FIRE PROGRAM

AS

MANAGEMENT

CASE STUDY
The purpose of this management-oriented paper is to broadly document the successful Project Fire program experience as a study in the philosophy and techniques employed by NASA to develop and manage a research objective.

How Objectives Were Defined and Supported

The basic organization utilized to develop the national program and its implementation is shown by the chart of figure 1. In February 1960 the "SVA Committee" as a NASA advisory recommended that NASA implement the ground facility research with flight tests in the actual reentry environment at super satellite velocities. This started an activity for definition of the objectives and planning a flight program that followed both the lines of authority on the chart and through the informal more direct contacts as indicated by the arrows on the chart. This chart (figure 1) emphasizes the interplay, indicated by the arrows, of the Centers and Committees in defining the requirements, goals, and concepts. Note that the flow is in both directions and not through the formal channels. The ground facility research by the Centers played a large part in the practical definition of the reentry flight test program.

The members and background of the SVA Advisory Committee and the LRC Steering Committee are given in Appendix A. The membership of these committees represented at that time the expertise of the Nation in heat protection materials, reentry aerodynamics, and reentry structures.

By the late summer of 1961 a flight reentry test program had been developed at LRC utilizing Scout vehicles to be done "in-house" at LRC, and an Atlas Agena program at 36 000 fps to be done under contract by LRC.
This 36 000 fps reentry project was known as Project Calorie. Project Calorie had two particular plans from which lessons were to be learned: (1) the project was to be funded by manned space flight resources, and (2) the prospective contractor was to define the implementation of the experiment on materials and reentry environment. At the time the request for proposals was about to be issued, Project Calorie was cancelled in September 1961. This cancellation was caused by withdrawal of funding support for the manned space flight program. Considerable advisory, technical, and management activity ensued. The SVA Committee enjoined the Administrator of OART, some members in person, that the flight reentry test at hyperbolic velocities was necessary for the National Space Program, and worthy to stand on its own merits. The Director of LRC and the Steering Committee with the support of the Ames Research Center recommended and requested OART support of the flight reentry test. The technical activity produced a payload concept that would measure the reentry environment of 37 000 fps; namely, the layered calorimeter approach and the onboard radiometer based on newly gained instrumentation experience. Also, a simpler space vehicle, the Atlas with a powered spacecraft was conceived that would reduce costs and logistics. This new approach called Project Fire was approved in December 1961 and funded through the resources of OART. The lessons learned from this were that a research objective that is worthy and required by the national program should be funded and supported on its own so that the resources cannot be withdrawn, and a concept of the experimental payload techniques should be presented to justify and lend assurance to the attainment of the research objective.
The management of the funding of Project Fire was done through the standard channels from NASA Headquarters down to the project obligation level. At no time during the history of Project Fire was the project delayed or the schedule threatened by management of funds at any level.

How Project was Managed

The project was managed at the Langley Research Center by the Flight Reentry Programs Office, a project office set up at the Division level by the LRC Director. The relationship of the project office to the Center organization is shown by the chart in figure 2. The project office reported to the Assistant Director for Flight Projects. As shown by the arrows on the chart the project office worked directly with the Divisions for support without going up through the Assistant Director level. The project office held a management responsibility only. The research divisions were called upon to supply scientific specialists, supporting tests, and data processing only when required. The Engineering, Technical Service, and Administrative Divisions supplied the procurement and contract administration, engineering, quality assurance, and normal administrative services. In fact the subsystem management and quality assurance monitoring was handled within the engineering and mechanical divisions through redelegation of this responsibility across the line organization rather than down through the line organization. All contacts with contractors were made through the project office only, even though supporting groups needed direct liaison with the contractors. This rule was strictly enforced. The project office worked directly with the Budget Office on
handling the funds without going through the Assistant Director. However, any document on funds and budget that was to go outside the Center followed the lines of the formal Center organization. The project office was granted authority by the Director to sign and issue correspondence outside the Center on business dealing directly with the execution of the project only. However, all correspondence dealing with budget, funds, and reporting to OART and Headquarters were handled through the Director's Office. As long as no policy, principles, or methods of approach were changed the project office managed the project autonomously making most decisions within the project office. The Project Manager, LRC management, and Headquarters management did, of course, provide for review of progress and problems on the subject. These higher-level reviews usually were concerned with major trade-offs between funding, schedules, and technical objectives, and general readiness to proceed with final launch preparations. However, these reviews were kept as informal as practicable.

The organization internal to the project is shown in the chart of figure 3. This organization was staffed with personnel having broad technical background and all key managers and subsystems managers had had previous experience in either engineering or research management. While the experience of most of these personnel was not directly involved with flight projects, they had had experience in making decisions and judgments of the type that would be required in Project Fire. This nucleus was kept small, eighteen to twenty-three persons. For each staff function, system and subsystem shown in figure 3, the responsibility was clearly defined by a written document, and delegated to the lowest possible management level. This definition and delegation produced excellent
esprit-de-corps and smoothed the working relationships between systems
which resulted in the desired interplay between systems rather than up
through the project manager for resolution of routine problems.

The organization of Project Fire in relation to the whole of the NASA
is shown by the block diagram of figure 4. As can be seen from this
organization, responsibility for the Launch Vehicle System and Launch
Operations was outside the Langley Research Center. Smooth working
relationships came about by early management agreements to establish direct
communication, responsibility, and action arrangements at the working
level within LRC, with other NASA Centers, and with the USAF.

The key to the success of Project Fire can be summarized as follows:

1. Laying a proper foundation for the project through intensive
   study.

2. Availability of and proper selection of key personnel.

3. Giving the project office responsibility for detailed
   execution with higher level management providing broad review and policy.

4. Clearly defining responsibility and delegating to lowest
   possible management level.

5. Availability of scientific and specialized support from
   line divisions.

6. Direct working arrangements across the line organizations
   at all levels.

A chronology of the important events in the history of the flight
reentry test program is given in Appendix B.
Effect of Results in National Space Program

The scientific community through the "SVA Committee" and other advisories to NASA have recognized the value of the results of Project Fire in effecting a wider scope to the knowledge of reentry heating at hyperbolic velocities. The actual flight tests in reentry conditions at large scale at 38,000 fps have provided anchor point data; thereby, with this flight data in hand new empirical theories will be devised to mathematically simulate the correct conditions. Similarly, the anchor point data has established a correlation with ground facilities which provide greater value and better interpretation of results from ground facilities.

A brief explanation of the technical reasons for developing experimental bench marks against which ground based theory and facilities can be evaluated and extended is given in Appendix C.
APPENDIX A

MEMBERSHIP OF COMMITTEES

NASA Research Advisory Committee on Missile and Space Vehicle Aerodynamics - "SVA Committee"

TO BE SUPPLIED BY R.W. MAY, JR.
DART - NASA HQTRS.

Reentry Science Program Steering Committee of the Langley Research Center - "RSP Steering Committee"

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Chief Flight Vehicles and Systems Division  
Branch Head, Mathematical Physics, DLD  
Manager, Flight Reentry Programs Office  
Office of Assistant Director  
Branch Head, Reentry Physics, APD  
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APPENDIX C

Technical Reasons for Developing Experimental Bench Marks

When Project Fire was in the planning stages, heating transfer theory stated that above 34 000 fps the stagnation radiant heating input was proportional to the velocity to the twelfth power, or possibly to the twenty-fourth power. At about summer of 1963 comparisons of the best available theoretical radiant heating input calculated for 37 000 fps showed them to differ by factors of 2, 4 and 9. At the time of the Project Fire flights the best available radiant heating input theories calculated for 37 000 fps still had large factors of variance, for example, 2, 3 and 6. This indicates that the ingredients used in the recipe for the theory still unknown as to what is important to emphasize in the mathematical model of the gas dynamics.

Basically, the problems of predicting the radiant heat input are as follows:

1. Equilibrium radiant heating is directly proportional to the shock stand-off distance, and hence the nose radius.

2. The factors affecting the absorptivity characteristics of the radiant gas, and the interplay of the gas dynamic properties with respect to the shock stand-off distance.

The models used for experimental tests in ground facilities are usually very small which means small shock stand-off distances with and more importantly, scaling the results. attendant difficulties in measuring radiant heating. Furthermore, simula-
APPENDIX C

(CONTINUED)

tion of the hyperbolic velocities in ground facilities usually means the physical characteristics of the gas constituents are not exactly like those experienced during actual reentry or are not in the same thermal-fluid scale as in reentry.

The mechanism of convective heating has always been better understood than radiant heating. However, large scale tests are required to confirm that and with opportunity for significant coupling of the radiative heating to the convective, at hyperbolic velocities, the convective heating continues to be inversely proportional to the square root of the nose radius, and that it increases in direct proportion to approximately the square of the velocity as predicted by theory.
APPENDIX B

CHRONOLOGY OF IMPORTANT EVENTS

Some milestones which are indicative of the pace and history of Project Fire are as follows:

February 1960  NASA Advisory Committee recommended reentry flight test
July 1960      NASA Reentry Flight Test Program proposed to NASA Headquarters
October 12, 1960 NASA Advisory Committee expressed support and expedi­
tion of NASA Reentry Flight Test Program
May 28, 1961   Organization of Reentry Science Program Steering Committee and the Flight Reentry Programs Office
September 15, 1961 NASA Headquarters approval of Project Calorie
September 28, 1961 Cancellation of Project Calorie
September 29, 1961 Steering Committee started formulation of new project to replace Calorie
October 4, 1961 NASA Advisory Committee strongly affirmed need for reentry flight test to NASA management
November 1961  Director of LRC and Steering Committee, with the support of Ames Research Center, recommended support of new project to OART
December 5, 1961 Layered heat shield approach agreed upon and payload concept finalized
December 19, 1961 Project Fire approved
January 2, 1962  Initiate procurement of Atlas Launch Vehicles
January 30, 1962 Reentry Package request for proposals mailed to industry
April 17, 1962   NASA Advisory Committee expresses gratification and support of Project Fire to NASA management
June 13, 1962   Formal award of Reentry Package contract to Republic Aviation Corporation
July 25, 1962    Formal award of Velocity Package contract to LTV-Aerospace Corporation
APPENDIX B

(CONTINUED)

September 30, 1963  Practice dry run of launching. All systems were ready with the exception of the Reentry Package.

April 14, 1964     Successful Flight of Fire I

May 22, 1965      Successful Flight of Fire II
Figure 2.- Relationship of flight project to Center organization.
PROJECT IMPLEMENTATION

PROJECT OFFICE HAVING MANAGEMENT FUNCTION ONLY

RESPONSIBILITY CLEARLY DEFINED AND DELEGATED TO LOWEST POSSIBLE MANAGEMENT LEVEL

EARLY MANAGEMENT AGREEMENTS TO ESTABLISH DIRECT COMMUNICATION, RESPONSIBILITY, AND ACTION AMONG STAFF AT WORKING LEVEL WITHIN LRE, WITH OTHER NASA CENTERS, AND WITH THE USAF

Figure 3.- Organization of project office.
Figure 4: Project Organization
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Figure 2.- Relationship of flight project to Center organization.

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Figure 3.- Organization of project office.

PROJECT IMPLEMENTATION

MISSION TECH STAFF

S/C SYSTEM

S/I SYSTEM

TEOA SYSTEM

SUPPORT PROGRAMS

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