RELATIONSHIPS BETWEEN RESEARCH & DEVELOPMENT OPERATIONS AND INDUSTRIAL OPERATIONS AT MSFC

Working Paper #19

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3. Reports which are unpublished documents submitted to NASA and other interested parties which represent the final results in particular areas of inquiry in the research project.

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RELATIONSHIPS BETWEEN R&DO AND IO AT MSFC

Working Paper #19

Bernard D. Wood

ABSTRACT

This paper attempts to explain, for the edification of all SU/NASA research participants, the complex relationships, both formal and informal, between the two directorates (R&DO and IO) at the Marshall Space Flight Center as they existed prior to the reorganization of February, 1969. Through a detailed expansion of selected sections of the official organization chart, a typical interaction between a sub-system manager in IO and a particular section of one laboratory in R&DO was examined.

The formal channels, the management matrices, and the modes of informal contact were reviewed as seen from the perspective of our numerous interviews at that center. In addition, the Change Board and the management "levels" throughout the Apollo program were examined.

Scope of Our Investigation

The concepts we are presenting in today's seminar (of which this is one of four parts) are related to the study of the Role of the Project Manager, which is one of the investigations sponsored by NASA through the Syracuse University/NASA program. Early in our work, we decided to concentrate our efforts in the Apollo program, and more specifically the Saturn V program of Apollo. We knew that this was still very large, but I am sure I can say that no individual in the group -- from Business Administration, Political Science, Sociology, or Engineering -- had but the slightest inkling of the enormity and complexity of both the administrative and the engineering problems involved.

The four volumes from the Office of Manned Space Flight on Apollo Program Management, covering Headquarters and the three centers (MSC, MSFC, and KSC), contain so much information so briefly stated and succinctly summarized that they instill false confidence in the research worker.

We noted (indeed it was specifically pointed out to us) that the relationships among a sub-system manager from program management, a technical expert within NASA, and a contractor's representative became a critical factor in achieving the goals of performance, schedule, and cost for sub-components of the whole system and therefore for the system itself. This is just one aspect of our enquiry, but we feel that it is a critical one.

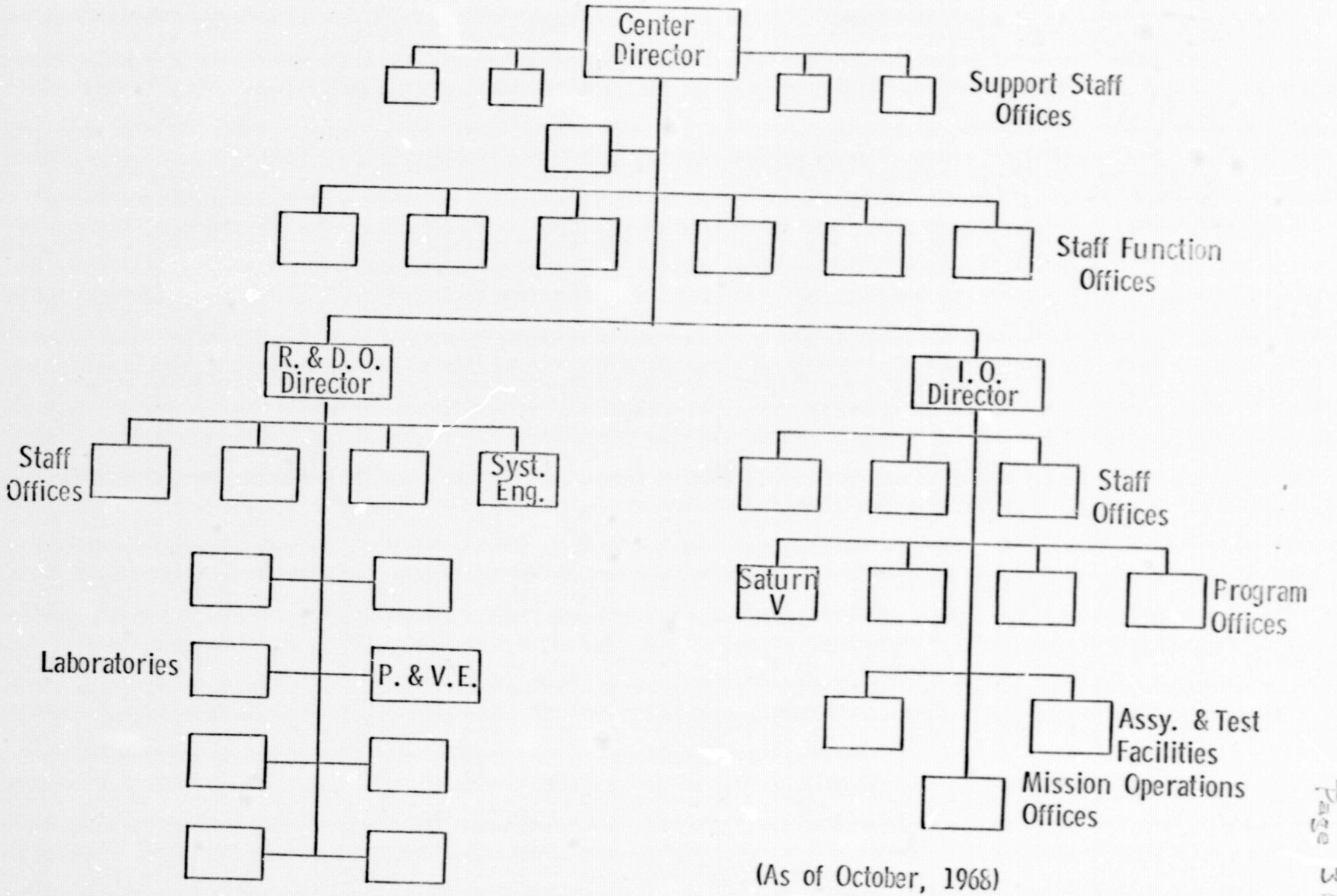
I myself have taken on the task of examining one side of this triangle at the Marshall Space Flight Center. In conjunction with Professor Wilemon who is concentrating on the project and sub-system managers, and Professor Drucker who is concerning himself primarily with relationships with contractors, I am looking at the relationship (interface, if you will) between project or sub-system managers in Industrial Operations (now Program Management) and technical personnel in the Research and Development Operations (now essentially Science and Engineering) at MSFC.

Organization Chart of MSFC

The chart I am presenting (Figure 1) shows the basic organization of the Marshall Space Flight Center as of October, 1968. There were significant changes in this organization in February, 1969, but the center is still in a transition stage, and it will be more useful to deal with the recent past. The relationships I want to discuss will remain very much the same I believe. (The changes made in February, 1969, are summarized in an Appendix to this paper. A chart of the new organization, dated February 14, 1969, is appended also.)

Figure 1 is just a skeleton of the organization chart. (This Figure and Figures 2 and 3 were projected on a screen during the oral presentation of the paper.) Only a few boxes have been filled in and I shall concentrate on those particular ones later. I want you to notice particularly the division, below the center staff function offices, of MSFC into two major directorates. What does not show is that the vast

MARSHALL SPACE FLIGHT CENTER



(As of October, 1968)

FIGURE 1

majority of center personnel work under the R&DO directorate, and that most of the center budget passes through the hands of the I.O. directorate. Also, what does not show is the relationship with Headquarters, particularly the Office of Manned Space Flight and the Apollo Program Office, in Washington. We must remember that, through this decade, most of the activity here and throughout NASA has been directed towards the Apollo program and that at this center much of that is focused on that one box marked Saturn V, the launch vehicle to put a man on the moon.

The apparent conflict of loyalties, to the Center and to the Program, are partly resolved when we realize that the Director of the Marshall Space Flight Center, Dr. Von Braun, has been given the responsibility "for the development, fabrication, assembly, and testing of the large launch vehicles required in the Apollo program." Also, the Director of Industrial Operations at MSFC, General O'Connor, is responsible "for conducting and managing Launch Vehicle System Projects" and he "acts as the Apollo Program Manager at this Center." Both of these men oversee other projects as well, but they have specific places in the Apollo program organization.

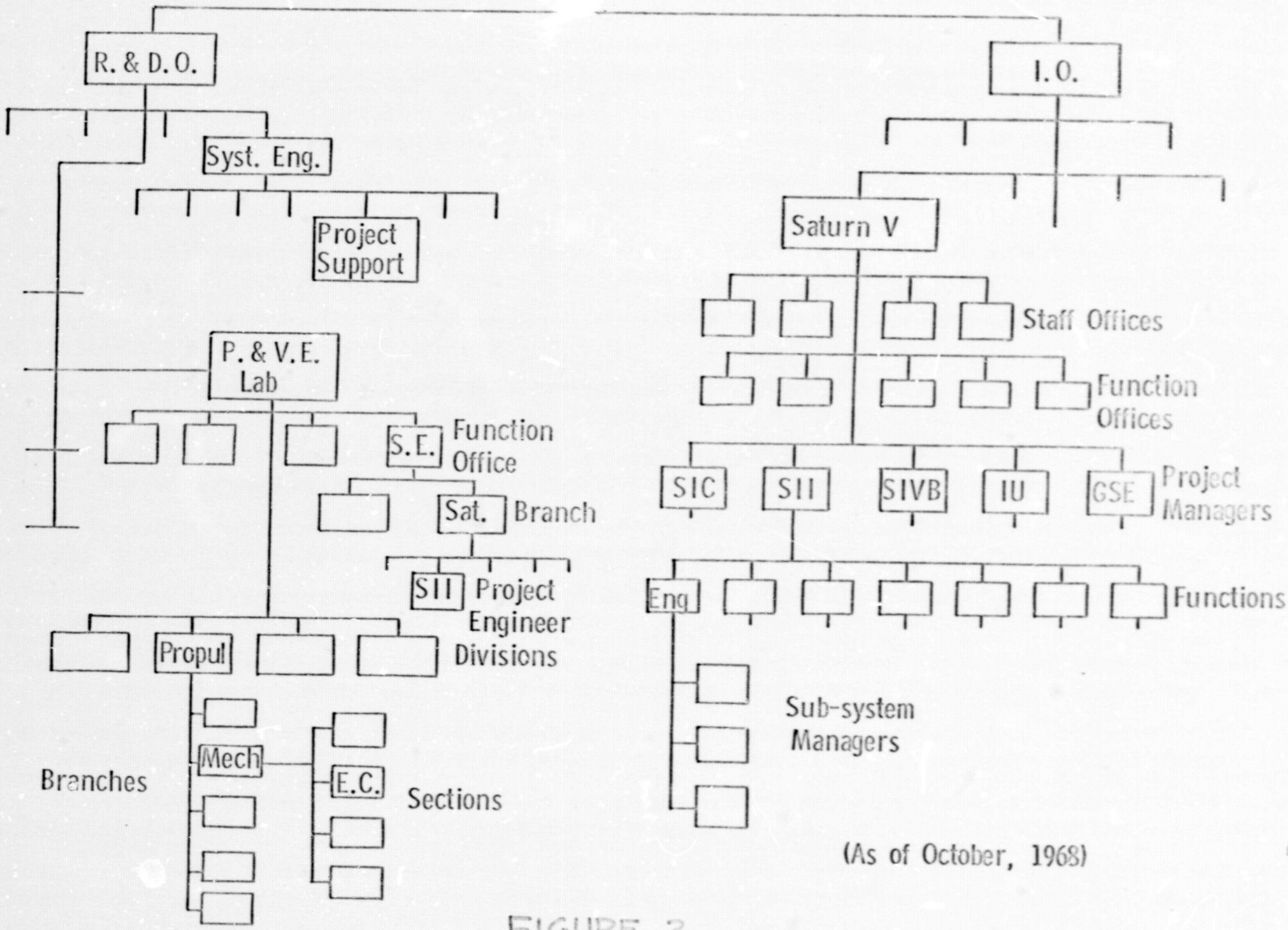
A generalization frequently encountered in discussions about the two directorates at MSFC is that Industrial Operations is essentially task oriented, primarily concerned with performance, schedule, and cost, while Research and Development Operations is discipline oriented, concerned only with performance. This is a gross over-simplification. Even in our limited interviewing, we have found many examples of cost consciousness originating with R&DO personnel, and certainly we have

found an understandable concern with schedule deadlines in addition to a pride in performance in that same side of the house. Nevertheless, it is true that the final responsibility for cost and schedule rests with the program and project managers, and it is inevitable that some of the more bitter conflicts between the two directorates have stemmed from that formal responsibility which has sometimes forced the managers to make a decision contrary to the advice of their own in-house experts who are in R&DO.

I.O./R. & D.O. Relationships

Perhaps the best way to appreciate the complexity of relationships between the two directorates at MSFC is to trace through those directorates to their smallest working elements, the sub-system manager in I.O. and the laboratory section in R. & D.O. To do this (in Figure 2), I have selected as an example sub-system managers in the Engineering functions of the SII stage (project) of the Saturn V program. Also, quite arbitrarily, I have selected the Environmental Control section of the Mechanical Systems branch of the Propulsion division of the Propulsion and Vehicle Engineering laboratory. So that we can trace formal relationships, it has been necessary to identify also the Project Support Office within the Systems Engineering office, a staff office in the R. & D.O. directorate. Further, one must note that there is a Systems Engineering/Project office within the P. & V.E. laboratory. Although it may not be referred to as such, this is an example of a functional office being "co-located" in another organization, reporting both to

EXAMPLE OF R&DO PROJECT SUPPORT



(As of October, 1968)

FIGURE 2

the director of that organization (the P. & V.E. laboratory in this case) and to the parent office (Project Support in Systems Engineering).

Again to emphasize the complexity of the whole organization, we should note the following:

a) Saturn V is one of four program offices currently in I.O. The others are:

   Saturn I/IB

   Saturn/Apollo Applications

   Engines

b) The SII project manager is one of five project (or stage) managers in the Saturn V program. The others are:

   SIC

   SIVB

   Instrument Unit (IU)

   Vehicle Ground Support Equipment (GSE)

c) Engineering is one of seven stage functions of SII. The others are:

   Program Control

   Test

   Reliability and Quality Assurance (R. & Q.A.)

   Manufacturing

   Configuration Management

   Logistics

d) Three sub-system engineers are shown on the chart, but in this particular office there is also a chief engineering manager (not shown). Other offices may have more or fewer sub-system managers.

e) In R. & D.O. there are eight laboratories:

Aero-Astrodynamics

Astrionics

Computation

Manufacturing Engineering

Propulsion and Vehicle Engineering

Quality and Reliability Assurance

Space Sciences

Test

f) In the P. & V.E. Laboratory there are four divisions:

Vehicle Systems

Propulsion

Structures

Materials

g) The Propulsion division of P. & V.E. Laboratory has five branches:

Engine and Power

Fluid-Thermal Systems

Mechanical Systems

Applied Research

Propulsion Systems

h) Not shown on the chart is the Projects office for the Propulsion division which has three engine project engineers (F-1, J-2, H-1) as well as project engineers for Saturn V, Saturn IB, S-IC and SIB, SII, SIVB, and AAP. These are liason men for the corresponding program and project offices in I.O.

i) The Mechanical Systems branch has four sections:

Advanced Design

Electro-Mechanical Systems

Environmental Control

Fluid Control

Fluid Feed

j) Sections, branches, and divisions have chiefs; laboratories have directors; programs, projects and stages have managers; and all these men have deputies and assistants.

k) These are all in addition to all the staff support and functions offices that were shown in Figure 1 and that are quite complex in themselves.

It is now clear that not all the management going on at this center is going on in Program or Project Management. But we could see that this had to be so from the historical development of project management here (as outlined by Professor Pooler). MSFC was not created from nothing. Its nucleus was formed under the Army in Redstone Arsenal.

Its technical competence grew up in the laboratories, and to a very large extent stays there. That operation requires a tremendous management scheme of its own which is essentially a line-and-staff organization.

Formal Channels

No formal agreement for the R. & D.O. laboratories to provide time or facilities to a project (which, after all, would require an allocation of funds) can be made without the knowledge and agreement of the Projects Support Office of Systems Engineering/Project Office located in that laboratory. Formal agreement for time and facilities allocations must eventually be made, when it has been determined what the requirements are likely to be.

Management Matrices

The number of individuals in I.O. who must communicate with various parts of R. & D.O. make it impossible to diagram such communication channels on a chart. Designated laboratory personnel are therefore listed in matrix form. For the Saturn V program alone, the R. & D.O. points of commitment (persons who can officially commit the laboratories for services), the designated technical persons (who cannot), the contractor counterparts and resident managers, the I.O. program, project, and sub-system managers, all are noted on 23 matrices, each on a separate sheet, which states who officially interacts with whom.

The development of such complex matrices, the insistence on their being up to date, and the heavy reliance on them in day-to-day operation apparently constitute a management innovation peculiar to the Saturn V program and represent a real contribution to the management techniques of complex technological programs.

Informal Contacts

The telephone is the most important instrument in the whole management scheme. The frequency of telephone contact between individuals in I.O. and in R. & D.O. (as well as between these men and their counterparts at the contractors and at the other centers) is unbelievably high. And more often than not, these phone calls are by-passing official channels.

The routes of formal communication, so carefully layed out to ensure maintenance of technical and financial responsibility, are too complex and time consuming for a time-critical program such as Apollo. Knowledge resides with people despite their office locations. Technical assistance and the willingness to expedite a solution with or without official direction may depend on mutual trust and respect and on personal commitment, dedication, and enthusiasm for the program.

Thus, the Project Support office in R. & D.O. will communicate informally with the Saturn V program office, and serves as a channel for Saturn V to Operations Management and Experiments, which are two staff offices in R. & D.O. comparable to Systems Engineering. Similarly, Project Support must deal directly with sub-system managers and

with designated or undesignated engineers in the various laboratories.

How frequently does a man by-pass his own superior or the superior of a man he wishes to contact? The answer depends primarily on his own personality and style and on the personality and style of the superiors concerned. (David Wilemon is commenting separately on the personality, style, and technical competence of project managers.) It depends as well on his own background. There is considerable mobility of personnel within the center and throughout NASA. (John Cicero is dealing separately with the question of mobility.) Many sub-system managers in I.O. have come from R. & D.O. and know the men they have to talk to very well. This cross-mobility is an advantage both ways. One laboratory manager in commenting on the move of one of his own subordinates to a sub-system manager's position in I.O. said, "It is useful to have a friendly Indian over there."

A project or sub-system manager who comes from industry or from NASA but not MSFC (and many do) has this problem of penetrating the R. & D.O. directorate added to his already complex job. Some have commented on the time necessary to establish informal contacts.

Lead Laboratories

It is in the nature of the Apollo Program and all others at MSFC that many problems either identified in the early stages of conception and design or encountered during testing and actual missions are likely to cut across the boundaries of the disciplines around which the laboratories are organized. When unforeseen problems arise, they

may have to be dealt with as a crisis because of the importance of schedule throughout the program.

For these multi-disciplinary or multi-laboratory problems, a lead laboratory is designated by the director of R. & D.O. It seems that the designation of a lead laboratory depends primarily on the individual chosen to lead the investigation and his particular affiliation rather than on a logical laboratory, though the two considerations are hard to separate.

The director of the lead laboratory then puts together a team from throughout the center, primarily from R. & D.O., and the other laboratories involved become supporting laboratories. An engineering manager is designated by the lead lab. director and each supporting lab. designates a project engineer for the particular problem.

This practice of drawing a working group from all concerned laboratories provides a flexibility in the operation of the R. & D.O. side of MSFC that again is not apparent from the formal organization charts.

Change Boards

Throughout the Apollo program, there are change boards to deal with hardware changes proposed or requested after design completion. These boards operate at levels 0, I, II, III, IV, and V that exactly parallel the management levels in the Apollo program. These levels are shown in Figure 3.

Engineering change proposals (ECP's) originate with the contrac-

Figure 3

CHANGE CONTROL AND CONFIGURATION CONTROL BOARD LEVELS

(SAME AS MANAGEMENT LEVELS)

LEVEL 0	NASA Administrator
	Manned Space Flight Office
	MSF Management Council
	Science and Technology Advisory Board
	MSF Experiments Board
	APOLLO Executive Group
LEVEL I	APOLLO Program Office, Headquarters
LEVEL II	Manned Spacecraft Center Director
	Marshall Space Flight Center Director
	Kennedy Space Center Director
	Program Managers
	Research and Development Laboratories
LEVEL III	Project Managers
	Research and Development Laboratories
LEVEL IV	Sub-System Managers
	Contractor Resident Managers
	R. & D.O. Personnel
LEVEL V	At Contractor's Plant

tor, and engineering change requests (ECR's) originate usually from within R.D. & 0. These proposals or requests, however, follow lengthy informal discussions in the critical team made up of the sub-system manager from I.O., the R. D. & 0. designated technical person, and the contractor's engineer who is the counterpart to the particular sub-system manager. There is continuous interplay within the team with any one of the members taking the initiative, usually by means of a telephone call.

Configuration Control Board directives to implement a change will come from the C.C. Board at the appropriate level, established by what other elements are affected (impacted) by the change. But these directives follow the decisions of the Change Boards after all arguments from management, laboratories, and contractors have been heard.

Naturally, there will be differences of opinion concerning almost all changes, and it is not always possible to reach compromises satisfactory to every party. It is fundamental to project management that the appropriate manager in I.O. (for levels IV and III) or at Headquarters (for levels II, I, and 0) must make the final decisions. Where R. & D.O. disagree at a lower level, the problem can be forced to a higher level for decision if the line management within R. & D.O. is willing to push it. In other words, whether a technical person in a laboratory can pursue his minority report, taking it to a higher level, apparently depends on his ability to convince his own superior within the R. & D.O. organization.

Concluding Remarks

From our trips both to MSFC and to the other centers and from our interviews to date, we remain convinced that the original premise of our investigation was valid: the triangle formed by a sub-system manager in I.O., a technical person from R.& D.O., and a contractor's representative is a critical structural member in the management framework of NASA at MSFC. The relationships among these three men can facilitate or impede the work of the project manager and, consequently, of the program manager. This epitomizes the checks and balances operating in the decision making that involves program management, in-house expertise, and the contractor.

I hasten to say, however, that what I have described is in some ways peculiar to the Marshall Space Flight Center. It is affected by the history of that center, by its management personnel, and by the type of work done at MSFC in contrast to the functions of the other centers. At this point we are neither ready to generalize on some of our observations nor to itemize differences between MSFC and other centers.

It is likely that a closer study of the February, 1969, reorganization of MSFC, outlined briefly in the Appendix, will help reveal some of the strong and some of the weak features of the previous organization. It is too early to tell. At the same time, it must be remembered that this reorganization reflects primarily a shift to a new phase in the Apollo program and the whole NASA operation.

APPENDICES

DIRECTORY CHART

GEORGE C. MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER ALABAMA 35812

DATE: OCTOBER 1, 1966

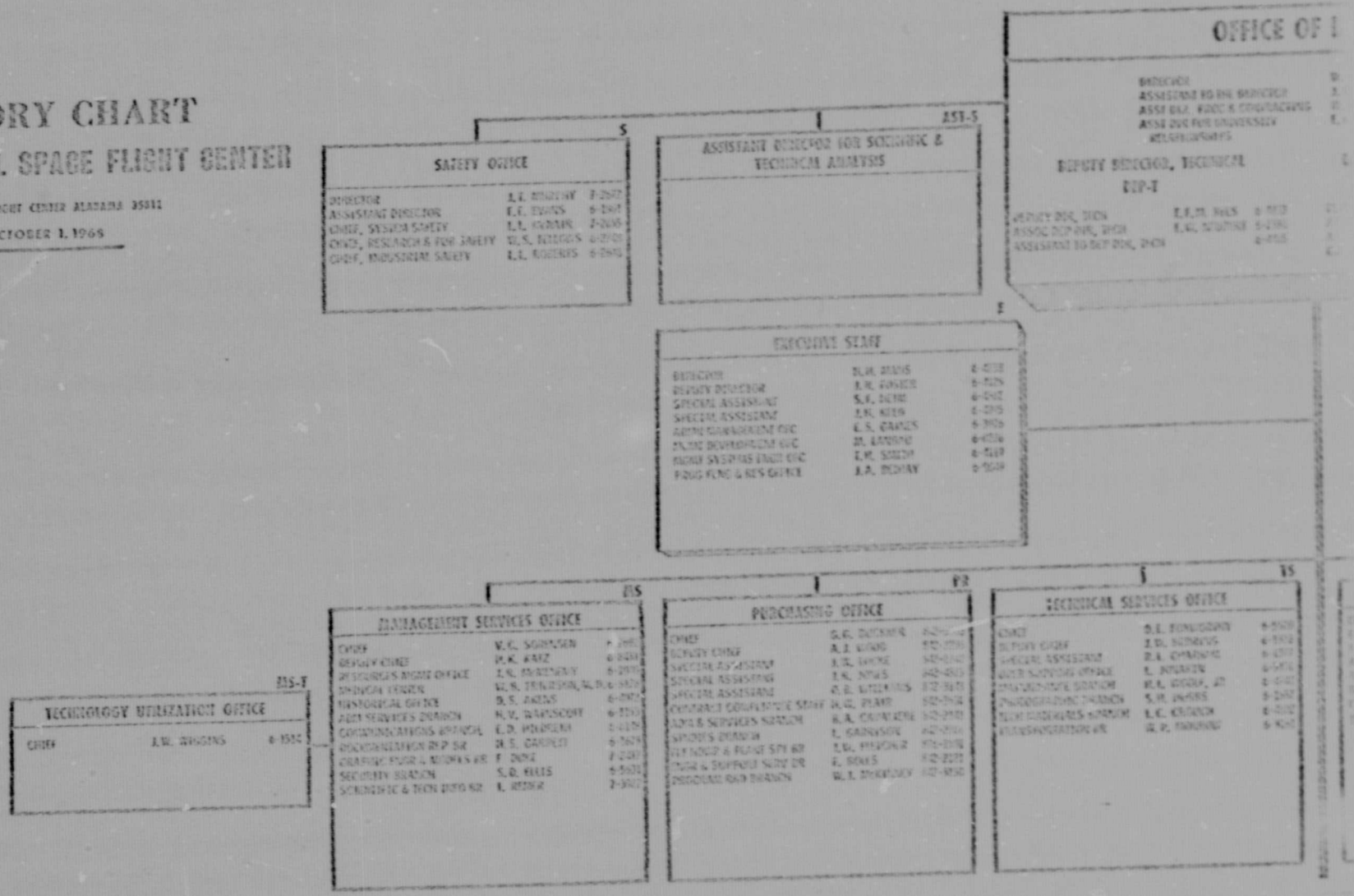


FIGURE A-1

Sheet 1 of 4

DIR

E OF DIRECTOR

	W. von BRAUN	6-5914
OR	J.T. SHEPARD	6-4226
CHING	W.S. DAVIS	6-3554
Y	E.D. MOURERE	6-5565

DEPUTY DIRECTOR, ADMINISTRATIVE

DEP-A

733	DEPUTY DIRECTOR, ADM	H.H. GORMAN	6-1764
35	ASSOC DEP DIR, ADM	D.H. MURPHY	6-1765
	ASSISTANT TO DEP DIR, ADM	C.W. MUSE	6-1434
	COST REDUCT & VALUE ENGR	A.D. SMITH	6-1297

PA

PUBLIC AFFAIRS OFFICE

CHIEF	B.B. SLATHERY, JR.	6-5363
DEPUTY CHIEF	F.A. HALEY	6-3450
ADMINISTRATIVE OFFICER	V.L. SHAFER	6-5720
MEDIA BRANCH	J.M. JONES	6-1919
CENTRAL SERVICES BRANCH	E.C. GOODIN	6-0739
EDUCATION BRANCH	R.B. PRATT	6-1761
PROTOCOL BRANCH	E.L. RIDDICK	6-2355

CC

CHIEF COUNSEL

CHIEF COUNSEL	W. E. GUILIAN	7-2361
DEPUTY CHIEF COUNSEL	E.R. LUSG	7-2362
ASSOCIATE CHIEF COUNSEL	V.S. LAVIS	6-2853
ASSOCIATE CHIEF COUNSEL	J.P. NAKAID, JR.	6-1061
ASSOCIATE CHIEF COUNSEL	R.C. JOHNSON	6-2360
ADMINISTRATIVE OFFICE	T. DAVIS	7-2367

PAT

PATENT COUNSEL

PATENT COUNSEL	L.D. WOFFORD, JR.	6-0760
FIRST ASST PATENT COUNSEL	C.C. DAVIS, JR.	6-0969
ASSISTANT PATENT COUNSEL	H.H. HIGGINS	6-2930
ASSISTANT PATENT COUNSEL	G.B. FORBIS	6-2350
ASSISTANT PATENT COUNSEL	J.M. BRUNER	6-0975
ASSISTANT PATENT COUNSEL	A.H. FISCHER	6-2930

FEE

FINANCIAL MANAGEMENT OFFICE

CHIEF	T.H. MARKMAN	6-1761
DEPUTY CHIEF	R.H. FRASER	6-1451
ASSISTANT TO THE CHIEF	W.O. SISCO, JR.	6-1471
ADMINISTRATIVE		6-2591
ACCOUNTING BRANCH	B.E. PHELPS, JR.	6-5612
BUDGET & OPER BR	L.E. SNYDER	6-6195
FINANCIAL SYSTEMS BR	L.G. JACKSON	6-0199
INTERNAL REVIEW BR	S.K. GOINS	6-6228

FEA

MANPOWER UTILIZATION & ADMINISTRATION OFFICE

CHIEF	P. SIVIES	7-3084
LABOR RELATIONS OFFICE	H. GOOCH	6-4730
PLANS & PROGRAMS STAFF	J. HAYES	6-5692
PERSONNEL OFFICE	A. SANDERSON	6-8750
EQUAL EMPLOYMENT STAFF	J. TEMPLE	6-9797
INCENTIVE AWARDS STAFF	L. ADERHOLT	6-4364
PROFESSIONAL STAFFING	N. HOCHBERGER	7-2726
PERSONNEL MGT ASST "A"	R. ABLE	6-9794
PERSONNEL MGT ASST "B"	B. BOYD	7-2541
PLAN & PROG ADM BRANCH	P. PERRY	7-2535
[illegible] BRANCH	J. DOGDY	6-7150
MANPOWER MGMT CONTROL OFC	M. KENT	6-5663
EMERGENCY PLANNING STAFF	H. SLAYDEN	6-5692
MANPOWER PLANNING BRANCH	K. LYLE	7-2950
COMMUNITY AFFAIRS BRANCH	A. JOHNSON	7-2000
PERSONNEL COMMUNICATIONS	W. THESSIN	7-3307

FED

FACILITIES & DESIGN OFFICE

CHIEF	C.W. HUTCHETH	6-1710
DEPUTY CHIEF	G.H. WADE (ACD	6-0175
ASST CHIEF, TECHNICAL	H.A. SCHULZE	6-0875
SPECIAL ASSISTANT	H. EHRNSEN	6-2525
CONSTRUCTION BRANCH	R.B. RAMSEY, JR. (ACD	7-2141
DESIGN BRANCH	*R.B. RAMSEY, JR.	7-2121
RESOURCES OFFICE	C.S. LITTLE	6-5107
PLANNING BRANCH	G.H. WADE	6-0175

*DUAL ASSIGNMENT

IG-DI

*NASA REGIONAL INSPECTOR

INSPECTOR	R.E. WOOD	6-5433
INSPECTOR	E.K. KANE, JR.	6-3542

*REPORTS ADMINISTRATIVELY TO DIRECTOR OF INSPECTIONS, NASA, WASHINGTON, D.C.

IG-DA

**NASA REGIONAL AUDIT OFFICE

MANAGER	G.W. NOEL	817-335-
DEPUTY OPERATIONS MANAGER	W.D. ELDER	817-335-
DEFC CONTRACT OVER BR	S. HUFFSTUTLER	205-876-
HUNTSVILLE AUDIT OFC	S. SMITH, JR.	256-2[illegible]
MISS TEST AUDIT OFC	J.R. SAVERANCE	601-8[illegible]

**REPORTS ADMINISTRATIVELY AND TECHNICALLY TO DIRECTOR OF AUDITS, NASA, WASHINGTON, D.C.

FIGURE A-1

Sheet 2 of 4

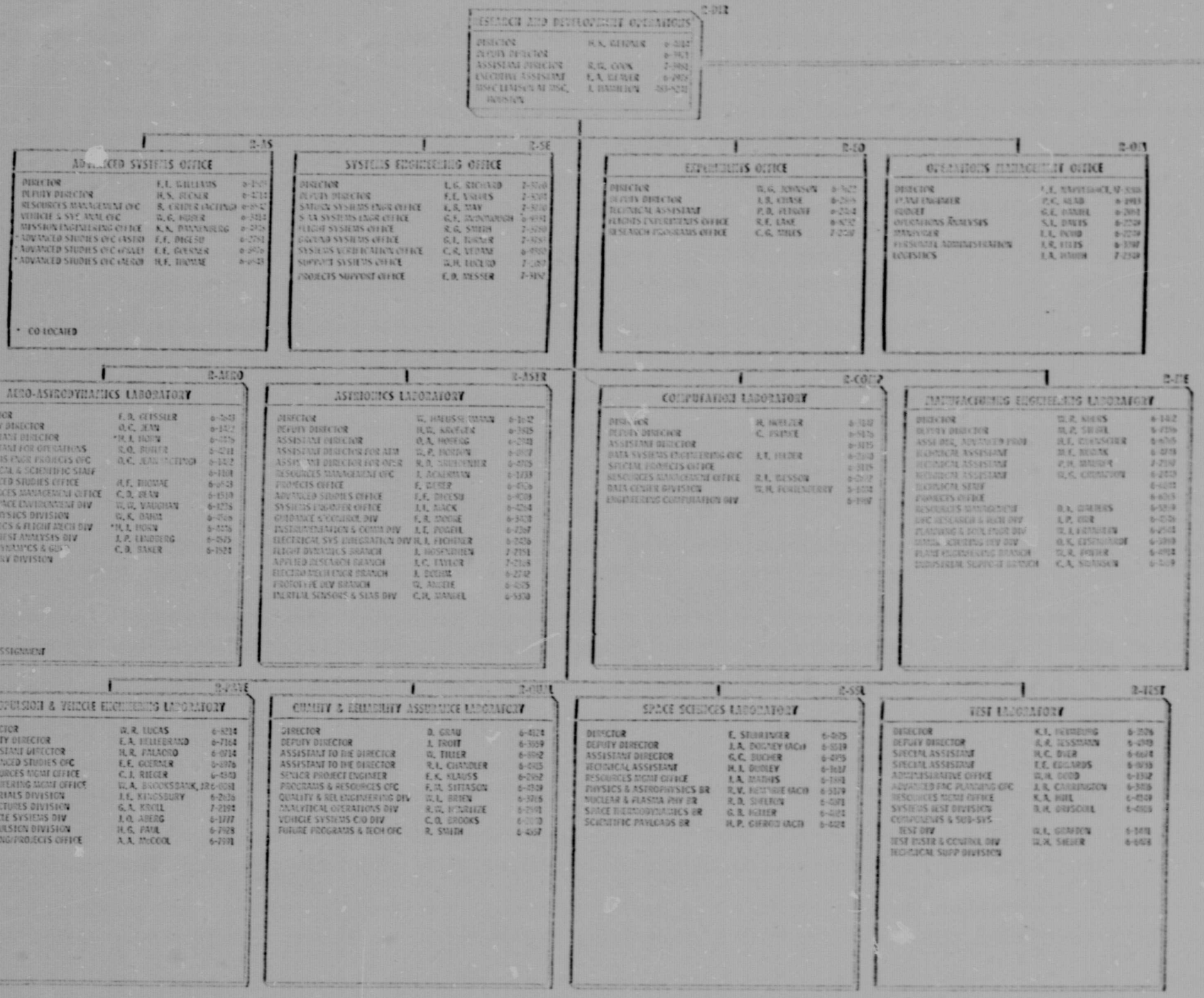


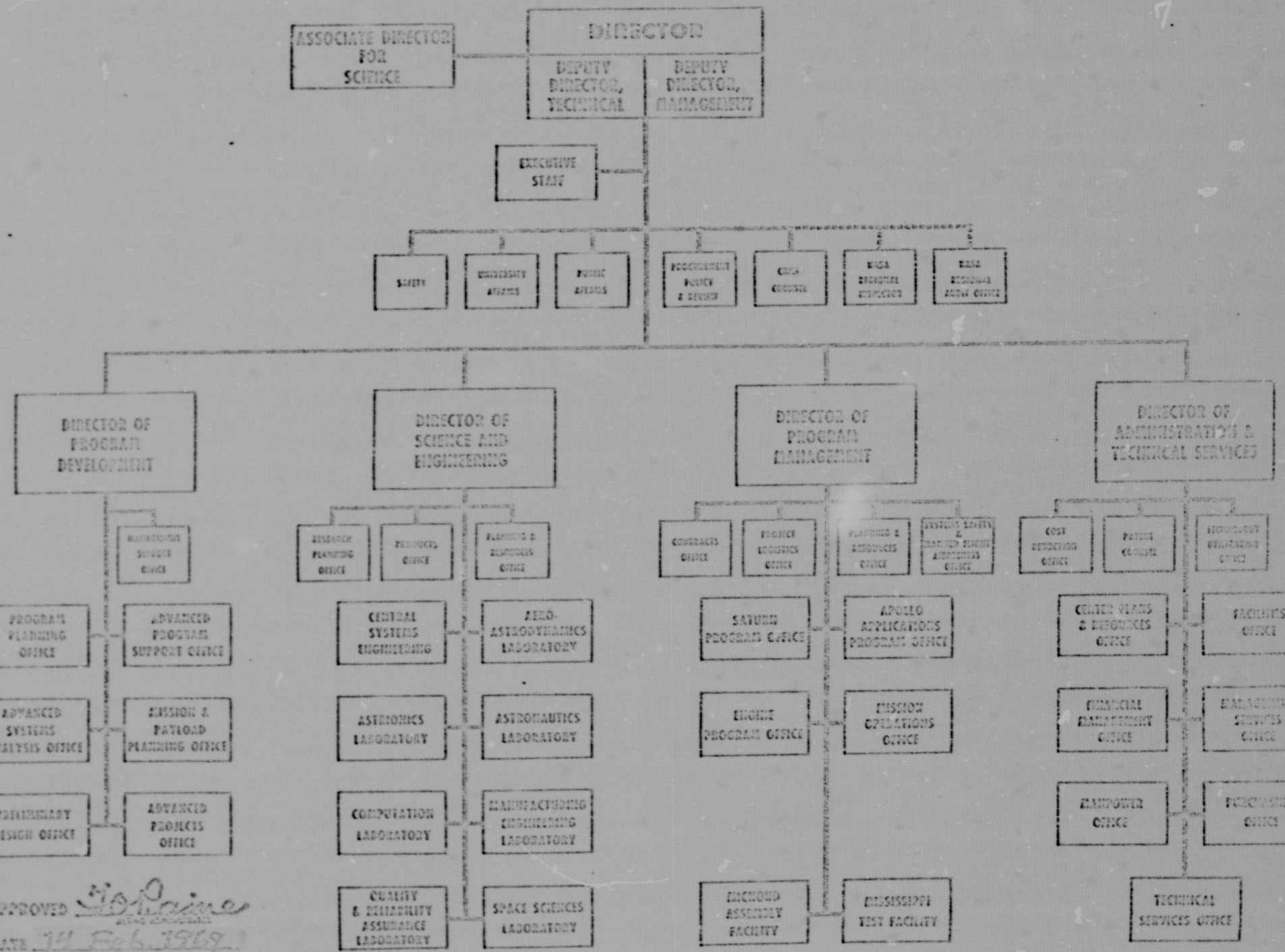
FIGURE A-1 Sheet 3 of 4

FIGURE A-1

Sheet 4 of 4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER



APPROVED Wernher von Braun

DATE 11 Feb 1969

CHANGES AT MSFC, FEBRUARY, 1969

A. RESEARCH AND DEVELOPMENT OPERATIONS CHANGED TO SCIENCE AND ENGINEERING DIRECTORATE.

Retained:

1. Aero-Astrodynamics Lab.
2. Astrionics Lab.
3. Computations Lab.
4. Manufacturing and Engineering Lab.
5. Quality and Reliability Assurance Lab.
6. Space Sciences Lab.

Changed:

1. Propulsion and Vehicle Engineering Lab. to Astronautics Lab. (Are these the same?)
2. Systems Engineering Office to Central Systems Engineering. (Are these the same?)

Deleted:

1. Advanced Systems Office (This seems to be split into several offices in the new Program Development directorate.)
2. Experiments Office (This seems to be the Advanced Projects Office in the new Program Development directorate.)
3. Operations Management Office (This may have been renamed the Planning and Resources Office in Science and Engineering; see below.)
4. Test Lab (Is this now part of Q and RA Lab?)

Created:

1. Research Planning Office
2. Products Office
3. Planning and Resources Office (Was this the Operations Management Office? See above.)

B. ADMINISTRATION AND TECHNICAL SERVICES DIRECTORATE CREATED.

Brought over from Center Staff Offices:

1. Patent Counsel
2. Management Services Office
3. Technology Utilization Office (Was attached to Management Services.)
4. Facilities Office (Was Facilities and Des gn.)
5. Financial Management Office
6. Manpower Office (Was Manpower Utilization and Administration)
7. Purchasing Office
8. Technical Services Office

Created:

1. Cost Reduction Office

C. STAFF LEVEL CHANGES (in addition to those moved to new directorate of Administration and Technical Services; see above.)

Created:

1. University Affairs (Was part of the Executive Staff)
2. Procurement Policy and Review
3. Associate Director for Science (Assistant Director for Science and Technical Analysis: post has not been filled recently.)