Space Science and Satellite Applications: Ingredients for Success

by John W. Townsend, Jr.

Dr. John Townsend retired from NASA as Director of the Goddard Space Flight Center in August of 1990. A memo he wrote to Goddard branch heads and project managers on January 21, 1963, recently surfaced and permission was granted to share it with a wider audience. While the memo is dated, it does capture the philosophy of one of the agency's up and coming leaders. That same year, 1963, Dr. Townsend won the Arthur S. Fleming Award as Goddard's Assistant Director of Space Science and Satellite Applications.

There have been a number of instances in the past several months when I have had opportunity to pause and reflect on Goddard's past flight program record. This has come about both as the result of our successes and failures, and those on programs run by other groups active in space research. In addition, I have also been reviewing our history to try to draw conclusions that would be meaningful in the preparation of a Goddard-wide "Reliability Assurance Policy."

To begin with, I must admit that our record is not perfect. However, on the positive side, there are some factors which have guided our performance and led us to such success as we have had. Some of these have been conscious and some, to a certain extent, have developed unconsciously.

The purpose of this discussion is to outline the basic philosophy that I believe we have been following, and by so doing, to help ensure that our younger generation at GSFC is aware of this thinking so that they can be guided accordingly. As I see it, the principal problem at the Center will be to assure that the knowledge and experience of our senior people are passed on in spite of the fact that our explosive growth has spread all of us too thin and made communications much more difficult.

I find, as the result of this exercise, that there are two sets of factors which have influenced us. The first set is, in a sense, environmental and includes many things that have just happened or are not under our direct control, such as management principles that we influence but do not set. The second set are rules that we do have under our control and have developed through experience.

Environmental Factors

In the first category, I would include the Center's personnel and culture.

Goddard's greatest asset is its personnel. We were fortunate, indeed, to inherit several large and skilled groups from the Department of Defense. Many of these people have had as many as 15 years experience with rockets and rocket instrumentation for scientific research. They have had their own successes and failures and have seen these in other programs. There is no substitute for such first-hand knowledge. I recognize that everyone is interested in "management theory" nowadays and that we get much free advice (and sometimes instructions) in this category. What pains

me is that some of the people giving such advice have never even seen a rocket firing.

We have been successful, by and large, in keeping our best people only through a policy of insisting that they be allowed to work on jobs that they wish to do and are good at. This presents a difficult management problem since management goals are not always the same as the personal goals of people doing the work, but the fact remains that there is no substitute for the person who really wants to do a job so badly that all else is of little importance. Where we have been allowed to assign our people in accordance with this policy, we have retained them. Where we have failed — for example, booster vehicles — we have lost good people.

We have been fortunate to date in not having "production" programs at GSFC. Since most of our missions have been "one of a kind" flights, we have all been impressed by the seriousness of one mistake — there haven't been "four more to fly in case this one doesn't work." I think this circumstance has resulted in closer identification of our people with the job and greater personal pride of accomplishment.

Most of us believe that the least management is the best management in an R&D effort. Goddard has relatively clean management lines with few splits in responsibility, authority, and accountability. We have also gotten along without large staff groups (at least in the technical areas).

I believe our basic policy of mixing the projects in with functional groups is a good one. This item may be controversial, but considering the job GSFC has to do, the people it has to do it with, and conditions under which we operate, I think the policy is wise. Conditions may change in the future, but for the present, organizing this way ensures a maximum cross-fertilization and prevents the projects from going off in a vacuum where the basic mission of the project is obscured by its size and importance.

We have insisted that we have "in-house" competence and experience in each area of endeavor where we monitor the work of others. We have also managed our projects and have done our mentoring with people who are scientists and engineers first and "management types" second.

The above factors, as I said before, are not completely under our control; further, several of them represent a philosophy based on personal opinion and are hence debatable.

Policies and Rules

The second category is considered to be more substantive and can be shown by our experience to have contributed directly to our success:

We have scaled our mission objectives to the possible.

We have followed a policy of assigning our experimenters and design engineers the task of following their units from birth to death, i.e., from concept through writing a final report. This procedure is somewhat unique in that most organizations of our type build up a system, bypassing subsystems, and the responsibility for them, from a design group, to a development group, to a fabrication group, to QA and test, and finally, to an integration group. In many cases, field operations are carried out by

still another group or by another agency.

By the time flight data wanders back, the design engineer frequently doesn't even recognize it and is at a loss to explain "what happened."

GSFC technical personnel have a suspicious nature — they don't take anything for granted. We try to follow the habit of assuming that the mission could fail and try to correct things before, rather than after, the fact. This is a mental attitude that I consider highly important. Be pessimistic about success up to the last minute; never stop trying to find the weak links.

Our better designs have either incorporated redundancy or have provided for isolation so that a single failure or a few failures do not ruin a mission. In this connection, it is good design to avoid a situation in which several events must occur in series before a desired operation takes place.

In general, it has been our practice to use components with very conservative ratings.

Resist schedule pressure if technological problems are pacing. There is no excuse for letting management deficiencies result in schedule slips, but when the problem is a research or development one, insist that the unit is 100 percent right before it is flown.

Testing Approach

The principal cornerstone of our development philosophy has been our belief and reliance in a strong testing program. This subject is in itself a matter for much more thorough coverage than possible in this note, but the following aspects are considered to be of paramount importance:

GSFC believes in the FULL SYSTEMS test approach. Every reasonable attempt should be made to test the entire system under as realistic conditions as possible and as early in the development cycle as feasible.

GSFC believes in 100 percent flight acceptance testing at expected average flight levels plus 2 sigma (95 percent level).

GSFC believes in testing a flight unit, designated a prototype, at approximately 150 percent of the flight acceptance tests.

After the testing program, the system should remain intact and last-minute changes avoided like the plague (firing jitters problem). In almost every instance of failure I can remember, the explanation began with the famous last words, "but we only changed..."

I would like to close this discussion with the comment that this Center is in no position to get big-headed about its progress. In the observatory class of spacecraft (Nimbus, OGO, OAO, AOSO) we have a new generation of problems to face that are at least an order of magnitude more difficult. It would be my hope that this discussion may serve to focus our attention on this situation and point a way towards success.