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ORGANIZATION OF A COUNTDOWN

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ABSTRACT

The Organization of a Countdown was developed over 8 years of missiles and space systems testing at the Douglas Aircraft Company, Sacramento Test Center. The experience on which this study was based includes the Thor development and acceptance testing, Titan I second stage engine development testing, development of liquid hydrogen handling techniques, Saturn S-IV and S-IVB development and acceptance testing. The intent of this paper is to examine the static test countdown organization and discuss the need for a systematic method to organize a countdown.

ORGANIZATION OF A COUNTDOWN

To attain the optimum use of manpower, it is essential that the Test Conductor apply accepted management techniques in order that each individual function may be accomplished with a minimum of friction and that a job may be done in a most efficient manner.

There are many methods that are available to a Test Condcutor that enables him to efficiently plot the functions of the countdown crew so that he can graphically present and evaluate all essential tasks. This presentation illustrates one method that the author has found to be very successful for initially organizing a countdown and is particularly valuable to a Test Conductor when he is attempting to improve the effectiveness and efficiency of a countdown organization.

SETTING STANDARDS

It has been said that a full day's work cannot be judged until standards have been set. The safe workload should be considered because an overworked person cannot do a full day's work. When an engineer is allowed to work as a technician, or vice versa, he is not given a full day's work. Setting standards is interrelated with a prerequisite for giving an individual a full day's work. The Test Conductor, just like any good manager, must have a good working knowledge of ways and means to set standards of operation. You live by standards and if you fail to meet those standards, you suffer the consequences. An example is driving your automobile. Anyone who fails to follow such standard operating procedures as driving on the right side of the road, stopping for a red light, going neither too fast nor too slow, displays to all who may observe him that his performance is not up to standard. The logical results of that person's actions might be damage to his car, injury to himself, or paying the penalty prescribed by law.

The Test Conductor must insure the proper setting of performance standards. This is mandatory to insure more accurate scheduling and safety of operation. It is poor management to attempt to "manage" without knowledge of how long it should take to perform work.

The successful countdown is based upon the Test Conductor's ability to accurately measure the time it takes to perform the various functions so that they can be accurately scheduled. Adhering to that schedule will permit all the personnel involved to know what is happening at any given time during the countdown.

Work measurements can be simply defined as "the evaluation of work in terms of time" and consists of the following basic types:

1. Statistical - A standard or average relating expenditure of labor and units produced and based upon a mathematical analysis of past performance.

2. Engineered - A standard time for doing a job according to a specified method, as determined by actual observation during performance of the job.

3. Pre-approximated - The time required to do a job based upon previous values of time for the basic elements accomplished by specific methods.

4. Estimated - The time it takes to do a job based upon the best judgement of those most familiar with its requirements.

If one evaluates these basic types of work measurement, it can be seen that under certain conditions the Test Conductor can use almost any one of the four. However, in the space industry, the fact that program schedules are usually dictated at the time of contract negotiations rather than as the program materializes, often technical requirements and restrictions are individually added which make the contracted milestones difficult or almost impossible to meet. The allowable time to perform the countdown often follows this same technique because a systematic approach is not used. This is wrong. Management expects good results from the test and if the Test Conductor fails to give proper attention to work measurement for setting countdown standards, his countdown schedule will fall apart thus creating confusion and demonstrating an undesirable image of the company, countdown crew and himself to all concerned.

Delays due to equipment malfunctions are understood by all as this creates a "hold" condition, but a "hold" caused by poor scheduling of functions or tasks creates many undesirable problems which in turn tends to jeopardize the effectiveness of the test. This brings us back to the choice of technique to measure the work required to accomplish the countdown so performance standards can be set. The easiest and quickest for each function and task is the Estimated. This technique is most often utilized, and in many cases without proper disciplines. The key is that the time estimated should come from that person most familiar with its requirements.

The technique is to make three (3) estimates as follows:

1. The shortest estimated time

2. The longest estimated time

3. The most likely time

A single estimate tends to bring out the question: "How come its taking you so long?", or "I can't do it in that much time". So, start out the countdown functions and tasks with three estimates. Utilize the most likely, but where the estimate varies widely between experienced individuals, make an Engineered measurement by running a mock function or task if the real thing cannot be accomplished.

Once you have systematically estimated the time it takes to perform each function and task required to accomplish the Countdown, you now have the performance standards by which to schedule.

The time required to accomplish different functions can be compiled into a card file which can be used for future countdownsin order to determine performance standards with which to schedule the different countdown tasks.

SCHEDULING

Scheduling the countdown efficiently has widespread implications. If a technician or engineer waits for the Test Conductor to get around to him personally, the scheduling is inadequate. The Test Conductor must develop a good schedule which is understood by all. This requires the following:

1. List all functions required to accomplish the countdown

2. Determine how much time is required to accomplish each function

3. Group the functions into tasks

4. Schedule the tasks in the order that they are to be accomplished.

Once the tasks and schedules have been established, the Task Leaders should then be assigned so that the Test Conductor builds his organization with the proper span of control to adequately control countdown activities.

SPAN OF CONTROL

Proper span of control means that the Test Conductor has the correct number of Task Group Leaders. If so, he can accomplish all of his work.

Span of control means the number of people a Test Conductor can efficiently control. The number of individuals a Test Conductor can effectively supervise is limited by his time, energy, and the complexity of the human relations involved. Therefore, there must be a limit to the number of individuals responsible to the Test Conductor. The factors that limit the number of individuals that can be effectively managed are:

1. The complexity of the task (technical or routine)

2. The work the Test Conductor must do himself

3. The skill level of the countdown crew members as to the amount of initial training or retraining necessary

4. The physical layout of the Test Complex

In the past, the concept that one could effectively manage no less than three nor more than seven workers was widely accepted. But situations may arise, due to the physical layout of the Test Complex, which locate two countdown Task Leaders large distances apart without proper communications, so that any Test Conductor would be taxed beyond his management capabilities. However, during portions of the countdown as many as 20 panel operators such as a routine propellant loading would not exceed the capabilities of most Test Conductors. Therefore, the number of personnel any Test Conductor can effectively manage is largely dependent on these and the following factors. The Test Conductor's work situation wil not remain stable if there are differences in objectives between various tests. This dictates the training and retraining of countdown crew members as a constant project. A Test Conductor that effectively managed a well-trained countdown crew may find that he is unable to effectively manage an inexperienced countdown crew because his span of control has been enlarged beyond the effective scope of his direction.

Another reason for limiting the number of Task Leaders under the Test Conductor's supervision is the number of relationships that exist between the Test Conductor and his Task Leaders, and between the Task Leaders themselves. When a small number of Task Leaders are being supervised, the situation is comparatively easy to cope with because of the relatively few relationships involved. However, it must be remembered that as Task Leaders are added the number of relationships increases at a much greater rate than the number of Task Leaders. The personality and general abilities of the Test Conductor should also be considered. These factors explain the reason why one man can supervise eight (8) Task Leaders fairly well and another man breaks down under the same load. Some countdown organizations burden the Test Conductor with as many as 25 activities under his direct supervision, in which some degree of success was occasionally achieved primarily due to highly trained workers, and Task Leaders being assigned who were eager to accept responsibility and able to assist the Test Conductor in getting a countdown accomplished successfully.

Experience in many and varied types of countdown situations has fully substantiated the concept of limiting span of control during the course of the countdown by limiting the number of tasks through homogeneous grouping and proper scheduling which restricts the amount of activity at any one time so that it can be controlled.

A careful analysis of many of the varied forms of countdown organizations reveals that the most successful organizations limited span of control to a maximum of five reporting directly to the Test Conductor during test operations which takes place prior to all personnel clearing the area and retiring to the Test Control Center. In the Test Control Center, it was found that the Test Conductor can effectively control up to 20 during the propellant loading, static firing, and propellant unloading tasks. This is when the Test Conductor is the Task Leader and the crew is molded together into a homogeneous team striving to accomplish one task at a time and the number of people involved is often a function of the instrumentation and controls equipment layout and design.

DELEGATION OF AUTHORITY

Following span of control, a proper delegation of authority affects the scheduling of assigned countdown personnel. For example, it has been said that whenever a line forms at the coffee machine, countdown crew members are not required for an essential function or given a full day's work and are not scheduled effiently.

The Test Conductor is vested with the responsibility and the authority to accomplish the work of the countdown organization. In the final analysis, success in performing the objectives of the countdown depends upon the Test Conductor. If the countdown crew has been well organized and trained, the principal of the span of control observed, responsibility and authority will be delegated to subordinate Task Leaders. The Task Leaders who become responsible for the performance of certain tasks must also have the authority necessary to carry them out. Proper delegation - will speed up production and insure a safe and successful operation by spreading the supervisory load, and also develop initiative and leadership.

It is a Test Conductor's responsibility to make such delegations as well as train subordinates to accept them. Train the Task Leaders to come to the Test Conductor with their own recommended decisions. If the Test Condcutor is burdened with a Task Leader who does incomplete work, the Task Leader must be trained or replaced. Complete problem solving includes the collection of facts, analysis of the problem, and the presentation of a solution in such form that the Test Conductor need only indicate approval or dissapproval. The Test Conductor should assign a Task Leader, be sure that he can do the job, then leave him alone. There can be no delegation of authority or assignment of responsibility to those who are not able to take it. There can be no decentralization of operations to those who cannot cooperate or the Test Conductor will lose his span of control. Delegation of authority requires that responsibility be assigned to another only when he is prepared to take it; and that full authority is to accompany full responsibilities at that very same instant.

Delegation of authority also requires that no matter what tasks are given, or what authority is delegated, the delegation is still accountable. The Test Conductor must accept the responsibility for a failure. The Test Conductor delegates the authority to accomplish a task to the assigned Task Leader who in turn delegates portions to the workers who actually accomplish the task. The Test Conductor must support his countdown personnel, even though they may err he is responsible and must see that it doesn't happen again. The Test Conductor should use the principle of "praise publicly and reprimand privately" in order to build Esprit de corps and develop leadership. He should delegate authority only to the extent necessary to meet the assigned responsibility - no more than is required, and no less.

ESSENTIAL TASKS

The word "essential" means essential to the objectives of the test, the objectives of the program, and the objectives of the company. Each man should be used on "essential" functions in the test.

As Test Conductor you should question the need for every function. You may find that there are jobs which are not really essential, that there are certain functions which contribute somewhat more than others but are not justified in terms of time and effort, or that there are some functions which are still being accomplished even though they have been determined to be non-essential to the objectives of the countdown.

Certainly, any work done for oneself or for another person uses time, material, and energy, and should contribute to the objectives of the countdown. Often restrictions must be disseminated to control non-essential work. Taking time out to brief visitors individually is an example of non-essential work during the countdown. This should be accomplished by someone other than countdown crew members so that their concentration will remain a part of the countdown. Question the need for every function, and eliminate those that have little or no value and are not worth the cost.

The Test Conductor's job should consist of directing not actually performing the duties. The essential functions done as an assigned member of the countdown crew becomes less important when a man becomes a Test Conductor. All essential functions must be considered by the Test Condcutor in making decisions. Thus a Countdown Distribution Study by the Test Conductor is necessary to visualize all essential functions as to their relationship and place in the countdown. In order to use a man fully on an essential function, the Test Conductor must check results. The best means of checking results is to follow the pattern of setting standards, establishing the standard, check the work against the standard, and to bring the countdown crew to standard. Finally, improving work methods contributes to proper scheduling through the use of assigned countdown crew members fully on essential tasks.

LOGICAL ASSIGNMENT

The principle of logical assignment has within its scope the assignment of all necessary functions within an organization to specific individuals, and it means that all employees must have a job to do. All countdown crew members must know what his area of work includes; that area must involve related jobs, and his job must fall within that area. There is a tendency toward less effeciency in miscellaneous jobs. It is the Test Conductor's responsibility to develop tasks and task leaders specialized in given areas or systems, not jacks-of-all-trades. A man who is trained to do his job which is a logical assignment will be enthusiastic and proud of his work. The morale of a man who does everything for everyone is usually not high. He should work within the area of his knowledge and training. Then he will understand his assignment and do a good job. One mistake is the assignment of engineers to responsible positions without the proper exposure to operational training under countdown conditions. The idea, that the engineer is an expert in the meaning and use of numbers is shared by engineers and laymen alike. Engineers have been exposed to varying degrees of mathematical discipline during their formal education and design experiance, and tend to think of a numerical solution as a fixed value, or that they know the one best answer to a problem, correct to seven (7) places on the slide rule which is not subject to variation, evaluation, or qualification. They seek the magic numbers on which to base the design of a product, a process, or test facility. However, away from the textbook problems, where real numbers are obtained in field tests, these numbers do not always come out the way the equations are written. Sometimes the agreement is good, and frequently we can paraphrase the waiver of the fiction writer, "any resemblance to the real process, living or dead, is purely coincidental".

It is the responsibility of the Test Conductor to pick the engineer who has had training and experience in a given field to become a task leader. Then he can be praised or blamed according to his work.

Logical Assignment requires that all functions within a task be specific, clear cut, and similar in nature. Of course the Structures Engineer should not setup the instrumentation systems. It is easy to understand those widely separated functions and occupations but the principle of logical assignment must be applied to a much finer degree. Checking circuit breakers is a logical assignment. But when the circuit breaker boxes are located in four different areas it is logical to assign those functions to a Task Leader performing similar functions in that area. This eliminates overlapping. Each Task Leader's functions should be clear cut within an area. Dividing work so that very little overlap on equipment or within an area occurs improves the quality and increases the quantity of output.

Responsibility must be fixed. No jobs should be left for all to do, because all will leave it to someone else and then — disaster. Countdowns have been scrubbed and missiles blown up because some jobs were left unassigned and overlapping of functions on the same equipment caused confusion.

COUNTDOWN DISTRIBUTION STUDY

The Test Conductor must analyze the work distribution in his countdown organization. He must see clearly all the activity of the countdown crew at a glance. In order to see the activities of the countdown crew in one place clearly, and know how each countdown crew member contributes to the total accomplishment, he should use a countdown distribution study for each and every countdown performed. The elements of a countdown distribution study are as follows:

1. Objectives of the test.
2. Tasks required to perform the test.
3. Functions required to perform the test.
4. Work distribution chart.

OBJECTIVES OF THE TEST

Objectives are assigned to each countdown. These goals or objectives are the end result that the assigned memebers of the countdown crew are responsible for achieving or producing. To be of any value, the objectives must be clearly and specifically stated. As an example, objectives of a Space Vehicle Static Firing Countdown are listed below.

The primary acceptance objectives are:

1. Demonstrate that, within the test complex capability, countdown operations can be performed in the sequence and within the time framework allocated for this individual stage portion of the KSC countdown.

2. Demonstrate that the engine exhibits operating characteristics compatible with the stage design requirements and consistent with Model Specification 215bs.

3. Demonstrate that LOX is supplied to the engine inlet within the established operating limits through the proper functioning of the LOX tank pressurization and supply system.

4. Demonstrate that LH2 is supplied to the engine inlet within the established operating limits through the proper functioning of the LH2 tank pressurization and supply system.

5. Demonstrate that the pneumatic control supply furnishes sufficient helium at the correct pressures to provide adequate pneumatic valve control and system purges.

6. Demonstrate that the PU (Propellant Utilization) system can control the loading and consumption of propellants within the design requirements of the stage and engine as applicable to acceptance firing.

7. Demonstrate that the data acquisition system is operating properly and is capable of performing assigned functions.

8. Demonstrate the proper operation of the stage control and power supply systems and stage GSE interface during the firing.

9. Demonstrate that the pressure and temperature levels of the hydraulic systems are within acceptable limits. Demonstrate servo system performance in gimballing the engine in response to servo valve input commands.

10. Demonstrate the structural integrity of the stage.

11. Demonstrate that the stage portion of the auxiliary propulsion system responds to commands from the Instrument Unit Substitute.

The secondary research and development objectives are:

R-1 Determine the performance of the fuel tank wet wall insulation system and the thermodynamic environmental and response of structures and components during cryogenic loading and the acceptance firing.

R-2 Determine the vibration input or response of propulsion subsystem components, electronic equipment, and primary stage structure. Determine the acoustical environment inside and outside the forward skirt.

The objectives are the first thing the Test Conductor should assemble when he starts the countdown distribution study. The objectives in a large measure define test configuration. All objectives should be listed as primary and secondary; which gives the countdown crew prior knowledge of critical parameters during the test which would: (1) cause a hold until the discrepancy is fixed, (2) it is safe and can the test be continued, (3) is there more to be gained by continuing rather than holding or scrubbing the test. This is the kind of decision which continually plagues the Test Conductor. He must be positive but at the same time depend upon the countdown crew members to furnish him with those facts to properly make the overall decision; and to those people who have their objective scrubbed, obviously it is often the wrong decision.

TASK LIST

The preliminary task list is first prepared listing all known tasks which may be required to perform the countdown. All technical and support groups should be contacted and asked to submit a list of tasks they think would be required to perform a countdown on the specific test stand. This list must include all possible tasks from housekeeping chores to fueling and firing the missile.

A typical list of tasks submitted for a static firing for a specific test stand would be as follows:

1. Pre-Countdown Check List
2. Countdown Initiation
3. Propellant Transfer Lines Preparation
4. Hydraulic Accumulator Charging
5. Circuit Breaker Setup - and Seal Box
6. Thermal Conditioning Setup
7. GH2 Storage Area Setup
8. Automatic Equipment Setup and Power Turn-On
9. Redline Checks
10. Helium and GN2 Storage Area Valve Setup
11. Vent Alarm Check
12. Abort Mode Checks
13. Manual Control Test
14. Common Bulkhead Sampling Setup
15. LN2 Purge Vaporizer Setup
16. Test Stand Prepartaion
17. LOX Storage Area Setup
18. Pneumatic Console GH2 System Leak Check
19. Burn Pond Inspection
20. Fuel Storage Area Setup
21. Fire Detection System C/O
22. Hydrogen Leak Detection C/O
23. Water System Setup
24. Camera Setup
25. Ground Firex System Verification
26. Integrated Systems Test Preparations
27. Aspirator and Deflector Plate C/O & Test Stand Firex Verification
28. Integrated Systems Test
29. Engine Bell Extension Service Unit Setup
30. Environmental Purge C/O
31. World Purge and GH2 Auxiliary Storage Bottle Checkout
32. LH2 System Sampling
33. Final Instrumentation Setup
34. Common Bulkhead Decay Start
35. Reverify water and Pneumatic Setup
36. Preventative Maintenance
37. Test Stand Clearing
38. Common Bulkhead Sampling #1
39. Redline Observer Briefing
40. Common Bulkhead VAC Securing
41. Transfer to High Press HE Supply
42. LOX Loading
43. Fuel Loading
44. Static Firing Preparations
45. Terminal Countdown and Firing
46. Propellant Offloading
47. Console "B" & Engine Start Tank Purge (HE)
48. Replace GN2 Crossover
49. Data Removal

50. Automatic Analog Self Check
51. Post Test Purges
52. Post Test Inspection
53. Test Stand Securing
54. LH2 Stor and Xfer Securing
55. LOX Stor Securing
56. Camera Unloading
57. Secure Water Systems
58. Facility Securing
59. Battery Installation
60. "Q" Meter Installation (Activation)
61. "Q" Meter Removal (Deactivation)
62. Battery Removal

It should be noted that in the Missile and Space System industry much confusion regarding the meaning and use of Function versus Task has in some cases caused the adoption of countdown methods with poor utilization of personnel, duplication, and non-essential functions. These countdowns have been successful but complicated countdown communications can drain heavily on the resources of a program and the company to perform them. This in turn dilutes the amount of information gained during a given time span.

A function is a specific piece of work to be done or work imposed to accomplish a task.

A task is an action including its planning and execution. Loading fuel would be a task, and the work required to accomplish this task would be the function.

Once the preliminary task list has been submitted to the test conductor, he can either accept the task list as is, or attempt to combine those in which he may think overlap or are duplication. However, this is not the proper time to reduce the number of tasks as each one has been only briefly described and all factors have not been evaluated.

It is first necessary to collect all the functions for the various tasks and lay-out of the countdown distribution study to determine where duplication of effort occurs which may cause the combining of tasks.

The typical countdown distribution study should follow the flow diagram shown. (See Figure 3-1).

Since we are following the typical flow diagram (Figure 3-1), we have collected the preliminary task list, the next step is to assign a countdown distribution study task leader to each preliminary task for purposes of listing all of the functions performed during a given task. The preliminary tasks should be listed on a countdown distribution study form (See Figure 3-2). To simplify this presentation only facility tasks will be used. It must be understood at this time that the task leader will list every function he thinks may be

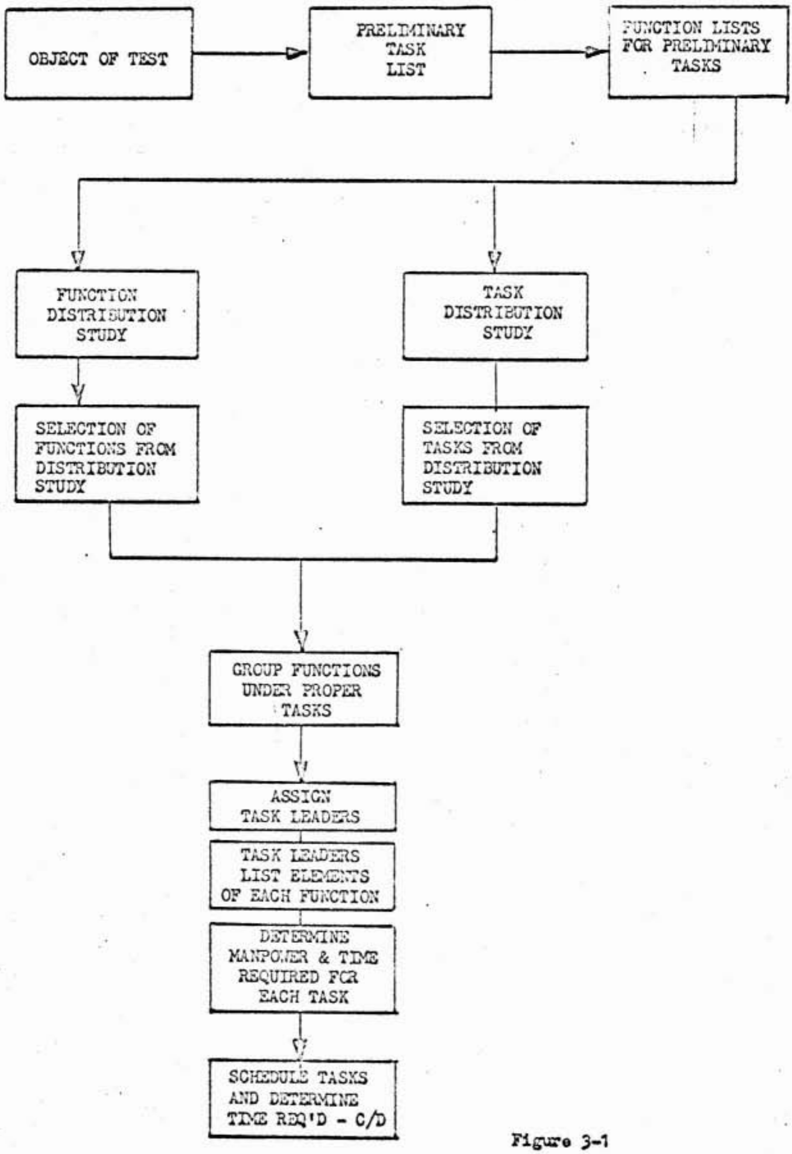

OBJECT OF TEST
PRELIMINARY TASK LIST
FUNCTION LISTS FOR PRELIMINARY TASKS
FUNCTION DISTRIBUTION STUDY
TASK DISTRIBUTION STUDY
SELECTION OF FUNCTIONS FROM DISTRIBUTION STUDY
SELECTION OF TASKS FROM DISTRIBUTION STUDY
GROUP FUNCTIONS UNDER PROPER TASKS
ASSIGN TASK LEADERS
TASK LEADERS LIST ELEMENTS OF EACH FUNCTION
DETERMINE MANPOWER & TIME REQUIRED FOR EACH TASK
SCHEDULE TASKS AND DETERMINE TIME REQ'D - C/D

Figure 3-1

COUNTDOWN TASK LIST		DATE
TASK NO.	DESCRIPTION OF TASK	REMARKS
7	GH2 Storage Area Setup	
10	Helium and GN2 Storage Area Valve Setup	
15	LN2 Purge Vaporizer Setup	
17	LOX Storage Area Setup	
19	Burn Pond Inspection	
20	Fuel Storage Area Setup	
21	Water System Setups	
25	Ground Firex System Verification	
27	Aspirator & Deflector Plate Checkout and Test Stand Firex Verification	
31	World Purge and GH2 Auxiliary Storage Bottle Setup	
35	Reverify Water and Pneumatic Setup	

FIGURE 3-2

necessary to perform the task and that the preliminary list of the functions are subject to change by deletion, combination, or addition as the countdown distribution study progresses. Also, it is important that the study task leader physically understand the equipment layout and location in order to include the functions of movement and pre-arrangement of equipment in performing the task. At this time in the countdown distribution study you are not interested in determining manpower requirements. This will occur later in the study after the selection of the necessary functions and tasks have been made. (See Figure 3-1)

Thus, 11 preliminary facility tasks have been submitted. It should be noted at this time that these 11 preliminary tasks could be accepted and merely collect the functions required to accomplish each and write the countdown without the benefit of a proper analysis through the countdown distribution study. Therefore, the countdown distribution study should be utilized to determine functions which may be incorporated into another task, or which tasks could be combined. All tasks and functions must be analyzed against the following:

1. Do the preliminary tasks meet the requirements of "ESSENTIAL TASKS" during a given time in the countdown?

2. Are the functions LOGICALLY ASSIGNED into the proper tasks?

3. Is the principle of "DELEGATION OF AUTHORITY" and "SPAN OF CONTROL" followed?

4. Are SAFETY and TECHNICAL CONSIDERATIONS satisfied?

5. Are available RESOURCES in terms of manpower and equipment available?

The function lists for preliminary facility tasks 7 and 10 would then be accomplished as listed. (See Figures 3-3 and 3-4). In order to simplify the presentation, the function lists are also concerned only with the facility items. At this point the preliminary task and the function lists have been accomplished. (See Figure 3-1).

The function and task distribution studies are now ready to be performed. This is accomplished by a work sheet (See Figure 3-5) which lists all of the preliminary facility tasks and functions.

In creating additional or combining existing tasks or functions, the basic factors previously listed must be considered. The Test Conductor's judgement must be based on these factors or he will lose control of the countdown. If there is a reasonable explanation for unnecessary movement, or an essential task which seems to be repeated, then the span of control must be maintained through proper communication and cooperation. Often, personnel are required to repeatedly enter an

FUNCTION LIST OF TASK

TASK DESCRIPTION		TASK NUMBER
	GH2 STORAGE AREA SETUP	7
FUNCTION	**DESCRIPTION**	**TIME REQ'D**
1.	Proceed to GH2 storage area	10 min.
2.	Set up GH2 trailers and record pressures	15 min.
3.	LH2 tank and vaporizer setup	10 min.
4.	Set up transducer boxes, communications, and junction boxes	5 min.
5.	Check all remotely operated valves and regulators	5 min.
		TOTAL HOURS OF WORK

DATE	TASK LEADER	DATE	TEST CONDUCTOR

FIGURE 3-3 -

FUNCTION LIST OF TASK

TASK DESCRIPTION		TASK NUMBER
HE & GN2 STORAGE AREA SETUP		10
FUNCTION	DESCRIPTION	TIME REQ'D
1.	Proceed to He/GN2 storage area	10 min.
2.	Set up He supply trailers and record pressures	15 min.
3.	Set up GN2 supply trailers and record pressures	15 min.
4.	LN2 tank and vaporizer setup	10 min.
5.	Set up transducer boxes, communications, and junction boxes	5 min.
6.	Check all remotely operated valves and regulators	5 min.
	TOTAL HOURS OF WORK	

DATE	TASK LEADER	DATE	TEST CONDUCTOR

FIGURE 3-4

area which results in a duplication of effort. This causes the possibility of failure by improperly configurating equipment which has been previously setup and checked out. If it is necessary to accomplish the function due to a technical or safety reason, or equipment availability, then this will be understood and followed by all. Through the principle of logical assignment, the reliability of the individuals accomplishing the functions of that task will be verified.

EXAMINING THE COUNTDOWN DISTRIBUTION CHART (Figure 3-5)

There are several questions one asks himself when a countdown distribution chart is being studied for improvement and effective use of manpower. The first question to ask is "Is there misdirected effort?" The related questions to be asked are: "Are all functions essential to the task or have some been assumed which are unnecessary or accomplished somewhere else?" and "Does each function contribute to the task and to the countdown?" A Test Conductor should study closely any work that is duplicated elsewhere because it may be misdirected effort. He should study very carefully the tasks and functions for misdirected effort.

The second question the test conductor should ask himself is "Are the functions and tasks used properly?" or "Are the tasks really a task or could a particular task be a function that should be combined with another task?" Those tasks should be logically assigned and all functions be logically grouped within a task as to area, proper use of skills, and work load.

The third question that a test conductor should investigate is: "Are the task leaders responsible for unrelated functions?" Points to keep in mind in this area are that the person assigned similar functions is easier to train and the assignment of unrelated functions to a task can result in poor work, less enthusiasm, and more fatique. The principle of delegation of authority and span of control must be followed. The test conductor should ask himself are the tasks spread too thin? In this case, the test conductor should look for tasks with small unimportant functions or some task given to many functions with no one individual responsible for them. The task with the small or unimportant functions should be combined into other tasks of similar functions and within the same area. The task with too many functions must be divided up then the principle span of control will be satisfied and proper control of the countdown maintained. You can well remember the old saying "Too many cooks spoil the broth", for it applies equally well in this situation.

The fourth question is: "Are the safety and the technical aspects satisfied?" This is more related with scheduling of the task because the safety aspects of tasks must be scheduled to prevent people from being in areas when hazardous conditions may occur. However, technical aspects must be satisfied but the schedule and arrangement of tasks and assignment of functions to tasks give way to the safety of personnel and equipment.

The fifth question that one must ask is "Are the available resources in terms of manpower and equipment available to assign given functions to a task?" Equipment availability may require the assignment of functions to a task. Safety and technical considerations again must be considered but do not necessarily control the arrangement of functions or tasks. This aspect is more apparent during the review of new countdown objectives. The amount of people available must be equated to the time span that is found to be required during the countdown distribution study. You cannot lay out a countdown and its tasks in a logical schedule without regard to available resources. One should aim for balanced workload among all tasks each according to area skills and work load. Study the present countdown distribution chart shown as Figure 3-5. The question technique is usually in red pencil but, since this presentation is printed on black and white a heavy black is used instead. We are now ready to make some proposals based on facts as they appear on the chart.

IMPROVE THE WORK DISTRIBUTION

After the question technique has been completed, the facts discovered show how the work situation may be improved. The test conductor then takes another chart and begins to fill in the changes he feels will improve the countdown distribution. In chart Figure 3-6 you will see how tasks have been combined and functions combined under similar tasks. Remember that this improvement is just a proposal. An approval for its implementation will have to be secured and tested against the countdown technical requirements safety requirements and the manpower resources. Do not forget the personnel who are to perform the task because they are affected; they too have to be considered and in many cases are able to assist the test conductor in planning the improvements. It is seen by the countdown distribution chart with the proposed improvement of facility tasks Figure 3-6 that the eleven tasks could be combined into four. As stated this is a proposal, there are many combinations that could be worked out. However, for the sake of this presentation it is probably easier to see that these four tasks could easily group the functions that were required or presented in the preliminary countdown study under the four task titles presented and in doing so, we will have adhered to the principles previously mentioned.

NO.	DESCRIPTION	FUNCTIONS							
7	GH2 STORAGE AREA SETUP	PROCEED TO GH2 STORAGE AREA	SETUP GH2 TRAILERS & RECORD PRESS.	LH2 TANK & VAPORIZER SETUP	SETUP EDUCER BOXES, COMMAND & JUNCTION BOXES	CHECK REMOTE OPERATED HAND VALVES			
10.	HE & GN2 STORAGE AREA SETUP	PROCEED TO HE/GN2 STORAGE AREA	SETUP HE TRLRS. & RECORD PRESS.	SETUP GN2 TLRS. & RECORD PRESS.	LN2 TANK & VAPORIZER SETUP	SETUP EDCR BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED HAND VALVES & REGS.		
15.	LN2 PURGE VAPORIZER SETUP	PROCEED TO LN2 PURGE VAP. AREA	VERIFY TEST STAND PURGE SUPPLY SETUP	LN2 TANK & VAPORIZER SETUP	SETUP EDUCER BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED VLVS AND REGS.			
17.	LOX STORAGE AREA SETUP	PROCEED TO LOX STORAGE AREA	SETUP MEN TO REMOTE OPER-ATED VALVES	LOX STORAGE TANK SETUP & RECORD LEVEL	SETUP EDUCER BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED VLVS AND REGS.			
19.	BURN POND INSPECTION	PROCEED TO FUEL STORAGE AREA	VERIFY SLED VLVS POSITION	SETUP LH2 AREA CONTROL PANEL BURN POND FUNCTIONS	PROCEED TO BURN POND AREA	VERIFY BURN POND SETUP & OPERATION	RETURN TO FUEL STORAGE AREA	COMPLETE BURN POND SETUPS AT FUEL STORAGE	
20.	FUEL STORAGE AREA SETUP	PROCEED TO FUEL STORAGE AREA [DUPLICATE]	VERIFY SLED VLVS POSITION	SETUP LH2 AREA CONTROL PANEL FUEL STORAGE AREA FUNCTIONS	FUEL STORAGE TANK SETUP & RECORD LEVEL	SETUP EDUCER BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED VLVS AND REGS.	PERFORM LH2 TRANSFER LINE PURGE	
21.	WATER SYSTEM	PROCEED TO WATER STORAGE & PUMP HOUSE AREA	SETUP WATER STORAGE & PUMP HOUSE						
25.	GROUND FIREX SYSTEM VERIFICATION	PROCEED TO WATER STORAGE AREA & SETUP WATER LINE VLVS		PROCEED TO LH2 VAPORIZER AREA & SETUP FIREX	PROCEED TO LN2 STORAGE AREA & ENVIRONMENTAL VAPORIZER AREA	SETUP WATER LINE VLVS TO LH2 & LOX STORAGE & T.S. #1	PROCEED TO LH2 STORAGE & SETUP FIREX	PROCEED TO LOX STORAGE & SETUP FIREX	
27.	ASPIRATOR & DEFLECTOR PLATE C/O & TEST	PROCEED TO THE TEST STAND		SETUP & CHK OUT ASPIRATOR SYSTEM	SETUP & CHK DEFLECTOR PLATE	SETUP & CHK TEST STAND FIREX & DELUGE SYSTEMS			
31.	WORLD PURGE & GH2 AUX. STORAGE AREA	PROCEED TO TEST STAND AUX STORAGE BOTTLE		SETUP & CHK OUT WORLD PURGE SYSTEM	SETUP & CHK OUT AUX GH2 SYSTEM				
35.	REVERIFY WATER AND PNEUMATIC SETUP	PROCEED TO WATER STORAGE & PUMP HOUSE SETUP	VERIFY WATER STORAGE AND PUMP HOUSE SETUP	PROCEED TO LH2 VAP AREA & VERIFY WATER & PNEU. SETUP	PROCEED TO GH2 STORAGE AREA & VERIFY SETUP	PROCEED TO HE & GN2 STORAGE & VERIFY SETUP	PROCEED TO GN2 ENVIRONMENTAL PURGE AREA & VERIFY SETUP	PROCEED TO LH2 STORAGE AREA & VERIFY LH2 STORAGE & BURN POND SETUP	PROCEED TO LOX STORAGE AREA & VERIFY SETUP

FIGURE 3-5

COUNTDOWN DISTRIBUTION STUDY

		FUNCTIONS											
1.	FACILITY GAS STORAGE SYS. T-1 DAY SETUP & CHECKOUT	PROCEED TO GH2 STORAGE AREA	SETUP GH2 TRAILERS & RECORD PRESS	LN2 TANK & VAPORIZER SETUP	SETUP INDUCER BOXES, CABLES & JUNCTION BOXES	CHECK REMOTE OPERATED HAND VLVS	PROCEED TO HE/GN2 STORAGE AREA	SETUP HE TRLRS. & RECORD PRESS	SETUP GN2 TRLRS. & RECORD PRESS	LH2 TANK & VAPORIZER SETUP	SETUP INDUCER BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED HAND VALVES & REGS.
	COMBINES TASKS 7, 10, 15	PROCEED TO LN2 PURGE VAP. AREA	VERIFY TEST STAND PURGE SUPPLY SETUP	LN2 TANK & VAPORIZER SETUP	SETUP INDUCER BOXES & COMMUNICATIONS	CHK REMOTE OPERATED VLVS AND REGS.						
2.	FACILITY PROP. STORAGE & TRANS. SYS T-1 DAY	PROCEED TO LO2 STORAGE AREA	SETUP PNEU TO REMOTE OPER-ATED VLVS	LOX STORAGE TANK SETUP & RECORD LEVEL	SETUP INDUCER BOXES & COMMUNICATIONS	CHECK REMOTE OPERATED VLVS AND REGS.	PROCEED TO FUEL STORAGE AREA	VERIFY SLED VALVES POSITION	SETUP LH2 AREA CONTROL PANEL BURN POND FUNCTS.	PROCEED TO BURN POND AREA	VERIFY BURN POND SETUP & OPERATION	RETURN TO FUEL STORAGE AREA
	COMBINES TASKS 17, 19, 20	COMPLETE BURN POND SETUPS AT FUEL STORAGE AREA	SETUP LH2 CONTROL PANEL FUEL STOR. AREA FUNCTS.	FUEL STORAGE TANK SETUP & RECORD LEVEL	SETUP INDUCER BOXES & COMMUNICATIONS	CHECK REMOTES OPERATED VLVS AND REGS.	PERFORM LH2 XFER LINE PURGE					
3.	FIREX & WATER SYS T-1 DAY SETUP & CHECKOUT	PROCEED TO WATER STOR. & PUMP HOUSE AREA	SETUP WATER STOR. & PUMP HOUSE	PROCEED TO VAP. AREA & SETUP FIREX	PROCEED TO LN2 STOR. AREA & ENVIRONMENTAL VAPORIZER AREA	SETUP WATER LINE VLVS TO LH2 & LOX STOR. & T.S. #1	PROCEED TO LH2 STORAGE & SETUP FIREX	PROCEED TO LOX STOR & SETUP FIREX	PROCEED TO THE TEST STAND	SETUP & CHK OUT ASPIRATOR SYSTEM	SETUP & CHK DEFLECTOR PLATE	SETUP & CHK OUT TEST STAND FIREX & DELUGE SYSTEMS
	COMBINES TASKS 21, 25, 27, 31	PROCEED TO TEST STAND AUX STORAGE BOTTLE AREA	SETUP & CHK OUT WORLD PURGE SYSTEM	SETUP & CHK OUT AUX GH2 SYSTEM								
4.	FACILITY SYS. T-0 DAY FINAL SETUP &	PROCEED TO WATER STOR. & PUMP HOUSE SETUP	VERIFY WATER STORAGE AND PUMP HOUSE SETUP	PROCEED TO LH2 TAP AREA & VERIFY WATER & PNEU SETUP	PROCEED TO GH2 STORAGE AREA & VERIFY SETUP	PROCEED TO HE & GN2 STORAGE & VERIFY SETUP	PROCEED TO GN2 ENVIRONMENTAL PURGE AREA & VERIFY SETUP	PROCEED TO LH2 STOR. AREA & VERIFY LH2 STOR.& BURN POND SETUP	PROCEED TO LOX STORAGE AREA & VERIFY SETUP			
	TASK 35											

FIGURE 3-6

COUNTDOWN DISTRIBUTION STUDY

1. Essential tasks or functions

2. Logical Assignment of functions to tasks

3. Delegation of authority and span of control

4. Safety and technical considerations

5. Available resources in terms of manpower and equipment

Now that the countdown distribution study is completed, we are down to the point of assignment of task leaders. (See Figure 3-1) It should be noted that the span of control has been improved by reduction of tasks. Since only the facility tasks are being illustrated we will then proceed to assign the four task leaders. The task leaders should be men most familar with the technical aspects covered, if at all possible have previous testing experience under countdown conditions, indicate adequate leadership capabilities and be familiar with the actual location and operation of the equipment covered in his task. Sometimes departmental responsibilities tend to control the task leaders assignments. However, the individual best qualified may not necessarily be from the expected department but from some related one. Each candidate for task leader assignment must be subject to examination as to his background and training.

After the four task leaders have been assigned the next step is for the responsible task leader to gather and list the elements of each function under each task. (Figure 3-1) Task three (Figure 3-6), "Firex and Water Systems T-1 Day Setup and Checkout", will be used to illustrate the task leaders job of collecting and listing the elements required to perform the functions listed. However, only a list of elements for one function, Setup Water Storage and Pump House, out of the fourteen listed for that task will be illustrated as follows:

1. Verify Water Storage Level Transmitter Isolation Valve V-1158 is OPEN

2. Verify Storage Tank Outlet Valve (BFV-1100) is OPEN

3. Report Reservoir Mechanical Indicator

4. Record Reservoir Level Indicated in TCC

5. (If Reservoir Level is less than 22-ft verify Tank is filling

6. Verify storage tank drain valve (V1351) is CLOSED

7. In the Pump House Verify the following Switch positions:
MCC 6C2 Panel
Diesel Engine Water Jacket Heater ON
Diesel Oil Transfer Pump 1109 Motor On-Off Switch ON and
Auto switch in AUTO

8. Verify all switches in DOWN or CENTER position

9. Verify the following Valve Positions for Pump #1101:
V-1101 (Diesel Pump Inlet Header Valve) OPEN
V1219 (Inlet Drain) CLOSED
V1342 & V1343 (Pump Packing Gland Water) OPEN and Water Flowing
Isolation Valves V1112 to PI-1112 & V-1360 to PA-1117 OPEN

10. Verify the following Switch Positions:
Diesel Pump Battery Charger Off/On Switch to ON
Engine Instrument Board and Annunciator
Panel Control Sw to AUTO
P1109 Local Lockout Switch Released
Diesel Generator Battery Charger Off/On switch to ON

11. Verify Water Systems Bypass Block Valve (V-1170) is OPEN

12. Verify Diesel Water Pump Set up as follows:
    a. Clutch Engaged
    b. Panel Control Switch to AUTO
    c. Verify Governor Setting - Fully clockwise to stop & then 1 turn counter clockwise
    d. Oil Temp Indicator 70 70° Deg ± 15 Deg F.
    e. Water Jacket Temp Indicator 120 Deg ± 10 Deg F (Outlet)

13. Verify the following valve positions for pump #1102:
V-1102 (Deflector Pump #1 Inlet Header Valve) OPEN
V-1220 (P-1102 Inlet Drain) CLOSED
V1340 & V-1341 (Pump Packing Glands Open and Water Flowing
Isolation Valves V-1113 to PI-1113 & V-1361 to PA-1118 OPEN

14. Verify P-1102 (#1) Local Lockout Stop is Released

15. Verify the following Valve Positions for Pump #1103:
V-1103 (Deflector Pump #2 Inlet Header Valve) OPEN
V1221 (P1103 Inlet Drain) CLOSED
V-1338 & V-1339 (Pump Packing Glands) Open & Water Flowing
Isolation Valves V-1114 to PI01114 & V-1119 to PA-1119 OPEN

16. Verify P-1103 (#2) Local Lockout Stop Released

17. Verify the following Valve Positions for Pump #1104:
V-1104 (Deflector Pump #3 Inlet Header Valve) OPEN
V-1222 (P-1104 Inlet Drain) CLOSED
V-1336 & V-1337 (Pump Packing Glands) OPEN & Water Flowing
Isolation Valves V-115 to PI-1115 & V-1362 to PA-1120 OPEN

18. Verify P-1104 (#3) Local Lockout Stop Released

19. Verify the following Valve Positions for the Firex Pump:
V-1105 (Firex Pump Inlet Header Valve) OPEN

20. Verify P-1105 (Firex) Local Lockout Stop Released

21. Verify following Conditions on the ALLIS-Chalmers Motor Control Panel:
P-1102 Switch to IN
P-1102 Lockout stop on Stop Button RLSD
P-1103 Switch to IN
P-1103 Lockout stop on Stop Button RLSD
P-1104 Switch to IN
P-1104 Lockout stop on Stop Button RLSD
P-1105 Switch to IN
P-1105 Lockout stop on Stop Button RLSD

22. Cycle the following Pumps on for 1 minute minimum time individually & verify talkbacks:
Electrical Pump #1
Electrical Pump #2
Electrical Pump #3
Diesel Pump

23. Record Operating Pressures:

Electric Pump (1102)	____________ PSIG
Electric Pump (1103)	____________ PSIG
Electric Pump (1104)	____________ PSIG
Diesel Pump (1101)	____________ PSIG

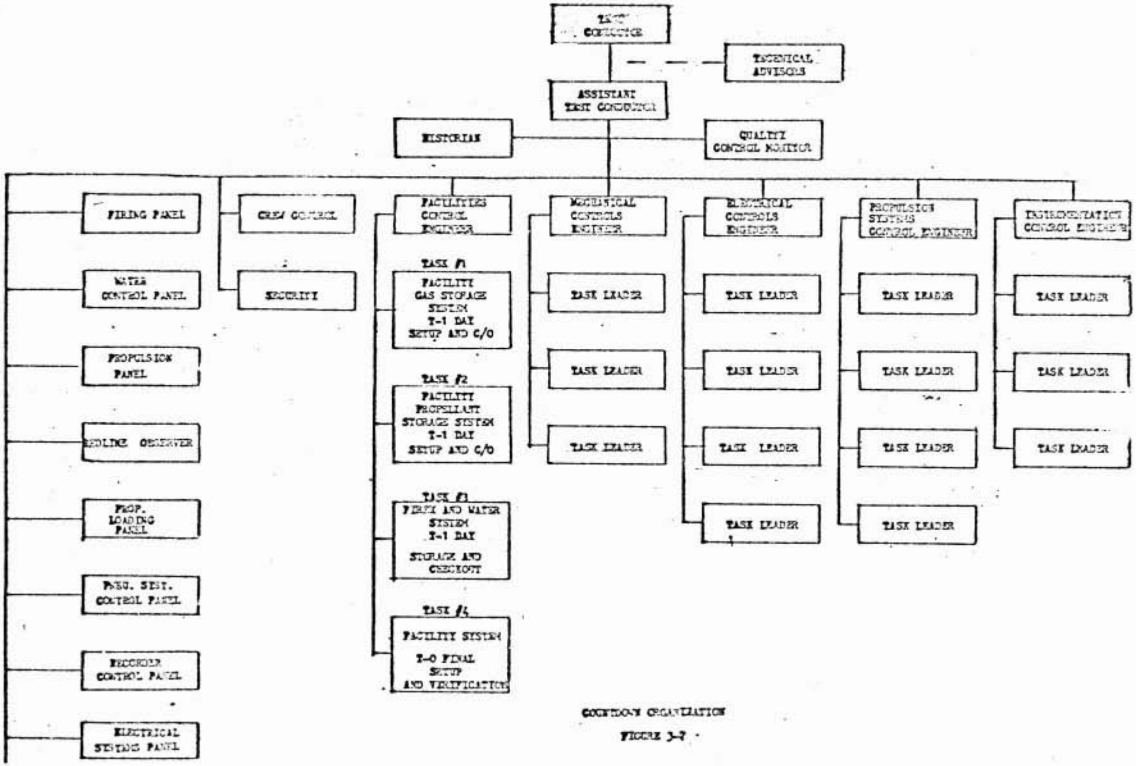
NOTE: MAXIMUM PRESSURES SHOULD NOT EXCEED 185 PSIG
MINIMUM PRESSURES SHOULD NOT BE LESS THAN 150 PSIG

It can be seen by examining the elements listed above for the "Set up Water Storage and Pump House", functions now need only to be sequenced into the Firex and Water Systems T-1 Day Setup and Checkout", tasks.

DETERMINE MANPOWER AND TIME REQUIREMENTS FOR EACH TASK

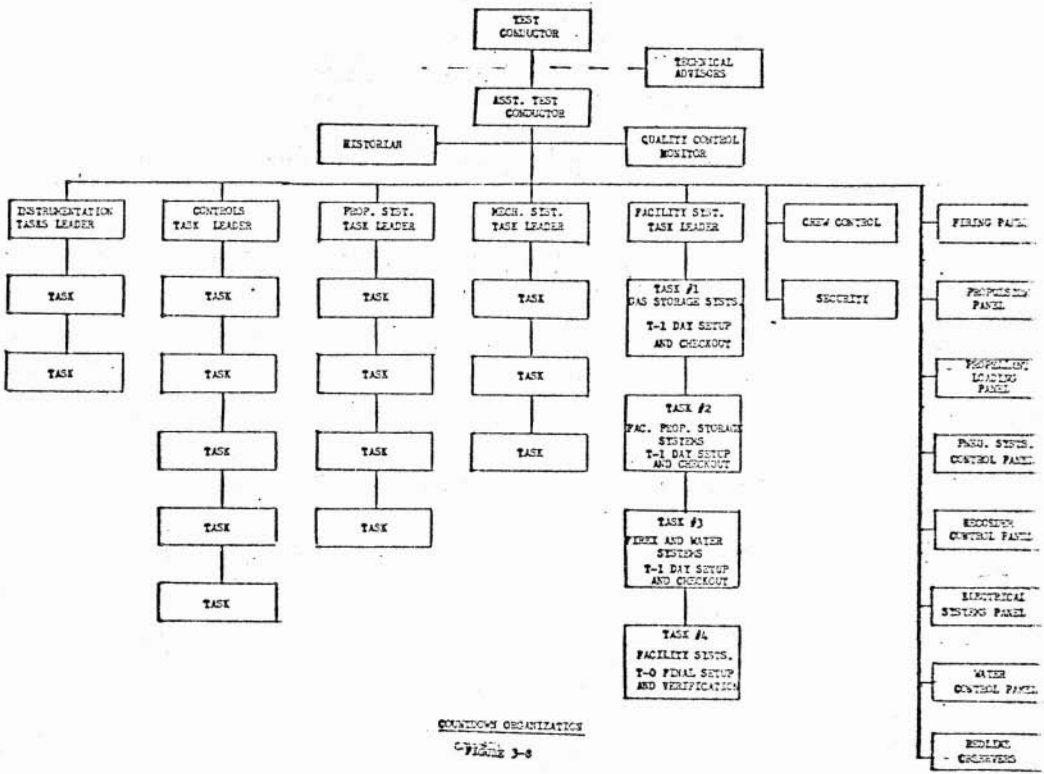
Determination of manpower requirements are made after the task leaders have been assigned to the tasks which are to be accomplished. The test conductor must issue an organization chart, because giving orders or directing, is all too often interpreted as the main function of a test conductor. However, an order should not be given without planning, and it cannot be successful without organization, and a knowledge of the art of handling people. A typical organization chart for a countdown is shown as Figure 3-7. This illustrates a chart that gives the test conductor an organization to direct. It fulfills the principle of the span of control by assignment of the setup countdown tasks to control engineers prior to propellant loading and clearing the areas to the test control center. When the propellant loading and static firing tasks are accomplished, the test conductor becomes the task leader and has direct control of the panel operators and all countdown personnel. In studying Figure 3-7 the facility tasks are only illustrated as we did not make a complete countdown distribution study.

Now that the organization chart has been accomplished, the test conductor can delegate the authority and assign the responsibility to the various task leaders to determine manpower requirements for their tasks. In addition, on Figure 3-7 you will note that control engineers have been added which were not previously mentioned. In large countdown organizations it is sometimes desirable to appoint control engineers with overall systems responsibility. These people should be supervisory personnel with the technical knowledge of the systems they are assigned to control. However, some test conductors feel that the technical advisors fulfill the role of being control engineers and that the task leaders reporting directly to the test conductor gives him better control of the countdown. Also, the duties of the control engineer tends to overlap the task leader thus complicating communications without clear assignment of responsibilities. It is also a fact that tasks can be constructed and scheduled in such a way as to allow one individual to become the task leader on several different tasks that fall within the same technology and area, see Figure 3-8. For example, if the same individual is assigned as task leader for all of the facility tasks and physically performs them with the assigned personnel, he will have first hand knowledge of all system subtleties and can quickly evaluate them against countdown problems as the test progresses. He is then better equiped to recommend a proper course of action to the test conductor. In any event these are suggested countdown organizations and illustrate the different choices the test conductor has in formulating the countdown organization. Regardless of countdown organization, the task leader assigned is responsible for putting together the elements of each function of the assigned task and therefore determines the personnel and time required to perform the task.



COUNTDOWN ORGANIZATION

FIGURE 3-7



COUNTDOWN ORGANIZATION

FIGURE 3-8

In organizing a new countdown or task, the test conductor should require that each task leader walk through his task with the test conductor so that they can determine the number of personnel required. This also familiarizes the test conductor with the task so that he may better schedule the countdown. After the number of personnel required to perform a task has been determined the test conductor should arrange to have a walk through of that task with the assigned personnel to determine the time required and see if the personnel requirement is correct. As previously mentioned the task leader has four basic methods to measure work as follows:

1. Statistical - A standard or average which relates expenditure of labor and units produced based upon a mathematical analysis of past performance.

2. Engineered - A standard time for doing a job according to a specified method, as determined by actual observation during performance of the job.

3. Pre-Approximated - The time required to do a job based upon previous values of time for the basic elements accomplished by specific methods.

4. Estimated - The time it takes to do a job based upon the best judgement of those most familiar with its requirements.

The most accurate method is the engineered. However, the estimated method is widely used but is not as accurate and often makes a countdown look bad. It is highly desirable to engineer the time to perform any new task, this not only gives more accurate scheduling but better utilizes personnel, and increases reliability and safety.

Once the method for determining the time to perform each function of a task has been settled, the task function lists, (See Figure 3-3 and 3-4) from the countdown distribution study should be utilized and filled-in with the time required to perform each function and task. Thus, the test conductor will have all the necessary information to schedule the tasks and determine the total time required to accomplish the countdown.

SCHEDULE TASKS AND DETERMINE THE TIME REQUIRED TO PERFORM THE COUNTDOWN

Once the manpower and time required to perform each task has been determined and listed on the task function lists of the countdown distribution study it is then a simple matter to arrange the tasks in such a manner as to determine the total countdown time, (see Figure 3-9). This step is necessary as some of the tasks run parallel and the total countdown time is not the total time required to run the tasks. Again for this paper only the facility tasks have been illustrated in Figure 3-10. It should be noted at this time that the scheduling of tasks must be analyzed against the following:

1. Availability of manpower
2. Equipment location and availability
3. Safety and technical requirements
4. Span of control
5. When the task is essential to the countdown

After studying Figure 3-10, it is easily seen that the same task leader can handle all of the facility tasks and thus have first hand knowledge of all system subtleties. Even if tasks are not combined as shown in Figure 3-9 the schedule can eliminate overlap and still permit a single task leader. Studying the two countdown schedules, it becomes obvious that the countdown can be simplified by combining tasks as was illustrated for the facility portion in the countdown distribution study. This would allow better span of control, and give better reliability and safety during countdown operations. Once the countdown has been scheduled the test conductor should not expect the crew to be perfect. The use of the countdown distribution study gives the test conductor a good management tool. However, the test conductor must be able to make good under almost any condition - - and if it is necessary to improvise, the countdown distribution study of tasks and functions can become the basis for improvising, if the test conductor finds himself in a situation where he must deviate from the written countdown. It is not hard to see that a test conductor could be placed in such a position.

COUNTDOWN TASKS SCHEDULE

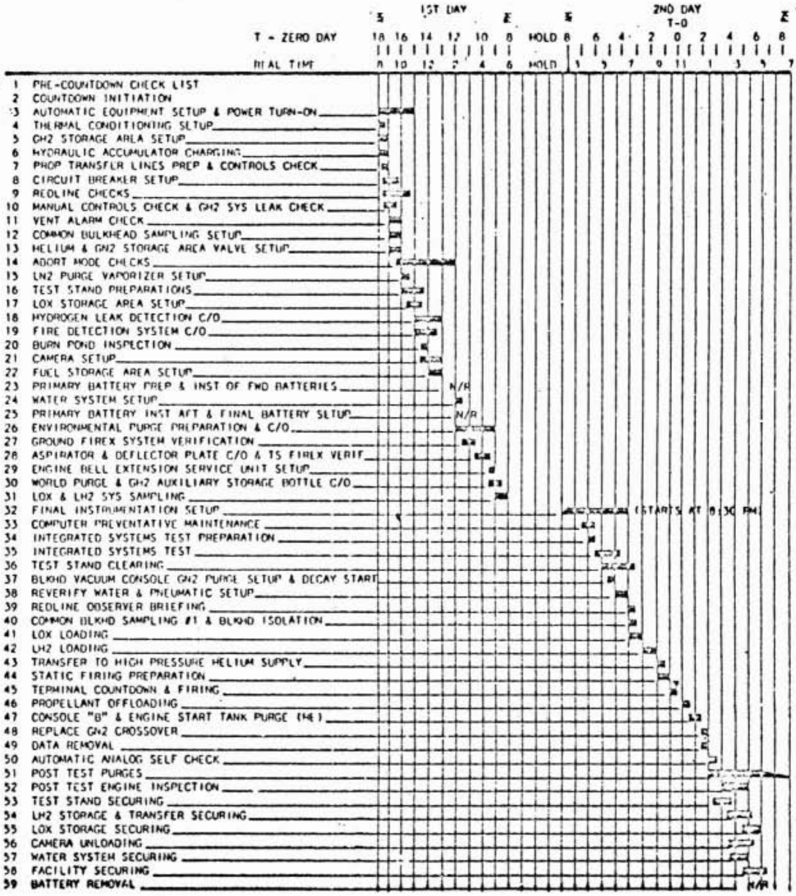
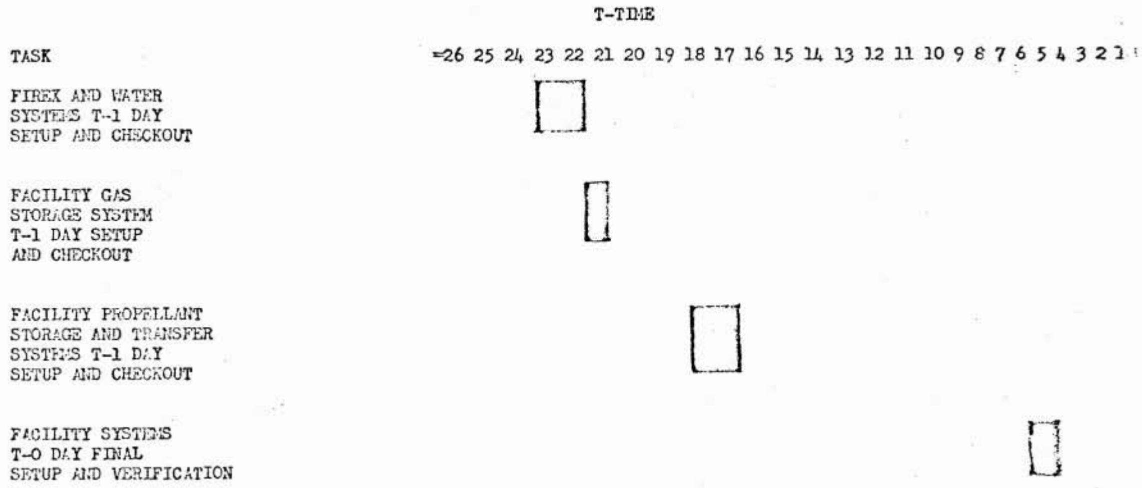


FIGURE 3-9



<u>FACILITY TASKS SCHEDULE</u>

FIGURE 3-10