SECTION 21. PROJECT MANAGEMENT

21.1. INTRODUCTION

This chapter surveys some of the issues raised when projects have to perform, or commission, radiation effects work. Timing is one of the most important and controllable factors and some time-tables are given. Usually, specialist assistance is necessary; therefore, attention is given both to which experts are most needed and, perhaps most important, to the means of ensuring that their advice is sought at the right time; the latter issue is called "Maintaining Project Awareness". The practices followed in the U.S., where much larger groups of radiation effects workers exist, are also briefly discussed.

Most engineers and managers, although highly skilled, are not familiar with many of the phenomena which are important in the radiation-induced degradation of components. Only in the fields of nuclear power, military operations and space is equipment likely to be exposed to significant doses of radiation. Thus, "Radiation Hardness Engineering" has not yet been introduced as a routine part of the discipline of Engineering. Management must be aware that their staff will need education as well as technical support from experts and therefore plan to start such procedures in the conceptual stages of a project.

An indication of this necessity is that one of the earliest choices made by a spacecraft project are the orbital parameters. While the objective of the mission may be feasible only in a limited range of orbits, systems engineers may well be able to increase spacecraft life greatly by careful orbit adjustment to minimise radiation damage. Therefore, radiation may be a significant design parameter from the earliest stage of a project. An early knowledge of the "no go" areas of space could thus save considerable effort or cost penalty.

Device technology is another issue which, normally, is decided in good time. The importance of the question may be made clearer by one example. Inappropriate decisions by device manufacturers on the choice of gate dielectric for MOS devices held back the use of MOS technology in space for several years and probably cost many millions of dollars in remedial research.

21.2. FLOW CHARTS

Figures 21.1 and 21.2 show a version of the flow and interrelation of tasks in the radiation-hardening of space equipment. It will be seen that there are roughly six major steps:

- Development of an environmental specification,
- Development of a suitable model of structure and materials used,
- Study of the interaction of equipment and environment,
- Prediction of degradation with or without testing,
- Development of a balanced plan of corrective actions from a wider number of options,
- Refinement of those options.

Normally, it is necessary to repeat these steps several times, starting from approximate solutions and refining them as the project proceeds. Timing is dealt with in a later section.

21.3. MAINTAINING PROJECT AWARENESS

This phrase is used here in the sense that "awareness" can be said to be maintained if design and systems engineers neither over- nor underreact to the threat of radiation-induced changes and introduce these considerations into their work just as they would for any other environment such as vacuum or vibration. Eventually, it may be that engineers will be equipped to handle this environment similarly to any other but, in the present era, the assistance of an expert is still required. Awareness is formally maintained in the form of written specifications. Some suggestions for the form in which radiation should be included in specifications have been given earlier.

In addition to the consideration of radiation in the design phase, methods for telemetering "housekeeping" data of radiation-induced effects in space are being developed. This is done by arranging electrical in-flight monitoring at known "weak spots" in existing flight circuitry and by the use of dosimetric devices. These methods are being developed as part of ESA's In-orbit Technology Demonstration Project.

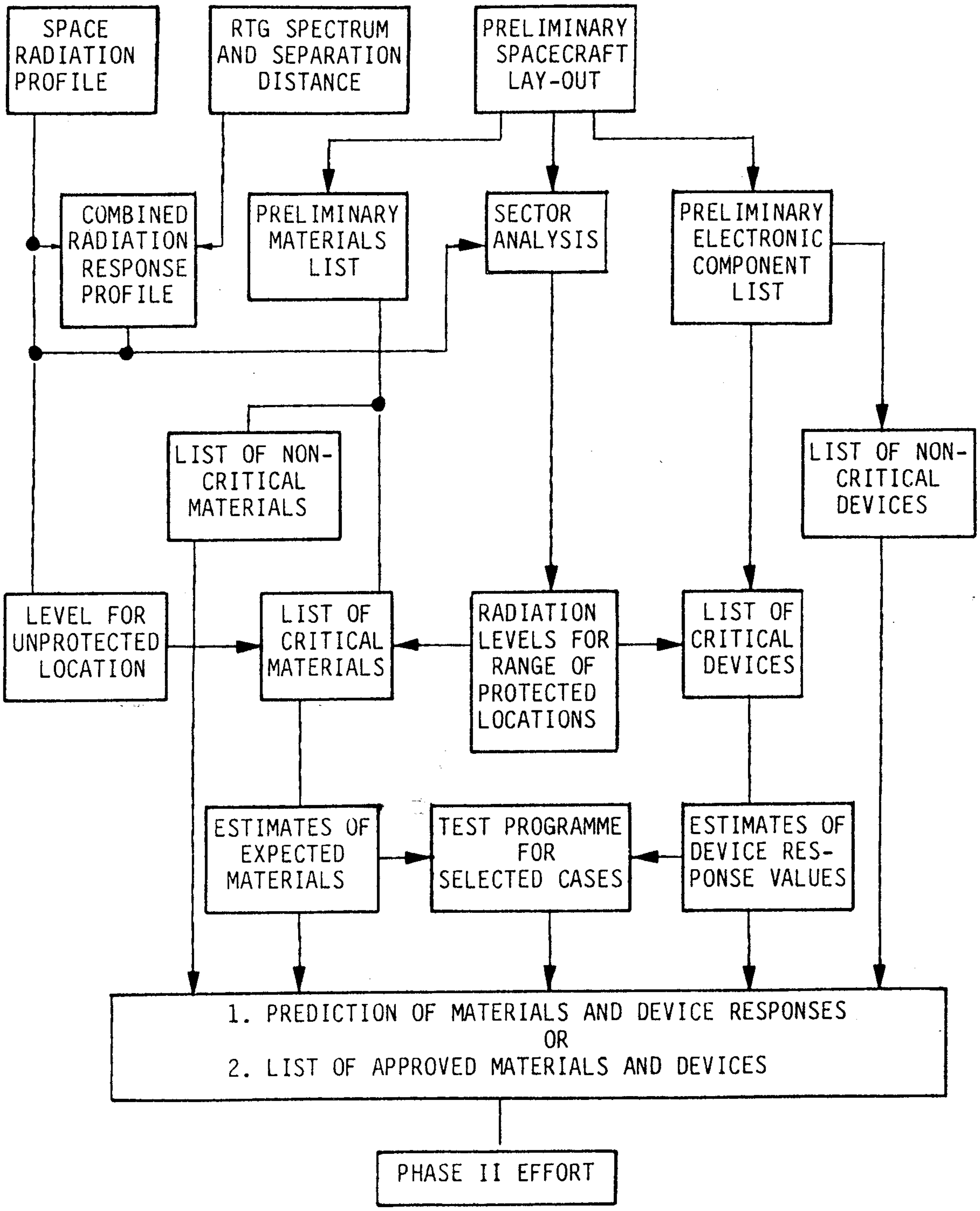


FIGURE 21.1 - PROJECT MANAGEMENT FLOW CHART: RADIATION ASSESSMENT OF SPACECRAFT - PHASE 1

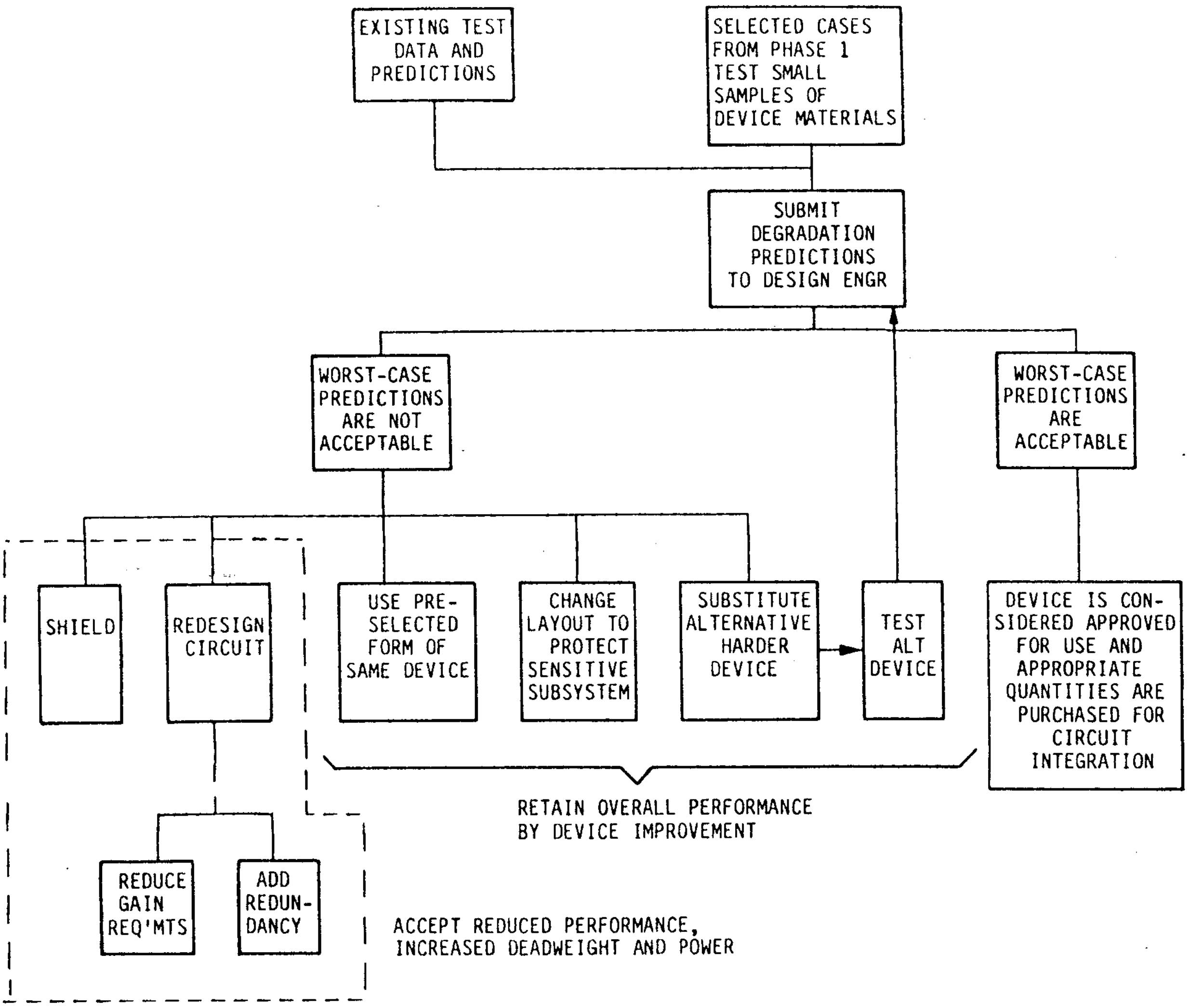


FIGURE 21.2 - PROJECT MANAGEMENT FLOW CHART: RADIATION ASSESSMENT OF SPACECRAFT - PHASE II

21.4. TIME SCHEDULE

The time schedule shown in Figure 21.3 was prepared in consultation with an ESA communications project. The "Simple Environment Assessment", "Sector Analysis" and "Detailed Sector Analysis" may require the tasks shown in Figure 21.1 to be repeated several times. Estimates are improved as design information is developed. Knowledge of device degradation will be accumulated together with data from "Forward Looking Research". Unexpected effects often occur in devices originally thought to be tolerant of radiation. The tasks shown in the prototype stage include the addition of last moment shielding to correct newly discovered problems of degradation ("band-aids") and "Lot Tests" to verify that purchased materials conform to the responses observed in trial samples.

Figure 21.4 shows a flow chart for investigations of piece-parts only, the interaction between a number of different engineering departments and appropriate sources of funding.

21.5. INFORMATION FLOW

The organisation of a Radiation Effects Engineering Group must ensure proper feedback of information between experimenters performing detailed applied physics work and engineers and physicists directly supporting the project. Preferably, all experts should have direct experience in project support and test work.

21.6. ROLES OF CONTRACTOR AND CONTRACTING AGENCIES

21.6.1. General

Like other engineering skills, "Radiation Effects Engineering" must be supplied by spacecraft development contractors. A contracting agency, for its part, needs to retain full cognizance of technical practices, promote new techniques, install some specialised test facilities and provide all contractors with environmental data in standard form.

It is the contractor's responsibility to understand the impact of the environment on his equipment and to design and test it accordingly.

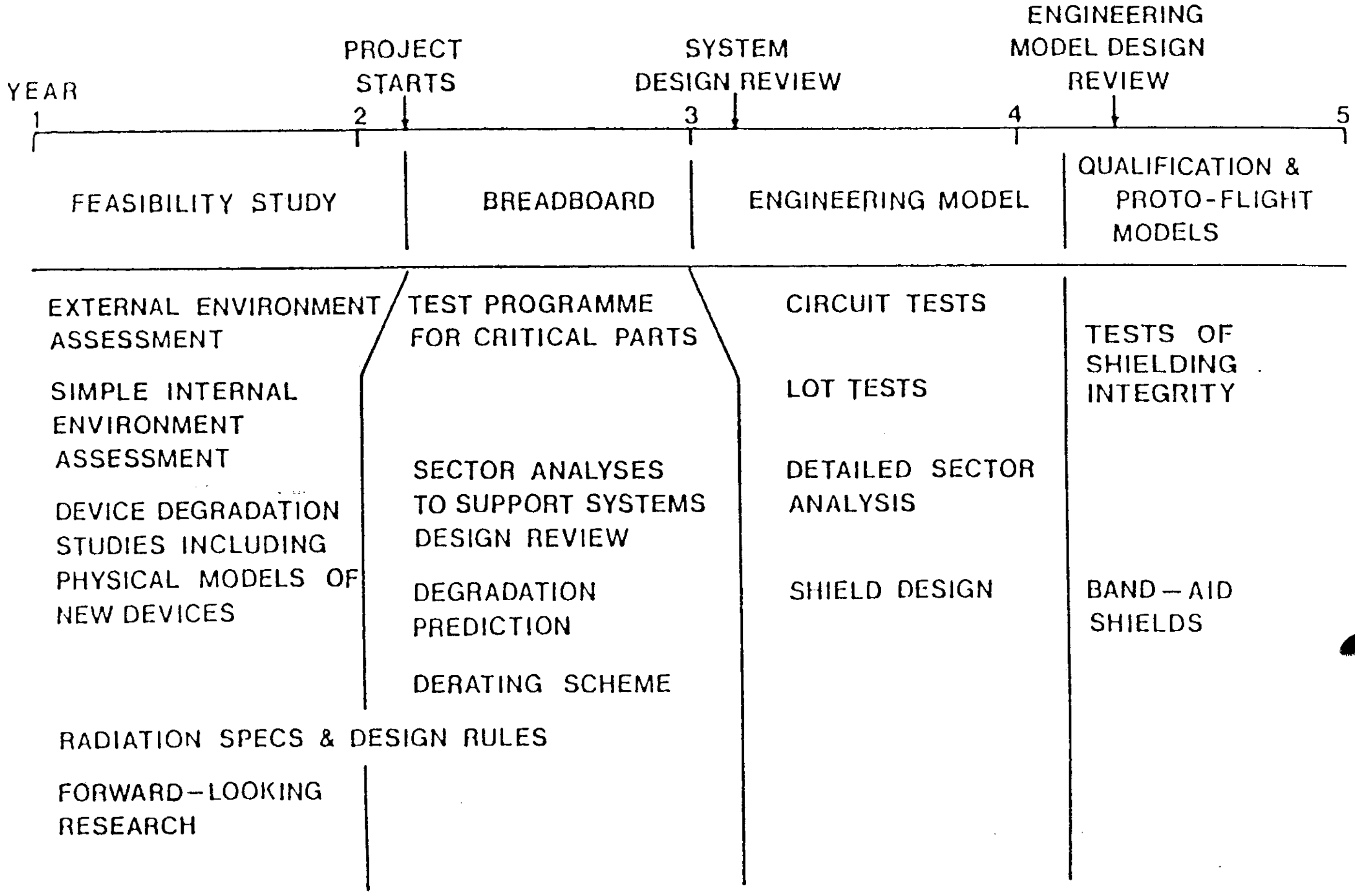
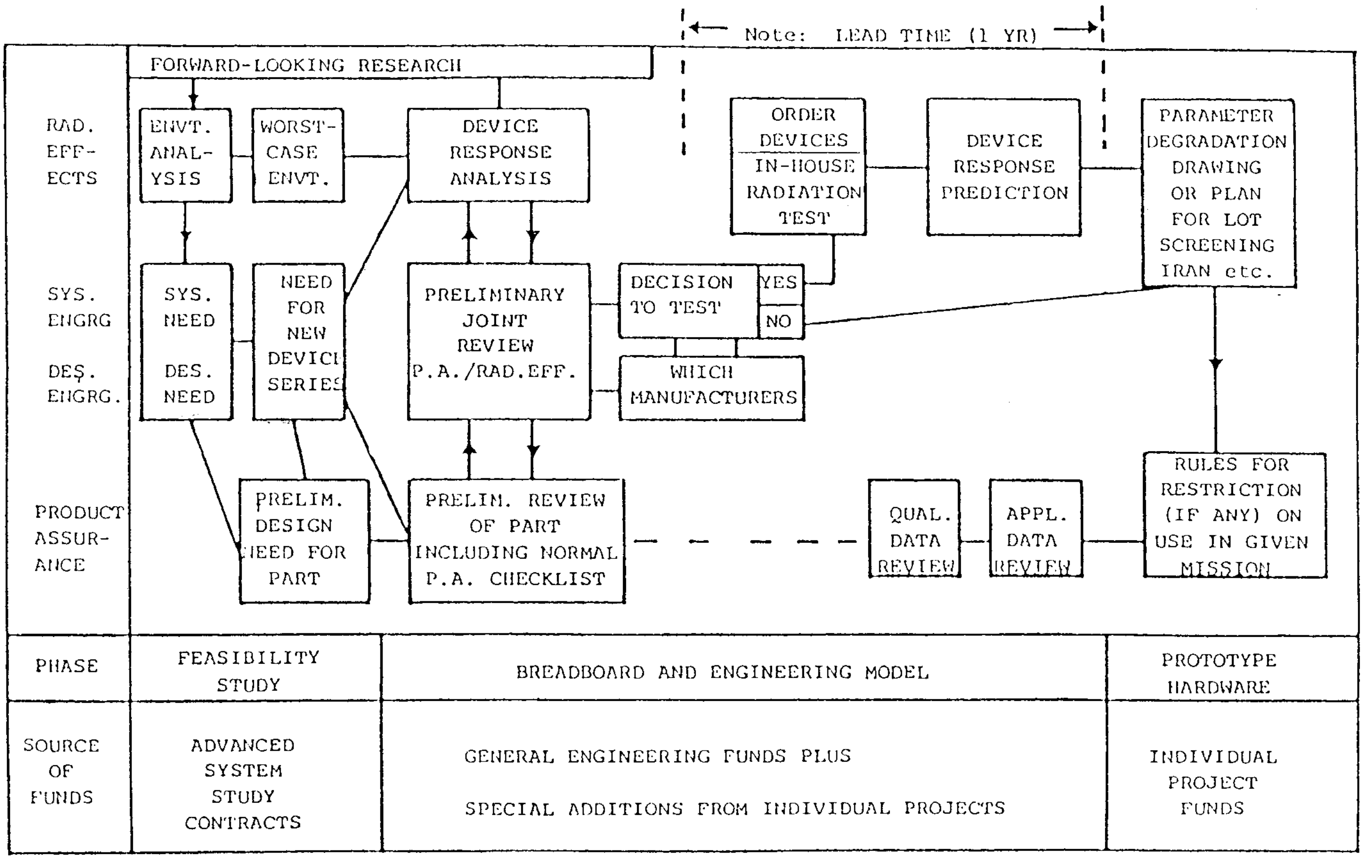


FIGURE 21.3 - PROJECT MANAGEMENT - TIMING



KEY: IRAN = Irradiate - anneal cycle
QUAL = Qualification, i.e. test and acceptance
P.A. = Product Assurance

FIGURE 21.4 - PROJECT MANAGEMENT - INTERACTION

TABLE 21(1) - U.S. PRACTICES IN RADIATION HARDNESS MANAGEMENT

1. Definition of environment		
For COMSAT	-	Contractor/COMSAT
For NASA	-	Customer
For Military	-	Customer
2. Identification of sensitive components		
For COMSAT	-	Contractor
For NASA	-	Joint endeavour
For Military	-	Contractor
3. Radiation analysis requirement		
For COMSAT	-	Completely in Contractor's hand. Approach is scrutinised and forms one of the criteria in contract award. COMSAT provides technical support.
For NASA	-	Varies according to Centre. GSFC: Contractor has overall responsibility, but analysis items are identified and deliverable for review and approval; GSFC has high degree of technical participation. JPS: Agency performs system circuit and parts analysis and selection.
For Military	-	Comprehensive analyses at all equipment levels required from Contractor. "Hardening", including extensive R & D, forms subprogramme.

21.6.2. Practices in the USA

Table 21(1) describes U.S. practices in the management of radiation effects. As implied by the term "management", most contractors in the USA have a Radiation Effects Group consisting of several workers.

The work is supported by:

(a) Pre-proposal or general engineering funds, the purpose of which is to improve the technical depth of proposals for large space systems contracts;

(b) Independent research and development funds, generally for the same purpose as (a), but emanating from the Government and loosely controlled by the latter;

(c) Technique contracts placed by agencies, which may or may not be directly connected with an individual space project;

(d) Direct funding by individual project offices to support the design of equipment.

To give an idea of the size of the "Radiation Effects Community" in the USA, the annual IEEE Conference on the subject is attended by over 1000 persons, possibly one third of whom are involved in space programmes.

21.7. GUIDELINES FOR DEVELOPMENT IN RADIATION EFFECTS

Some recommendations for future actions in the field of Radiation Effects Engineering are made later. At the present time, the most urgent needs are:

1. The establishment of a database on which predictions can be made,
2. Physical models permitting engineering predictions (still incomplete),
3. Formal guidelines for radiation effects control,
4. Development of testing techniques and facilities.

21.8. CONCLUSIONS

From the foregoing discussion, it will be clear that the management of radiation effects may create problems not encountered in other engineering fields. If penalties incurred by late reaction to such problems are to be avoided, then the organisation, timing and staffing to deal with them must be planned from phase A onwards.

REFERENCES

N.J. Rudie, "System Invisibility in the Nuclear Age", Defence Science and Electronics, pp. 16-26 (July 1985)

W.S. West, W. Poch, A.G. Holmes-Siedle, H.W. Bilsky and D. Carrol: "Subsystem Radiation Susceptibility Analysis for Deep Space Missions", NASA TR R-371, NASA Goddard SFC (Nov. 1971)