In the
      business sector, most applications have been concerned with overall
      integrated management systems encompassing all functional areas with-
      in a profit oriented firm or have been concerned mainly with the
      delegation of authority and accountability to responsibility centers
      such as cost or revenue centers, profit centers, discretionary cost
      centers, or investment centers. These industrial systems have little
      applicability to ARC Procurement. Various management systems such
      as MAPS--A computerized Management and Planning System designed by
      Donald R. Packe--are designed to provide fast and economical informa-
      tion for managers of large technical projects but have not direct

application for ARC Procurement. Other systems in use such as contract management systems used by industrial firms to establish performance measurement criteria on major defense contracts also do not have a direct application for ARC Procurement. It is concluded that the uniqueness of the organization requires the design of an individual system. The general outline of such a system has been developed and conceptually integrated with the Purchase Request (PR) tracking system. The general type of reports which can be generated and the data base are discussed below.
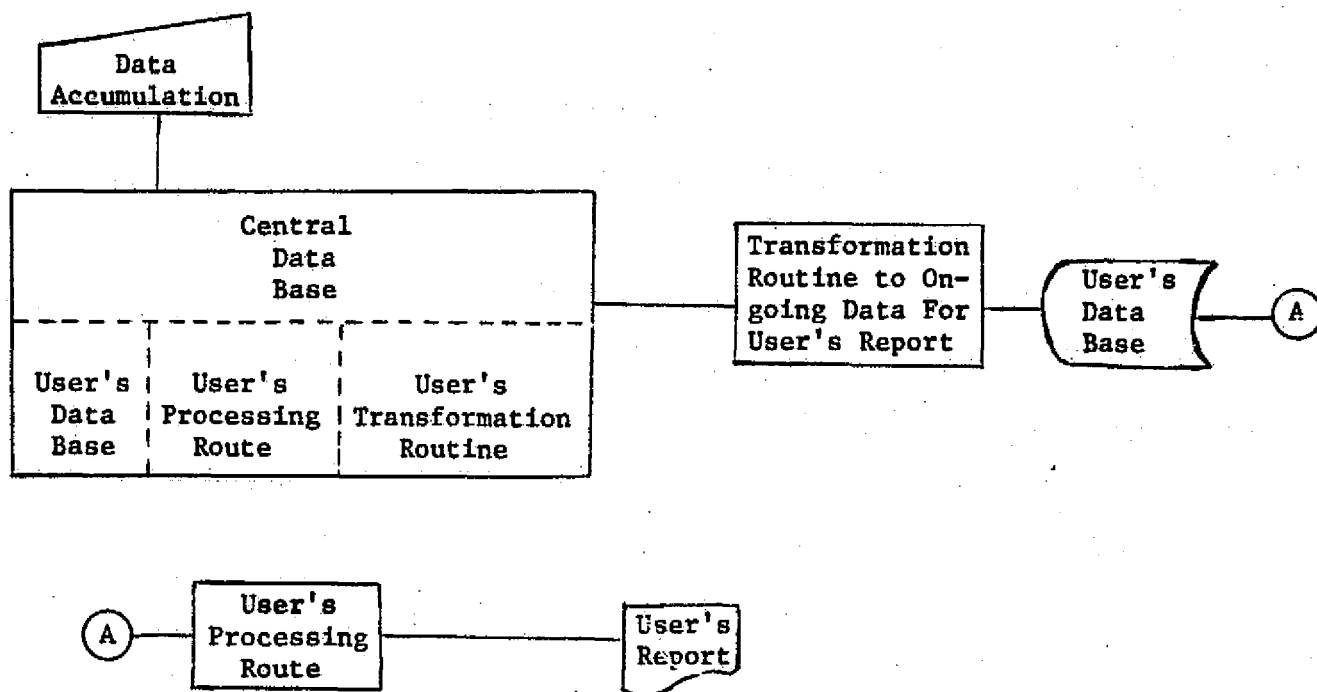
2. The advisability of using 'standards' has been investigated. It would appear that no single definition can encompass all meanings of the term. While circumstances may dictate comparison of present to past performance, it is by no means clear that this is a pertinent yardstick. It does, however, provide a starting point. In most organizations, the setting of standards is primarily an engineering function. When establishing standards a decision must be made on the level (tightness) at which the standards should be set since implicit in the concept of a standard is an acceptable level of perfor- mance. A theoretical performance standard is a perfection standard since it represents the best performance possible with the given capabilities. This standard would include allowance for rest periods, but not for lost time. The standards are goals for improving efficiency but the standards are not expected to be attained. An attainable good performance standard does not eliminate lost time but includes this element to the extent that management considers it impractical of elimination. An average past performance standard contains average past inefficiencies of the organization. Such a standard is consider- ably looser than the preceeding standards. Normal performance standards

are expected to characterize the average over a number of future periods--they are often between the extremes of attainable good performance and average past performance. Setting labor time standards involves two basic questions: what operations are to be performed and what time is to be allowed in each operation. Estimates of what time is to be allowed may be determined by averages of past performance, time and motion study, test runs, advance estimates or standard motion-time data. If operations have been performed in the past, a simple way to set standards is upon averages of past performances. Time and motion study involves study of average workmen with a stop watch as the operations are performed. Test runs may not be reliable because the working conditions are never static and two jobs rarely take the same time. Advance estimates are primarily useful where the operation has not been performed before. Standard motion-time data involves a system of predetermined times associated with basic or fundamental motions. After a review of the literature in the field, it has been tentatively concluded that the most appropriate standard for use at ARC is a standard based on estimated past performance. The classification for various milestones performance will be similar to that developed by Langly Research Center (see Appendix 5-A) for a brief description). The Langly Research Center estimates are the calendar days necessary to reach certain milestones. ARC procurement will have similar but slightly different estimates as well as a different contract classification. (see ARC classification in Appendix 5-B). The original estimated standards will be modified as more accurate information becomes available through accumulation of historical data. The standard labor hours necessary to achieve the milestones will also be developed and modified as historical data becomes available. While the basic purpose of the standard is to create visibility to management of

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possible problems for investigation, a secondary purpose is the development of a manpower evaluation system (as explained in Professor Pohl's track) as well as to help in manpower planning.

3. A management control system depends to a large extent on the type of data base that is generated. Various conceptual types of data bases have been investigated. In view of a basic goal of this project-- achieving some level of generality within the total NASA organization-- an events management information system as proposed by Lieberman and Whinston seems to be appropriate. While such a system uses a mass data base, it enables each user to express his own view of the data base allowing him to organize the format of reports to suit his individual preference. This type of data base has the capability of using functions defined by the user to operate on selected data. The management system makes use of this structured definition to retrieve the desired information. Since the individual user is concerned with only a portion of the entire data base, the subset data is used to prepare the desired reports.

The following diagram indicates the relationship between the general data base and the user's reports.

```
 _____
|Data            \
|Accumulation    |
|_____/
        |
 _____|_____              _____        _____
|           Central                     |            |Transformation    |      /User's    |
|           Data                         |-----------|Routine to On-    |-----| Data      |----( A )
|           Base                         |           |going Data For    |      \ Base     |
|- - - - -T- - - - - -T- - - - - - - - - |           |User's Report     |      |_____|
|         |           |                  |           |_____|
| User's  | User's    |    User's        |
|  Data   | Processing|  Transformation  |
|  Base   | Route     |    Routine       |
|_____|_____|_____|


                 _____
                | User's       |                        _____
      ( A )-----| Processing   |----------------------/ User's    |
                |  Route       |                      | Report    |
                |_____|                      |_____|
```

4. Data base design. The data base will provide information for various

    tracks in the research project: Procurement Cycle Similuator Project,

    Work Load Scheduling Model, Determination of Influences on Contract

    Type and Structure. The ARC purchase request tracking system is

    currently installed for contracts equal to or over $10,000. A weekly

    status report as well as a weekly milestone report are prepared, (see

    Appendix 5-C for samples of the reports). The data base of the PR

    tracking system forms much of the central data base (detail of the PR

    data base is provided in Appendix 5-D). Additional data must be pro-

    vided by the Buyers as they complete the following milestones:

                    M1   Information available to support request
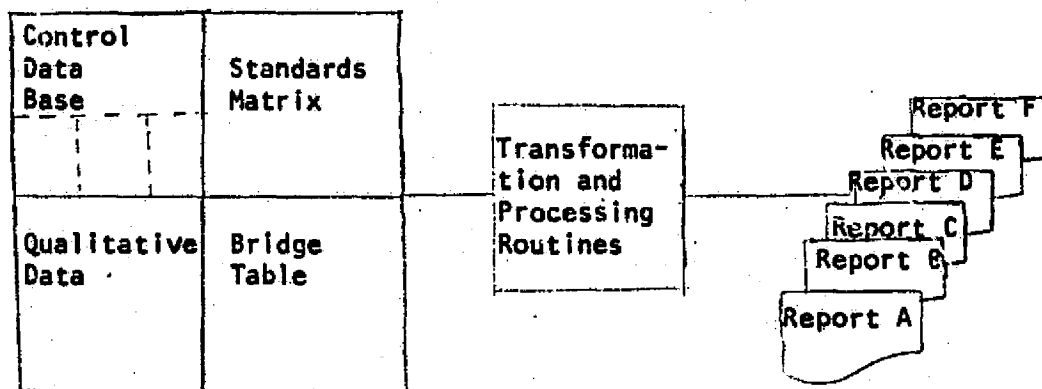   M2   Solicitation issued

M3 Proposals received
M4 Proposals evaluated
M5 Negotiations complete
M6 Contract awarded

To simplify the data collection tasks for the buyers, a perforated route sheet will be attached to the PR and as a milestone is reached it can be detached and collected. At this time any expected deviation from the standard time expected to achieve the next milestone will be recorded also. If the standard time is expected, no additional information will be necessary.

Additional data must be provided to show the milestone standards in hours and work days by the basic contract classification (this basic classification is shown in Appendix 5-B). This standard basic milestones matrix can be updated as additional historical information becomes available. In addition, a bridge table to convert the demand from the various technical divisions into the expected volume of contracts according to the basic contract classification must be provided. This bridge table can also be updated as historical data accumulate.

Data must also be provided by the review function concerning quality attributes. This data is necessary to help insure the effectiveness of the procurement mission and to assure that quality as well as standard time for the milestones are considered. This data should include direct feedback, perhaps on a sample basis, from the technical divisions. If it is desired to accumulate data on an ongoing basis to determine Influences on Contract Type and Structure, the review function will also have to furnish some additional information. The following diagram shows the general data base system. As explained above, this general data base is modified through transformation routines to generate the reports mentioned in section 5 below.

Control Data Base	Standards Matrix
Qualitative Data	Bridge Table

Transformation and Processing Routines

Report F
Report E
Report D
Report C
Report B
Report A

5. <u>Types of reports generated.</u> The following reports are considered part of the total management control system and can be generated in any frequency desired.

A. Milestones missed--a report showing milestones missed on contracts and the responsible buyer. This report is based on the exception principle.

B. Manpower planning requirements--after an estimate of contract demand by technical divisions has been provided, a report will be generated showing the manpower requirements necessary to process the expected contracts according to the standards established.

C. Buyer proficiency report--will show the details of buyers performance according to work measurement and evaluation criteria established in Professor Pohl's track.

D. Productivity Analysis--a report showing the number of contracts processed by basic contract classification and total and average hours and days needed to complete milestones.

E. Procurement cycle simulation--provides the details of Professor Vancura's track.

F. Purchase request tracking reports--as presently generated.
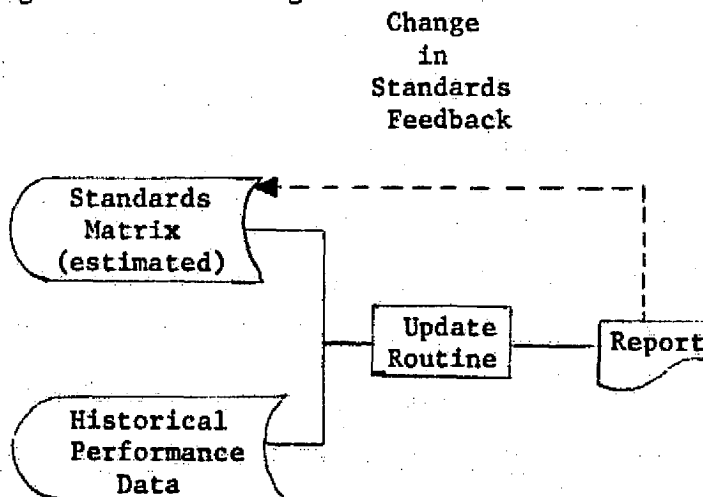
(See Appendix 5-C for detail)

B. Work in progress

Currently the appropriate scope of the management control system is being evaluated. The question under consideration is the following: should the system be completely automated from the task of printing contracts to generating reports or must there be several subsystems? This question is most applicable when considering the generality of the system to NASA as a whole. In addition, evaluation of the appropriate computer configuration is under consideration.

C. Description of problems encountered

1. Originally there was a problem in the linkage of the management control system with the PR tracking system. This problem has been overcome.

2. The problem of adjusting coefficients used in the input-output report format (originally a conceptual problem) has been solved by selection of a standard based on estimated average past performance. As discussed above, there are two basic types of standards--engineered and historical. The use of a historical standard allows modification when working conditions change as indicated below:

Change
in
Standards
Feedback

3. One problem which has not been solved is the availability of
past performance data. The lack of data necessitates a period for
data accumulation before some reports become operational. The only
practical effect, however, is to delay implementation. It will also
be necessary to gather data for use in other tracks of this research
project as discussed above.