−2v, the kinetic energy of the ion at the probe would then be about 12.5 ev.

It was found that the minimum potential on a single grid necessary to repel all 14 ev particles was about 18 v. The probe screens were run at −20 v, the ion repulsion grid at +20 v.

The fidelity with which the difference in logarithms of the probe currents followed the idealized expression derived previously:

$$V_1 - V_2 = K \log[\cos(30° - \alpha)/\cos(30° + \alpha)]$$

was thoroughly tested for all values of α up to 45°. It was found that the simple formula was followed with an error of less than 2° up to values of $\alpha = 30°$.

The plane of the axes of the two probes in the pair was then rotated 30° away from the vertical, and the fidelity was again tested. It was found that the error was less than 2° for angles up to 25°.

These tests have shown that an attitude sensor consisting of two ion probe pairs in planes at right angles can be relied upon to give both angle of attack and angle of yaw accurately up to 25° for either or both to within less than 2° error. It is estimated that, with refinements that are evident now, the accuracy can readily be improved to give the angles to less than 0.5° error.

Determination of Probability of Success of Mission Given the Component Probabilities

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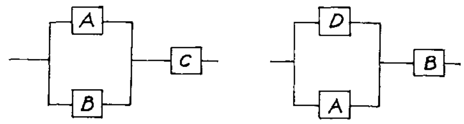
THIS note presents a simple model for the estimation of success of well-defined systems of general complexity as a function of time and based on the probabilities given for the components of the system. The technique assumes that the components (blocks, subsystems, etc.) are clearly identified and that the connections among the components are precisely specified and fixed for each phase of system operations. If the connections are not well defined, the system is clearly not sufficiently designed and not analyzable. For each such organization of components, a Boolean equation is formulated.

It is also assumed that the components have two states, either fail or not fail. This assumption is made only for convenience. Three states, or, in general, n states might have been assumed, but this would only have increased the computational complexity without offering a conceptual change.

Finally, it is assumed that the probability of fail of each component is given as a function of time over the whole interval of operation of the system. If the likelihood of failure of one component depends on that of another, a unique functional relation still obtains for each component.

With these assumptions, the computational procedure is as follows: 1) formulate the Boolean expression for the organization of components for each phase of the mission; 2) evaluate each of these Boolean functions for all of the two-state variables, using standard logic table methods; 3) construct the probability of success (or fail) functions for each row entry in the table for each of the Boolean, or phase, functions; 4) join the probability functions for the sum of the success entries for each of the Boolean functions; 5) form the product probability of the success entries over all of the Boolean functions; and 6) substitute the time-dependent component functions into this product. The result is a probability of success function for the whole system as estimated from the starting point. This function also might have been constructed from any later time point, but the new state conditions must be used. The presence of a failed unit would obviously reduce the unit's probability of success to zero. Consider the example shown in Fig. 1 with logic in Table 1.



a) b)

Fig. 1 a) Phase I structure; b) phase II structure.

The probability of success (or fail) for each row entry for each column is formed by taking the product of the variable state occurrance probabilities for each argument of the function. For example,

$$P_{1,1} = P_A P_B P_C \qquad P_{1,6} = P_A(1-P_B)P_C$$

where P_A, P_B, P_C, and P_D are the probabilities of success of the components A, B, C, and D.

The sum of the row entry probabilities for all of the rows having a value 0 for the specified phase function gives the probability of success for that phase. Thus, the probability of success for phase I is

$$P_1 = P_{1,1} + P_{1,2} + P_{1,5} + P_{1,6} + P_{1,9} + P_{1,10}$$

similarly for phase II probability. Of course, a simplification can be made by considering the minimum number of table entries for each set of arguments, but the principle is unchanged.

Finally, the product probability $P = P_1 P_2$ gives the probability of success of the system. If the probabilities of the components are given explicitly, say in the form $P_A = e^{-\lambda\tau}$ a simple substitution will give the explicit probabilities of success.

Now, consider the general case. Suppose that there are m phases of a mission. Let the probability of success of the ith phase be denoted by P_i. Since the phases necessarily occur in series, the probability of total success is given by $P = P_1P_2\ldots P_m$. Let the ith phase be characterized by an organization of n_i elements, the Boolean equation for which is

$$B_i = B_i\ (A_1, A_2 \ldots, A_{n_i})$$

Its associated logic table and probability functions are given in Table 2.

Table 1 Logic data: where 0 = success and 1 = fail

A	B	C	D	$(A \cup B) \cap C$	P_{ij}	$(D \cup A) \cap B$	$P_{2,j}$
0	0	0	0	0	$P_{1,1}$	0	$P_{2,1}$
0	0	0	1	0	$P_{1,2}$	0	$P_{2,2}$
0	0	1	0	1	...	0	...
0	0	1	1	1	...	0	...
0	1	0	0	0	...	1	...
0	1	0	1	0	...	1	...
0	1	1	0	1	$P_{1,7}$	1	...
0	1	1	1	1	...	1	...
1	0	0	0	0	...	0	...
1	0	0	1	0	...	1	...
1	0	1	0	1	...	0	...
1	0	1	1	1	...	1	...
1	1	0	0	1	...	1	...
1	1	0	1	1	...	1	...
1	1	1	0	1	...	1	...
1	1	1	1	1	$P_{1,16}$	1	$P_{2,16}$

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Table 2[a] Generalized 2-valued system

A_1	A_2	...	$A_{n_{i-1}}$	A_{n_i}	B_i	P_{ij}
0	0	...	0	0	$v_{i,1}$	$P_{A1}P_{A2}\ldots P_{Ani}$
0	0	...	0	1	$v_{i,2}$	$P_{A1}P_{A2}\ldots P_{Ani-1}(1 - P_{Ani})$
...	...	...	...	...	...	:
1	1	...	1	1	$v_{i,k}$	$(1 - P_{A1})(1 - P_{A2})\ldots(1 - P_{Ani})$

[a] $k = 2^{n_i}$.

The probability of success of this phase is a function of the success states, namely, the row entries for which $v_{ij} = 0$. It is assumed again for the sake of convenience that there are only two states, denoted by 0 and 1, where 0 means success.

The probability of occurrence of the typical row entry is simply the product of the probabilities of occurrence of the given values of the variables A_1 to A_{ni} for that row. These are the functions P_{ij}, $j = 1,2\ldots 2^{n_i}$, given in the table.

Consequently, the probability of success of the ith mission phase is given as the sum

$$P_i = \Sigma_l P_{i_l}'$$

where l enumerates those P_{ij}'s associated with $v_{ij} = 0$.

Multiple Rocket Firing Unit for Altitude Testing

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THE test firing of small, solid propellant rockets under simulated altitude conditions has generally required test facility occupancy time in excess of 1 hr/motor at Arnold Engineering Development Center (AEDC). It has been necessary to complete the cycle of installing, pumping to altitude, calibrating, firing, returning to ambient conditions, and removing the test article for each motor tested. When a limited number of motors of a type are to be tested, little can be done to reduce the time consumed in completing the cycle. However, when large numbers of nearly identical motors are to be tested, automatic techniques are suggested.

Two of the more time-consuming portions of the small motor testing cycle are the operations of pumping to altitude and, after the firing, returning to ambient conditions. By firing several motors in the test cell during a single pumpdown period, the facility occupancy time can be reduced considerably. This could be accomplished by mounting several motors in the test cell, each attached to a separate load cell, but by so doing a homogeneous sample would be violated in that a common instrumentation system would not be used for all test articles. Such data accuracy refinements as deadweight thrust calibration would also be difficult to achieve.

In order to provide the best possible data while alleviating the problem of high occupancy time when testing large numbers of relatively simple motors, a multiple rocket firing unit (MRFU) has been designed and fabricated at AEDC.

The MRFU is a high accuracy, high testing rate system. It is composed of an electrically controlled and hydraulically operated conveyor mechanism located inside an altitude test cell and various support equipment both inside and outside the test cell (Fig. 1). The present system is capable of testing, during a single pumpdown period, a maximum of 13 motors producing up to 5000-lbf thrust each, at simulated altitudes in excess of 100,000 ft.[1] Also available are 6 deadweight thrust calibration steps and a test article temperature conditioning capability ranging from −100° to +250°F.

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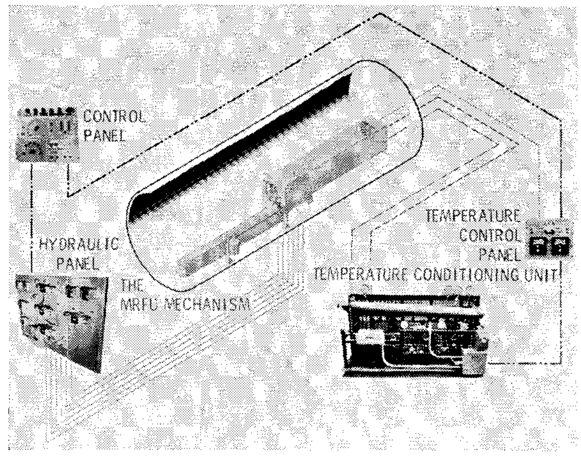

Fig. 1 Schematic diagram of the MRFU system.

Operating Sequence

The test articles are attached to special adapters and mounted nozzle-up between spring-loaded clamping arms along the horizontal conveyor (Fig. 2). A typical operating sequence begins with the conveyor and motors inside the temperature conditioning box. A selection is made at the master control panel, and the conditioning box doors open automatically; the conveyor positions the first motor over the thrust train, and the vertical positioner extends depressing the spline mounted clamping arms, thereby lowering the motor into the firing position. As the motor is lowered, electrical connectors for the firing circuit and motor instrumentation are mated. The motor is locked to the thrust train by hydraulic pressure and isolated thereon by the extension of the isolator wedge, which separates the clamping arms. Data acquisition systems may then be calibrated and the motor fired.

Thrust Train

To keep installation and instrumentation variances at a minimum between test articles, it is desirable to test all articles using highly repeatable installation techniques and common instrumentation. Both these criteria are met by the MRFU thrust train (Fig. 3). The major components of the thrust train are the adapter, locking chuck, thrust calibrator ring, and load cell. The adapter, with the test article attached, is locked to the chuck as hydraulic pressure draws the cone pin down and expands the split head inside the adapter.

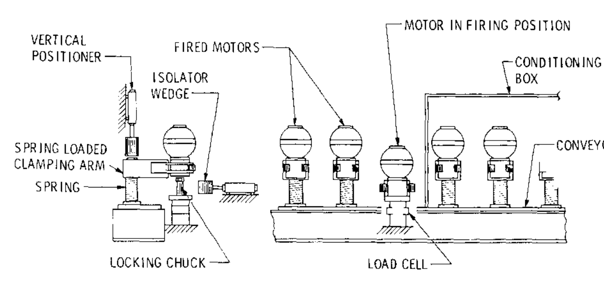

Fig. 2 Schematic diagram of the MRFU mechanism.