SPACE SCIENCES RESEARCH CENTER OF THE UNIVERSITY OF MISSOURI

An Experiment in

University Research Management

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The relationship of the University to the national space effort has been under discussion and development ever since the National Aeronautics and Space Administration was formed in 1958(3). And NASA has played a leading role in the growth of space-related activities at American universities.

In particular, NASA pioneered in the development of imaginative institutional support programs, including the so-called step-funded traineeship and multi-disciplinary research grants,* which many universities have felt to be particularly suited to their objectives. Furthermore, the bulk of the scientific advisors participating in the planning and definition of experimental and exploratory objectives for the space program have, quite properly, been faculty members. There has thus been a natural involvement of many leading university departments in some aspect of space-related research, training or development activities.**

MANY PROGRAMS

As a consequence of these activities, and of the post-Sputnik general growth of public interest, some 200 out of approximately 600 U. S. universities or colleges with graduate degree programs now have one or more active space-related programs(2). Many of these are identified by their institution as "Space Centers," or a similar term, presumably because they involve more than one faculty member, discipline, department, or college of the university.

Space Center at Missouri

The University of Missouri is now entering the third full year of development and operation of such an activity, identified as a Space Sciences Research Center. Because the genesis, administrative policies, and programs of this activity are different in many respects from those at other universities, it may be of interest to review them as still another example of the experimental innovations in university management and administration which are occurring with increasing frequency throughout higher education(1).

To start with, the SSRC at Missouri is the only space center, to our knowledge, which was originated by a local legislative body and supported initially by major local (state) funds. As part of the 1963-65 biennial budget, the General Assembly appropriated $2 million capital and facilities funds and an initial $250,000 operating fund for use by the University in organizing and establishing a major multi-disciplinary research program in space-related science and technology. The appropriation was initiated by the Governor on the recommendation of his Science Advisory Committee. This is a group of leading representatives of the scientific, industrial, and university community, appointed to advise the Governor's office on the role of reseach and development activities in the State.

One of the most desirable and important consequences of this local support is the free-

*The step-funded mechanism originated by NASA is slowly being utilized by other federal agencies(4).

** Two conferences have reviewed NASA-University programs in some detail: the first in Chicago in 1962 and the second in Kansas City in 1965(6,7). A particularly helpful outline of NASA's institutional grant activities was presented at the second conference(5).

dom it gives the University to plan and organize an activity to meet its own requirements as an institution of higher education, rather than those of some branch of the federal government. This freedom is reflected first in the Center's administrative policies and organization.

State-supplied funds for the Center's activities have now grown to more than $800,000 annually. Of course, as with any university program, considerable federal agency and other outside support for individual research projects is being continually sought and obtained. In addition, a NASA step-funded multi-disciplinary research grant to the Center's program on the Columbia campus is in its second year. The University does not intend, however, for the Center to become at any point completely dependent on federal grants, and the presently accepted goal is a 1:1 ratio of outside to University financial support. Outside support on an annual basis now totals about $500,000 or a 0.6:1 ratio.*

Briefly the Center's objectives are:

To attain pre-eminence in selected areas of space related research.

To train and develop independent scientific investigators.

To stimulate faculty and student interests in research.

To attract creative new faculty and students to the University.

These objectives are similar to those of any university research activity with a serious commitment to graduate education as well as to production of new knowledge. In formulating administrative policies to meet them, however, Missouri has developed a number of departures from the generally accepted models for new graduate and faculty research activities. Some of these are of the type which produce hopefully beneficial administrative tensions analogous to those found in industrial or governmental R & D ventures where project and functionally oriented structures coexist in the same organization.

* The Center is also actively interested in securing additional support from industrial or non-profit organizations whose missions may parallel the program. One cooperative program with a large national industrial corporation is already under way based on arrangements which safeguard faculty autonomy and educational objectives of the Center, while promoting mutual interests in productive basic research. Under these arrangements, one of the company's research staff is studying for his Ph.D. in an appropriate University department and conducting research on Center projects.

UNIVERSITY PROGRAM

The University of Missouri, a multi-campus* land grant institution, is rapidly expanding in all areas of university activity: undergraduate training, graduate education and research, and extension and community services. There is, therefore, a constant and growing pressure to diffuse available resources to meet the often opposing demands of these activities as well as the requirements of a varied and growing faculty. In order to minimize the effect of these pressures on SSRC programs, the Center has a University-wide charter to support programs on all the campuses with active graduate training in the sciences, but only as they meet criteria which the Center itself develops. Obviously, the minimal requirement for support is some type of relationship to space science and exploration, but much more is ordinarily required of a Center supported activity.

At the same time, however, the Center is not a separate institute. The strength of a separate institute in attaining primarily research objectives is well-known, but its direct contribution to graduate education objectives is sometimes questionable. At best, this contribution is often delayed until after the "institute's" reputation is established and it has begun to attract students and faculty to related departments at the parent university. At worst, it competes directly with academic departments for creative new faculty and tends to isolate them from all but a select few of the student body.

* There are four campuses: Columbia, Rolla, Kansas City, and St. Louis. In addition, graduate instruction in some fields is offered at cooperating centers on the State College campuses at Cape Girardeau, Maryville, and Springfield.

Faculty appointments

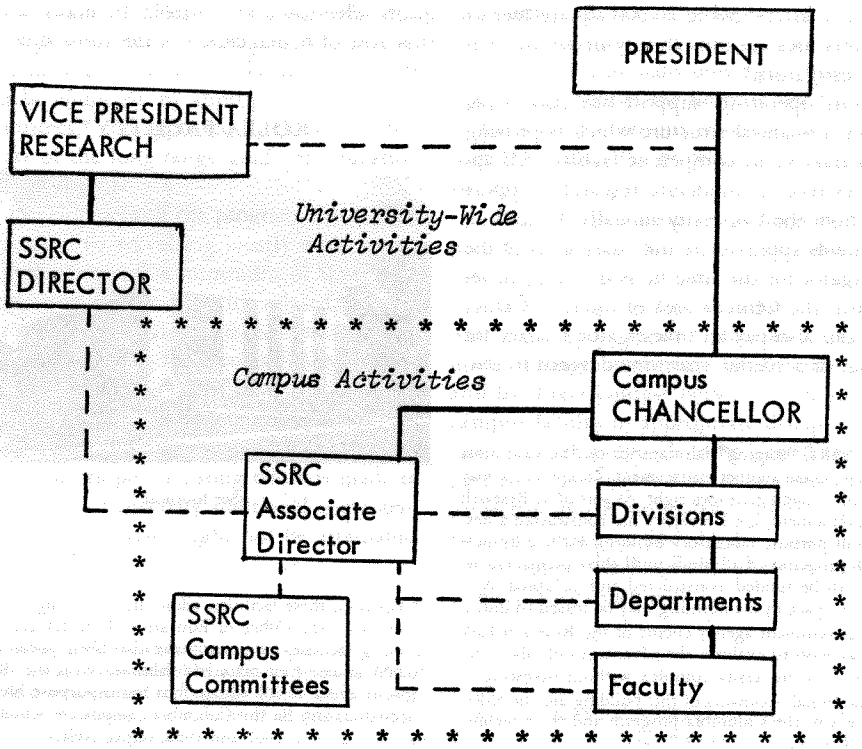
To maximize the contribution of the SSRC to graduate training, therefore, all professional staff are appointed primarily in appropriate academic departments on one of the campuses, and secondarily as Investigators or Research Associates in the Center. Both full- and part-time Center appointments are made, depending upon the degree of responsibility outside his own research program desired by the individual. Even those faculty with full-time Center appointments are, however, expected to supervise graduate student research and to participate in the educational function of their academic department, if not through formal teaching, at least by seminars, graduate counseling, or similar activities. No "courtesy" departmental appointments are made or envisioned for Center faculty.

Administration and support

The SSRC is administered by a Director who is responsible to the University Vice-President for Research, although he functions through Associate Directors on the individual campuses who report in line to the campus Chancellor or his designee. University funds for programs and operations are, however, allocated solely through the Director's office. These relationships are briefly outlined in the chart in which the analogy to industrial development and marketing teams, or to the military special project organization is obvious.

Other advantages of the major local support for the Missouri Center relate to the problems of rapidly initiating any new program in a university environment. The difficulties of planning and funding new activities which will bring together program ideas, sup-

ORGANIZATIONAL RELATIONSHIPS
Space Sciences Research Center

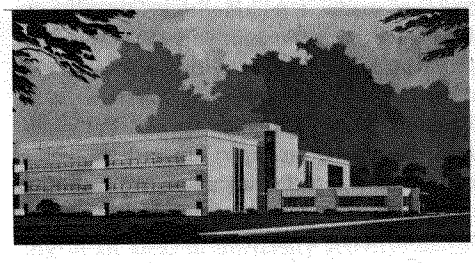


porting funds, creative staff, and laboratory space on any reasonable timetable are all too well known. Most of these inefficiencies are due to the difficulties of attracting and holding creative research-minded faculty, without laboratory space or research support funds, for projects which may not meet granting agency requirements, particularly in tight federal budget years. Agency requirements often fluctuate much too rapidly for sound development of university programs—defense-oriented research is big today, poverty tomorrow, and so on.

Both of these problems have been overcome to a considerable extent by local support. To begin with, the Center's operating budget lessens faculty dependence on project grants. Even more importantly, however, the State's capital appropriations have enabled early planning for future laboratory space on two campuses. Definite timetables for permanent laboratories have also made it possible for the University to assign "staging area," or temporary laboratory space, to the Center on these campuses pending completion of permanent quarters. Some 20,000 square feet of laboratory area are thus already in use by Center investigators.*

State operating support has also made possible a financial structure which is proving very attractive to competent faculty. All appointees receive moderate research support funds from the University annually. In general, these funds approximate the salary level of the investigator for the time he is devoting to research in the Center's area of interest. Center funds can also pay an investigator's salary for summer or academic year time devoted to center research. Jointly appointed faculty are thus not completely dependent on project grants for either salary or research support.

COLUMBIA FACILITY

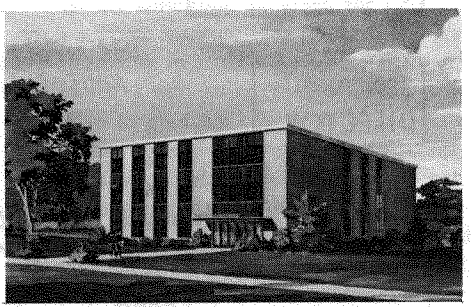


See footnote*

Program selection and control

In parallel with these administrative policies and operations, the Center has experimented with a number of approaches to program selection and control. In many ways, this area of management is the most difficult

ROLLA FACILITY



See footnote*

* The SSRC "staging" laboratories on the Columbia campus represent another management concept which may be of some interest in its own right. As part of its Research Park development, the University has constructed a flexible, multipurpose laboratory building for use by new research programs of all kinds until their permanent facilities can be funded, constructed and occupied. At a later date, space in the building may be leased to industrial or government agency clients of the Research Park who may wish to evaluate the advantages of laboratory activities in a university complex without investing in facilities. Initial occupants of this building are the SSRC appointees in the Columbia program and their technicians and students.

* For both these facilities, additional matching support funds from the Office of Education Title III graduate training facilities program have also been secured. A 30,000 square foot materials laboratory on the Rolla campus and a 40,000 square foot multi-purpose life science laboratory on the Columbia campus are scheduled for occupancy in 1967 and 1968, respectively.

of all in a university program because it impinges directly on amorphous, but obviously essential, concepts of faculty autonomy.

Furthermore, any multi-disciplinary or broad problem emphasis in a research program is generally contrary to the quite properly discipline-oriented structure of "standard" university organizations. Here again, however, the local funding has been invaluable because it encouraged the various planning committees to structure a research program which stresses fundamental research of maximum value for graduate training and of long-range, rather than immediate, application to the space effort. These two qualifications are essential if an activity such as the Center is simultaneously to produce meaningful new knowledge and contribute to graduate education.

Three general approaches to programming are now in use. In the FIRST, which utilizes the bulk of the Center's operating budget, a broad, interdisciplinary research area with a fundamental relationship to space science and exploration is selected for development as a campus program. Selection is made only after thorough consultation with the Administration and interested faculty on the campus. It must be endorsed by appropriate operating committees,* and approved by the Chancellor as part of the long-range graduate education plan.

Development of the program area is then undertaken by recruiting jointly with appropriate departments a minimum of three full-time Center appointees with related research interests. In general, these are senior individuals (associate or full professor) whose research interests are relatively well-defined and creative. Although these appointments can be, and in some cases have been, offered to faculty already on campus, a strong effort is made to attract to the University additional competent staff who otherwise might not be attainable.

The three man minimum has been regarded intuitively as a sort of "critical mass" requirement for the development of an area—a "tigers need other tigers to growl with"—sort of thing. Our limited experience to date, however, suggests that a somewhat larger full-time "cadre" may be more rewarding in terms of impact on graduate training and eventual research preeminence. This need for a larger size group is particularly evident on larger campuses such as Columbia, where a dozen or more departments may have interests which could interact with a major program area.

Once these appointments are made, however, the investigator is free to utilize his University funds (and any outside support) for research projects and problems which he defines himself, or with his colleagues in the Center or elsewhere on the faculy. Individuals with appropriate research interests are thus led to interact with the Center's program and, as they plan and carry out their research, to further shape and develop it.

The major program selection procedure thus differs dramatically from that in an industrial, mission-oriented organization, and even from that in many university "institutes." Specifically, neither the Director nor his counterparts on the various campuses attempt to dictate or select the projects to be carried out by staff.

The SECOND program management approach is closely akin to that of most institutional grant mechanisms, except, of course, that it involves University, rather than solely outside, support funds.* Here an attempt is made, through appropriate faculty committees and by direct contact between staff and on-campus faculty in appropriate disciplines, to elicit research proposals to be carried out on a part-time basis with Center support. These project proposals are reviewed by the Center's faculty committee and the Directors for potential support and selected, as far as possible, to meet criteria such as:

* For example, on the Columbia campus, the initial program area was recommended by a faculty planning committee and reviewed and endorsed by the Research Policy Committee, consisting of the deans of all divisions with graduate research programs.

* Actually, NASA multi-disciplinary grant funds are also involved on the Columbia campus.

UNIQUENESS or an area of largely unexplored or poorly understood phenomena.

Sufficient SCOPE to permit the training of independent investigators (graduate students).

Intrinsic INTEREST for investigators trained in different scientific disciplines.

APPLICATION to space science or exploration.

Although a number do so, projects selected for support do not always fall directly into major program areas, since exploratory development of other, space related areas has value to the University. Furthermore, both this programming procedure, and the final one can lead to a highly desirable matching of interests across University campuses—in that research supported on one may well relate to a major program emphasis on another.

FINALLY, program selection is also carried out through the part-time joint appointment mechanism. These individuals are usually selected through the project procedure, but receive definite joint appointments because their long-term interests match a major program area. Except for the time limitation on their Center-funded research activities, part-time appointee positions are similar to those of the "full time" cadre. Their research activities, therefore, also help shape the Center's program as they develop.

Faculty relations

From the faculty viewpoint, the program and appointment structure thus offers a progression of possibilities for interaction. These range from partial project support on an annual or shorter term basis,* to full time research in the Center. Even the latter still requires, however, an active contribution to the graduate program in the department, as outlined previously. Only the primary academic appointments to the University department carry tenure and academic rank. Faculty members are, therefore, free to move out of the Center's program, or from full-time to part-time to project support solely, as may best suit their own and their department's objectives.

* Summer support from the Center is particularly advantageous for faculty in Arts and Sciences and other 9-month academic year schools.

CONCLUSION

It may be of some interest to recapitulate briefly the actual research program as it enters the third year. Two of the major areas for graduate and research development—one each on the Columbia and Rolla campuses—were defined and selected early in the Center's development and are now well under way. An additional area for development on each campus has been selected, and the consultation and review procedure is now under way at the Kansas City campus to select the Center's major emphasis in its developing graduate program.

In addition, the project programming procedure has developed a number of other less major programs which do, however, seem to fit the four criteria. From an overall viewpoint, the Center's program now involves about 60 faculty, including 11 full-time research "cadre" in the major programs at Columbia and Rolla; and research is active on more than 70 problems.

Future prospects

The eventual success of the SSRC in meeting its objectives is difficult to forecast. It is even more difficult to judge whether a "separate institute" or other more classical organization for the SSRC would, in the end, be more useful to the University.

To date, however, progress seems to have been generally effective, and probably more so than a separate institute approach. Through its second full year of operation, (the spring term of 1966) Center staff published, or had accepted for publication, some 16 papers in refereed journals, as well as many more (over 40) presentations at meetings, discussions, and notes; and on-going projects were involving more than 80 graduate students through their dissertation research.

Investigator(s)	Department Affiliation	Project Title
		ENVIRONMENTAL PHYSIOLOGY
Depressed Metabolism Studies		
*David H. Baeder	Pharmacology kc	Chemically Induced Hypothermia Lipid Metabolism During Hibernation
*R. R. J. Chaffee	Zoology c	Basic Problems in Cellular Bioenergetics Experimental Selection for Hibernation in the Hamster
*R. R. J. Chaffee C. H. Conaway	Zoology c Zoology c	Chemical Thermogenesis in Acclimated Primates
*R. G. Cooper	Ag. Chemistry c	Blood Chemistry in Hibernating Species
*H. D. Dellmann	Vet. Anatomy c	Microneuro-anatomy of the Hypophysis
*H. D. Johnson	Dairy Husb. c	Neuro-endocrine Mechanisms in Torpidity
*X. J. Musacchia *R. M. Barr	Physiology c Radiology c	Radiation Resistance in Hibernation and Cold Torpor Effects of Radiation on Intestinal Absorption
*X. J. Musacchia	Physiology c	Sympatho-Adrenal Influences on Intestinal Absorption
*W. S. Platner	Physiology c	Induction of Hypothermia during Electroanaesthesia
*F. E. South	Physiology c	Adaptation of Rats to Deep Hypothermia Cellular Metabolism in Hibernating Species
*J. W. Twente Janet Twente	Zoology c	Arousal Mechanisms in Hibernation
Gaseous Environment Studies		
*J. E. Bauman, Jr.	Chemistry c	Thermodynamics of Haeme Analog Systems
†Olen R. Brown	Microbiology c	Oxygen Toxicity at the Cellular Level
*R. R. J. Chaffee *W. S. Platner	Zoology c Physiology c	Cellular Membrane P-lipids at Various Oxygen Tensions
*X. J. Musacchia	Physiology c	Physiological Effects of Helium: On Behavior in Isolated Hamsters On Isolated Mammalian Tissues
Adaptation Studies		
*R. R. Kuntz	Chemistry c	Photochemical and Radiation Decomposition of Amino Acids
†D. F. Millikan †E. H. Coe	Horticulture c Field Crops c	Effects of Environmental Stress on Aging in Plants
*M. W. Sorenson *R. R. J. Chaffee	Zoology c Zoology c	Environmental Physiology of the Tree Shrew
*A. A. White	Biochemistry c	Hormonal Control of Calcium Homeostasis
*R. L. Wixom	Biochemistry & Pediatrics c	Amino Acid Metabolism in Autotrophic Bacteria (e.g., Hydrogenomonas)
Microbial Ecology Studies		
†J. N. Farmer	Zoology c	Photoperiodicity and the Host Parasite Relationship
*R. W. Loan	Vet. Micro. c	Effect of Radiation on Interferon Production
Behavioral Studies		
†R. G. Combs †P. C. Anderson	Electrical Engr. c Medicine c	Basal Skin Resistance as a Measure of Alertness and Physiologic Condition
†R. S. Daniel †G. V. Lago	Psychology c Elec. Engr. c	Electroencephalographic Studies of Vigilance

Investigator(s)	Department Affiliation	Project Title

MATERIALS RESEARCH PROGRAM

*R. Bell	Physics r	Surface Impurity States Plasma-Restrahl Shift
†C. A. Eckroth	Physics c	Energy Levels of Rare Earth Elements
*R. Gerson *W. J. James	Physics r Chemistry r	Ferroelectric and Magnetic Properties of Perovskites
*O. H. Hill *R. Bell	Physics r Physics r	Thermal and Radiation Induced Decomposition Absolute, Soft X-Ray Dosimetry
*W. J. James *J. W. Johnson	Chemistry r Chemistry r	Anodic Oxidation of Hydrocarbons
*W. J. James *J. W. Johnson *M. E. Straumanis	Chemistry r Chemical Engr. r Metal. Engr. r	Metallic Corrosion Processes
*G. Lewis	Ceramics r	Studies on Evaporation Behavior and Mechanisms
*G. Lewis *W. J. James *M. E. Straumanis	Ceramics r Chemistry r Metal. Engr. r	Thermodynamic Properties of Non-Stoichiometric Materials
*T. O'Keefe *G. Lewis	Metal. Engr. r Ceramics r	Hot Shortness in Steels
*T. O'Keefe *W. J. James	Metal. Engr. r Chemistry r	Magnetic Alloys of Rare Earths with Transition Metals
*N. Kreidl *G. Lewis J. Wolfe	Ceramic Engr. r Ceramics r Avco Corp.	Non-Crystalline Materials Formed by Reactive Sputtering
*M. E. Straumanis	Metal. Engr. r	Solid Solubility of S, Se, Te in Mo Solid Solubility in the Au-In System High Temperature Expansions of Metals in Vacuum and Various Gases
*R. Venable	Chemistry r	Radiation Induced Polymerization of Monomers in Vacuum
H. Weart	Metal. Engr. r	Surface Diffusion on Atomically Clean Metallic Surfaces

OTHER RESEARCH AREAS

Electronics and Instrumentation

*Charles A. Goben	Nuclear Engr. r	Nuclear Radiation Effects on Silicon P-N Junctions
*Donald L. Branson	Ceramic Engr. r	Reactive Sintering of Pb-Zr-Ti Ferroelectric Ceramics
†E. J. Charlson	Elec. Engr. c	Gallium Arsenide Surface Field Effect Transistor
*Norman G. Dillman	Elec. Engr. r	Negative Resistance in CdS
*C. E. McFarland	Physics r	Ultrasonic Investigations in Solid State Physics
*G. K. Patterson	Chem. Engr. r	Measurement of the Complex Shear Rigidity Modulus in Dilute Polymer Solutions
*Lyle G. Rhea	Mech. Engr. r	Optical-Electrical Instrumentation for a Shock Tube

Transport Phenomena—Fluid-Surface Interactions

†L. E. Marc deChazal †G. W. Preckshot	Chem. Engr. c Chem. Engr. c	Behavior of Simulated Zero Gravity Liquids
†R. E. Harris †L. B. Thomas	Chemistry c Chemistry c	Thermal Accommodation Coefficients at Very High Temperatures
†R. P. Morgan	Chem. Engr. c	Heat Mass Transfer at the Evaporative Interface in Porous Materials

Investigator(s)	Department Affiliation	Project Title
Bulk Properties of Materials and Structures		
†K. P. Buchert	Civil Engr. c	Buckling of Doubly Curved Orthotropic Shells
†D. L. Creighton	Mech. Engr. c	Fatigue Development in High Vacuum
Atmospheric and Astrophysics		
*Ralph S. Carson	Elec. Engr. r	Electrical Spraying of Liquids
†G. L. Darkow	Atmos. Science c	Radiation Fluxes in Earth's Atmosphere
†T. W. Edwards	Physics c	Theoretical Studies of Stellar Thermodynamics
*James L. Kassner, *John C. Carstens, L. H. Lund	Physics r; Physics r; Physics r	Theory of Interacting Diffusion Droplet Growth
*James L. Kassner, *Robert B. Oetting, J. Rivers	Physics r; Mech. Engr. r; Physics r	The Development of Non-Freezing Clouds
†A. W. Peterson	Physics c	Radiation from Interplanetary Dust
*D. Vincent Roach, *Jack L. Rivers	Chemistry r; Physics r	Measurement of Thermal Accommodation Coefficients
†D. L. Waidelich	Elec. Engr. c	Electric and Magnetic Field Meters
†J. E. Willett	Physics c	Longitudinal Waves in Tenuous Plasmas
Exobiology		
*C. W. Gehrke	Ag. Chem. c	Gas Chromatographic Techniques for the Identification of Nucleosides
*T. D. Luckey	Biochemistry c	Biological Activity of 1-Adenosine
*C. P. Merilan, J. D. Sikes	Dairy Husb. c; Dairy Husb. c	Effects of Temperature and Dehydration Stress on Mammalian Cells
*Frank Millich	Chemistry kc	Non-enzymatic Catalysis in an Acid-phosphatase Analog System

* S.S.R.C. joint appointee
c Columbia campus
r Rolla campus
kc Kansas City campus
† NASA sustaining grantee

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