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ASSESSMENT OF SCIENCE AND ENGINEERING INFRASTRUCTURE AT THREE UNIVERSITIES IN KANSAS: IDENTIFICATION OF WEAKNESSES AND BARRIERS TO RESEARCH

prepared for

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Preface

Sixteen states and the Commonwealth of Puerto Rico have been funded by NSF for periods of three or more years during the 1980's in the NSF Experimental Program to Stimulate Competitive Research (EPSCoR). In 1991, Kansas and Nebraska were declared the 17th and 18th states eligible to participate in EPSCoR. Kansas applied for and was awarded an EPSCoR Planning Grant by NSF during the summer of 1991. As part of this planning, NSF predicated that an assessment be conducted of the participating universities to determine the barriers which were impeding Kansas' competitiveness for federal R&D dollars, specifically in the areas of science and engineering (S&E). This report therefore identifies barriers, and wherever possible, the impact of those barriers to the competitiveness of Kansas State University (KSU), the University of Kansas (KU), and Wichita State University (WSU) with respect to research and its funding.

We believe that it is important for the readers of this report to understand the data base that provides the rationale for Kansas being eligible for EPSCoR. In 1989, Kansas ranked 33rd (17th from the bottom!) among the states in federal research and development support. It received less than one-half of one percent of all federal R&D expenditures to colleges and universities. Furthermore, while federal R&D support of colleges and universities rose by 450% between 1971 and 1989, the figure for Kansas institutions was only 250%. In the R&D race, our state was (and is) steadily losing ground.

EPSCoR's goal is to bring S&E research endeavors in EPSCoR states to nationally competitive levels. It is a model for building the nation's S&E infrastructure. It is a stimulus for change. It is an opportunity for Kansas to broaden the base of R&D capability, to enhance the capacity and to bring about permanent, systemic changes in how it conducts research.

As already noted, Kansas has fared poorly in the race for research and development funds from federal and industrial sources during the last two decades. NSF data indicate that in 1989 the top 10 states received an annual per capita average of $45 in R&D funds. The U.S. average is $36, while EPSCoR states and Kansas average $16 per capita. What about our competitiveness with surrounding states and institutions?

Table 1 shows that federal R&D dollars to Kansas universities and colleges increased from $24.7 million in 1982 to $39.1 million in 1989. This is an increase of 58% whereas the neighboring states of Colorado, Iowa, Missouri and Nebraska increased by 91%, 115%, 86% and 76%, respectively. On a per capita basis for 1989, we, like Oklahoma, simply are not competing for a fair share of the federal R&D research dollars.

TABLE 1: COMPARISON OF FEDERAL R&D FUNDS TO UNIVERSITIES & COLLEGES BY STATE				
State	1982 to 1989 (in thousands)	% Change	1990 Census (in thousands)	$ Per Capita 1989
Colorado	77,139 — 147,301	91	3,308	44.5
Iowa	47,898 — 103,214	115	2,787	37.0
Kansas	24,678 — 39,105	58	2,486	15.7
Missouri	80,978 — 150,269	86	5,138	29.2
Nebraska	15,572 — 27,462	76	1,585	17.3
Oklahoma	22,795 — 30,968	36	3,1589.8	
Source NSF: Selected Data on Federal Support to Universities & Colleges FY 89 NSF 91-316.				

Table 2 summarizes the total federal R&D funds in 1989 to KU, KSU and WSU compared to several institutions of our neighboring states (1989 is NSF's latest data base). The data are rather self-explanatory.

TABLE 2. COMPARISON AMONG INSTITUTIONS FOR TOTAL AND FEDERAL R&D FUNDS IN 1989 (in thousands)					
Institution	Total $* (rank)	Federal R&D $ (rank)	Engineering $*	Phys Sci. $*	Math/ Comp. Sci. $*
U. of Colorado	143,694 (28)	130,430 (20)	15,613	21,121	3,950
U. of Iowa	105,900 (46)	94,237 (31)	8,710	13,114	1,986
Iowa State U.	103,174 (49)	54,627 (71)	25,225	4,276	8,603
U. of Nebraska	68,281 (74)	a	7,253	4,861	1,103
Colorado State U.	64,351 (79)	51,652 (75)	13,853	4,832	915
U. of Kansas	57,111 (83)	37,118 (97)	3,728	5,710	621
U. of Oklahoma	53,956 (90)	a	8,529	5,276	1,512
Kansas State U.	47,302 (99)	a	4,651	3,841	508
Wichita State U.	3,443	1,921	no data	no data	no data
* Includes federal and non-federal dollars for S&E. a. Not in top 100. Source NSF: Academic Science/Engineering R&D Expenditures, FY 89, NSF 90-321.					

Finally, there is a general perception that perhaps EPSCoR states do not support nor invest in their institutional S&E research. NSF data for 1989 suggest otherwise. That is, the average academic R&D expenditures is $18 per capita from *state and institutional sources* for the top ten states compared to an average of $15 per capita for EPSCoR states. The larger discrepancy occurs with the academic R&D expenditures from *federal and industrial sources;* the U.S. average is $36 per capita, whereas the top ten states average $45 compared to $16 for EPSCoR states.

In the context of the above background, we respectfully submit this report on the assessment of barriers that Kansas needs to consider in order to address our quest to become more research competitive.

Introduction

Describing the status of Science and Engineering (S&E) research and infrastructure in Kansas requires consideration of the capacity to conduct research as well as the culture that supports and encourages research. Although science and engineering programs at Kansas' three doctoral granting universities have many strengths, the purpose of this study was to identify and assess weaknesses, problems, and barriers. This report describes the current status of funded research in Kansas and then summarizes state, university, and departmental barriers to conducting funded research identified by faculty and administrators.[1]

Status of Science and Engineering Research

We assessed the level of science and engineering (S&E) research productivity to provide a baseline for future evaluation and to determine how Kansas's science and engineering faculty compete for external funds, particularly NSF funds. Kansas is not currently funded by EPSCoR and we have not previously assessed the level of S&E research productivity in the context of EPSCoR requirements. We cannot, therefore, address all areas of infrastructure in great detail. The following areas will be addressed:

* Human Resource Development including number of active S&E faculty, postdoctoral associates, graduate students, and support personnel;

* Institutional Research Priorities including available facilities and salaries;

* Knowledge Transfer including linkages among state institutions and major research institutions and industry;

* Research Support including ratio of federal to state and local research spending and the level of state and local support of S&E research; and

* Level of S&E Research Productivity including grants received.

Profile of Participating Universities

KSU is a land-grant university with core strengths in the physical, social and natural sciences (including basic agriculture) and engineering. Atomic physics and materials sciences are two

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[1]A copy of this report may be obtained from the Institute for Public Policy and Business Research, 607 Blake Hall, University of Kansas, Lawrence, Kansas 66045.

strong areas in the physical sciences. In the natural sciences, cellular, developmental and molecular fields and environmental sciences represent strengths. Chemical engineering and manufacturing are prominent components of the engineering programs. Social sciences are often centered on rural geography and sociology.

Core S&E strengths at KU are sited in biological, pharmaceutical and chemical sciences, ecology, and systematics research centers and institutes. Faculty associated with the Higuchi Biosciences Center are well known for bioanalytical, biomedical and drug delivery research. The Institute of Life Span Studies is known for research in child development and handicapping conditions. Engineering strengths are found in aerospace, tertiary oil recovery, environment, structures, transportation, telecommunications and remote sensing.

WSU is changing in emphasis from teaching to research. In 1990, WSU graduated enough doctoral students to move out of NSF's designation as a "primarily undergraduate institution." Wichita is the center for private aircraft manufacturing in the U.S., and the industry tends to be the focus of research activities. WSU's program strengths are in engineering, especially aerospace. Other areas, such as math and science, are developing. For example, molecular medicine is developing as a result of collaboration with the local medical community and funding from the Wesley Foundation.

Human Resource Development

S&E Personnel.

Kansas State University has 362 science faculty. Of those, 250 or 69% are tenured. KSU has proportionally more junior and fewer senior faculty than its peer institutions.[2] There are 247 graduate teaching assistants and 238 graduate research assistants. Technical support is provided by 97 staff.

The University of Kansas, Lawrence Campus, has 414 science[3] and engineering (S&E) faculty. Of those faculty 316 or 76.33% are tenured. Very few S&E faculty are under 30 years of age, and the largest portion were 40 to 49 years of age. In addition to faculty, 76 academic staff contribute to S&E productivity. Included in this category are museum curators and scientists (senior, associate, assistant). Over 200 other staff hold professional positions that contribute to the teaching and research capacity by

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[2]*Annual Report on the Status of Faculty Salaries and Fringe Benefits at Kansas State University, 1991.*

[3]This group includes faculty in microbiology, biological sciences, anthropology, chemistry, economics, geography, geology, human development and family life, mathematics, physics and astronomy, psychology, sociology, computer science, pharmaceutical chemistry, pharmacology, and medicinal chemistry.

serving as lab and program directors, program assistants, administrative assistants, and research associates/assistants/aides. Forty-five postdoctoral positions exist in the sciences, but engineering has none. Overall, there are more graduate teaching assistants (GTA = 427) than student research assistants (SRA = 380). Technical support (i.e., laboratory staff, repair technicians, graphic designers, etc.) is provided by 66 staff.

Wichita State University has 116 tenured and 51 non-tenured tenure track faculty. Faculty are supported by 120 other personnel (10 nontenure track faculty, 30 other, 58 adjunct lecturers, 22 adjunct professors). There are 71 GTAs, 11 GRAs, and 33 GAs.

Institutional Research Priorities

Available Facilities. Space available for science research at Kansas State University totals 550,397 gross square feet. Lab area covers 213,693 square feet, service area is 76,674 square feet, and greenhouses and animal space is 260,030 square feet.

In 1990, space available for organized research at the University of Kansas' Lawrence campus totaled 459,616 square feet or 10.2% of the total space. Since 1986, space assignable to organized research has increased by 6.5%. However, nonclass lab space (research labs) net assignable square feet fell from 345,097 (10.3% of total) in 1989 to 335,813 (9.7%) in 1990. Construction of a bioscience research center (22,000 square feet) is in the planning phase.

Faculty Salaries and Size. Salaries at Kansas State University and the University of Kansas fall below the average for Big Eight institutions (Table 1). Kansas State faculty salaries have been the lowest in the Big Eight for six consecutive years and are in the bottom 20 percent among land-grant universities. Among Big Eight Schools, KSU professors' and associate professors' salaries ranked eighth and assistant professors' salaries ranked sixth. Salaries for assistant professors at KU ranked seventh among Big Eight Schools and fifth for associate professors and professors.

To determine the state's financial commitment to maintaining competitive levels of faculty salaries, average salaries at the University of Kansas were compared with peer institutions (University of Colorado, University of North Carolina, University of Oklahoma, University of Iowa, University of Oregon). University of Kansas' salaries were below the average of peer institutions (Table 2). Salaries are not keeping up with those offered at peer institutions.

Table 3 shows a similar story for salaries at Kansas State University. KSU ranks fifth out of six peer institutions (Colorado State, Iowa State, North Carolina State, Oklahoma State, Oregon State). According to KSU's annual report on the status of faculty salaries, low salaries have made KSU a "training center for junior

faculty who accept positions at KSU and, when experience is gained, leave for higher paying positions elsewhere." Salary compression is undermining senior faculty morale as salaries of new faculty move closer to those of senior faculty who have been teaching for ten to twenty years.

TABLE 1

Comparison of Big Eight Institutions' Average Salary:
Preliminary Data FY 1991

	Rank	Average Salary*	Full Time Headcount
Colorado	1	50,361	904
Iowa State	2	49,480	1,265
Nebraska	3	46,683	1,111
Oklahoma State	5	42,825	824
Oklahoma	6	42,646	752
Missouri	7	42,564	873
Average		45,760	
Kansas	4	44,864	939
K-State	8	40,889	894
Average		42,877	

*Salary average computed using the peer average dollars by rank.
Source: Annual Survey of Faculty Compensation 1991, Maryse Eymonerie Associates.

TABLE 2

Comparison of Cost Study Peer Institutions' Average Salary:
Preliminary Data FY 1991 for KU and Peer Institutions

School	Prof Salary	Prof F-T H*	Assoc Salary	Assoc F-T H	Asst Salary	Asst F-T H	Avg w/o Inst**	Total H Fac	Inst Salary	Inst F-T H	Avg w/Inst	Total F-T H
Colorado	60,400	425	45,400	248	38,100	212	50,854	885	27,400	19	50,361	904
Iowa	64,600	477	48,000	302	40,300	238	53,983	1,017	31,000	9	53,782	1,026
Kansas	52,800	464	40,300	261	33,600	204	45,072	929	25,600	10	44,864	939
North Carolina	65,800	560	47,300	313	38,100	221	54,911	1,094	37,900	15	54,681	1,109
Oklahoma	53,300	273	40,800	231	33,200	235	43,000	739	22,500	13	42,646	752
Oregon	49,200	233	37,800	191	31,700	179	40,394	603	25,100	71	38,783	674
Weighted Avg	59,147	2,432	43,805	1,546	36,012	1,289	48,982	5,267	26,998	137	48,424	5,404
KU Diff From Wtd	-6,347	-3,505	-2,412	-3,910	-1,398	-3,560						
Wtd Avg w/o KU	60,644	1,968	44,517	1,285	36,465	1,085	50,803***		27,108	127	50,551***	
KU Diff From Above	-7,844	-4,217	-2,865	-5,731	-1,508	-5,687						
KU Rank	5/6	5/6		4/6	4/6	4/6	4/6					

*Full-time headcount.
**Instructors.
***Salary average computed using the peer average dollars by rank and the KU head count for each rank.
Source: Annual Survey of Faculty Compensation 1991, Maryse Eymonerie Associates.

Table 3

KSU Compared to Regent Peer Institutions
FY 1991

School	Average Salary
North Carolina State	52,141
Iowa State	49,480
Colorado State	46,527
Oklahoma State	42,825
Kansas State	40,889
Oregon State	39,891

Source: Annual Report on the Status of Faculty Salaries and Fringe Benefits at Kansas State University.

Salary data highlight the seriousness of the problem facing Kansas. Low salaries place Kansas's doctoral granting institutions in a poor competitive situation for attracting and retaining quality faculty.

Knowledge Transfer

Kansas has made significant progress in recent years in building linkages between its research institutions, state institutions, and industry. Centers of Excellence have been established at various state universities. Each center has its own technical focus and provides, in the context of knowledge transfer, networking and training programs, seminars and workshops, news releases and quarterly publications, regional industrial liaison offices and technical consulting. These centers are:

Center for Advanced Manufacturing Institute, KSU
Center for Computer Aided Systems Engineering, KU
Center for Technology Transfer, Pittsburg State University
Higuchi Biosciences Centers, KU (includes centers for Bioanalytical research, for Molecular Engineering and Immunology, for Drug Delivery Research, and for Neurobiology-pending)
National Institute for Aviation Research, WSU

The state's research institutions also have formed research linkages that promote collaboration across campuses. These include an agreement concerning joint aerospace-related research, biomedical research funded by the Wesley Foundation, and collaboration among several researchers in various departments.

Research Support

Kansas State University ranks 99th and The University of Kansas (Lawrence campus and Medical Center) ranks 83rd in the nation in yearly R&D expenditures for science and engineering. When compared to other Big Eight institutions' S&E expenditures, the University of Kansas ranks fifth and Kansas State University

ranks eighth. Kansas's institutions have not shown the growth in R&D that other Big Eight schools have enjoyed (e.g., University of Colorado, Iowa State University) (Table 4).

The University of Kansas ranks third among Big Eight schools in federally funded R&D expenditures in FY 1989. Kansas State University ranked last among Big Eight schools (Table 5). In FY 1989, federal funds supported 41.07% of R&D expenditures at Kansas' three doctorate-granting institutions. State/local governments and institutional funds accounted for another 50.40% (Table 6). These data show that Kansas's institutions do not have the competitive levels of R&D expenditures of neighboring states's institutions.

TABLE 4

Yearly S&E R&D Expenditures of Big Eight Institutions
(Dollars in thousands)

		Total			
	Big Eight Institutions	1989	1988	1987	1986
28	Univ Colorado-Boulder	143,694	128,015	112,276	104,576
49	Iowa State Univ	103,174	86,726	78,351	72,642
68	Univ Missouri-Columbia	74,055	66,365	61,212	57,653
74	Univ Nebraska-Lincoln	68,281	60,788	56,066	55,158
83	Univ Kansas-Lawrence	57,111	51,723	50,603	47,853
90	Univ Oklahoma-Norman	53,956	50,047	45,350	37,328
93	Oklahoma State Univ	53,655	56,636	47,420	45,919
99	Kansas State Univ	47,302	43,174	40,587	40,708

Source: NSF: Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989.

TABLE 5

S&E R&D Expenditures of Big Eight Institutions: FY 1989
(Dollars in thousands)

Rank	Big Eight Institutions	Total	Federal Govt	State/ Local Govt*	Industry	Institu- tional funds	All other sources
28	Univ Colorado-Boulder	143,694	109,145	1,692	6,728	12,175	13,954
49	Iowa State Univ	103,174	28,895	23,718	4,408	42,644	3,509
68	Univ Missouri-Columbia	74,055	22,312	11,210	6,434	29,864	4,235
74	Univ Nebraska-Lincoln	68,281	25,803	22,006	2,675	15,931	1,866
83	Univ Kansas	57,111	26,420	2,674	2,809	23,640	1,568
90	Univ Oklahoma-Norman	53,956	17,020	3,052	1,991	24,226	7,667
93	Oklahoma State Univ	53,655	14,116	1,853	1,645	34,613	1,428
99	Kansas State Univ	47,302	15,951	21,133	1,790	6,384	2,044

*Caution: Institutional policy determines whether unrestricted state support is reported as state or as institutional funding.

Source: NSF: Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989. NSF 90-321, Table B-25.

TABLE 6

S&E R&D Expenditures in Kansas by Source of Funds: FY 1989

Institution	Total	Percentage of Total				
		Federal	State & Local	Industry	Institutional Funds	All Other Sources
Kansas St University	$ 47,302,000	33.72%	44.68%	3.78%	13.50%	4.32%
University of Kansas	57,111,000	46.26%	4.68%	4.92%	41.39%	2.75%
Wichita St University	3,443,000	55.79%	10.22%	17.08%	5.23%	11.68%
Total	$107,856,000	41.07%	22.40%	4.81%	28.00%	3.72%

Source: Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989. NSF 90-321, Table B-25.

Level of S&E Research Productivity

Grants Received. Total R&D expenditures at Kansas' three doctorate-granting institutions was $107,856,000 in FY 1989 (Table 7). Compared to its neighboring states and Iowa, Kansas ranks fifth among the six states in R&D expenditures. Table 7 shows that the state of Kansas is not competing effectively for its share of federal support for R&D. Colorado and Iowa are much more successful in obtaining federal funds.

TABLE 7

S&E R&D Expenditures at Doctorate-Granting Institutions: FY 1989
(Dollars in thousands)

State and Number of Institutions	Total	Federal Govt.	State & Local Govt.	Industry	Institutional Funds	All Other Sources
Public and Private Institutions						
Missouri (N=9)	$255,009	$139,677	$14,509	$25,151	$59,615	$16,057
Colorado (N=5)	226,428	166,981	10,681	14,381	17,753	16,632
Iowa (N=4)	209,327	103,360	24,839	14,711	60,796	5,621
Oklahoma (N=5)	113,279	33,067	5,062	5,667	60,063	9,420
Kansas (N=3)	107,856	44,292	24,159	5,187	30,204	4,014
Nebraska (N=4)	93,916	36,823	22,971	9,098	20,905	4,119
Public Institutions						
Colorado (N=4)	$217,490	$160,156	$10,499	$12,953	$17,250	$16,632
Iowa (N=3)	209,230	103,274	24,839	14,711	60,791	5,615
Missouri (N=5)	111,612	30,270	12,895	10,738	51,397	6,312
Oklahoma (N=3)	108,744	31,851	4,965	3,640	59,179	9,109
Kansas (N=3)	107,856	44,292	24,159	5,187	30,204	4,014
Nebraska (N=3)	85,982	34,437	22,804	3,869	20,753	4,119

Source: Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989. NSF 90-321, Table B-25.

Analysis of NSF submission trends indicates that the number of proposals submitted from all three universities to NSF peaked in 1988 and has not recovered to that level (Table 8). However, number awarded has remained relatively stable since 1988. Dollars awarded to the University of Kansas, Kansas State University, and Wichita

state University from NSF rose to $5.3 million in 1989 and fell to $4.9 million in 1990.

Kansas has difficulty attracting the large program projects. This is a deficit that must be addressed if the state wants to make significant gains in its level of funded research. At the University of Kansas, twenty-four (25.81%) of the 93 faculty who have submitted NSF proposals in the past are responsible for 66.26% of the total NSF dollars awarded. More mentoring of young faculty, more "in-house" peer review of grant applications and development of program projects needs to occur to increase the pool of faculty bringing in large NSF awards.

TABLE 8

NSF Funding in Kansas

	1986	1987	1988	1989	1990
No. Submitted	175	183	249	226	235
No. Awarded	67	58	73	70	73
% Awarded	38.29%	31.69%	29.32%	30.97%	31.06%
$ Awarded	$4,418,569	$4,226,108	$5,204,054	$5,363,726	$4,905,376

Source: Institutional Data Bases.

Graduate Enrollment. Table 9 summarizes the 1991 student enrollment and distribution profile of KSU, KU and WSU. Minority enrollment is 10% of the 63,151 students in these institutions. S&E minority graduate students represent 3.4% of all graduate students, which is considerably lower than the average of peer institutions. In 1989 Kansas' academic S&E faculty numbered 2,387 (NSF 90-324), the three Ph.D.-granting institutions had 1,111 according to 1991 institutional data.

TABLE 9

Institutional Profiles -- Fall 1991

Category	KU*		Kansas State		Wichita State		Total	
	Number	%	Number	%	Number	%	Number	%
Undergaduate	19,427	73%	17,105	83%	13,099	83%	49,631	79%
Graduate	7,234	27%	3,607	17%	2,679	17%	13,520	21%
Total	26,661		20,712		15,778		63,151	
S&E Graduate	1,656	23%	1,199	33%	527	20%	3,382	25%
Minority (% of Total)	1,899	7%	1,423	7%	2,750	17%	6,072	10%
Total Faculty	1,086		1,288		544		2,918	
S&E Faculty**	414	38%	481	37%	216	40%	1,111	38%

*Does not include Medical Center Campus.
**Assistant, associate, and full professors.
Source: Office of Research and Planning, KU; Office of Planning and Evaluation, KSU; Office of Research and Institutional Planning, WSU.

According to 1989 NSF data (NSF 90-394), graduate students in engineering number 276, 398, and 319 at KSU, KU and WSU, respectively, compared to 1,092 at the University of Colorado (Boulder), 737 at Iowa State University (Ames), 1,095 at the University of Wisconsin (Madison) and 493 at the University of Missouri (Columbia). In order to be competitive in engineering, we need to raise the number and quality of graduate students.

Barriers and Accomplishments

As reported above Kansas has fallen behind in funded research in the areas of science and engineering. To determine the reasons for this limited success, in-depth interviews with 96 S&E faculty, staff, and administrators at the University of Kansas, Kansas State University, and Wichita State University were conducted. Those interviewed included departmental heads, NSF-funded faculty, NSF-aspirant faculty, externally funded faculty who did not have NSF funds, faculty recently hired who had funding at other universities, grant support staff and administrators. Findings are divided into state, university, and departmental issues although we fully recognize interrelations among them. These findings summarize the views of those interviewed; they are perceptions that reflect how the universities view themselves.

State Issues

State funding for science and engineering education and research is not adequate. There was general consensus that faculty salaries were below national averages and peer institutions. Researchers at the University of Kansas felt that too little overhead money is returned to or reinvested in the departments and investigators to serve either as a reward for grant success or seed money for future effort. Researchers at Wichita State University had similar complaints. The level of support of all three institutions by the state is such that extramural funding overhead is used to meet basic instructional resource needs, rather than reinvesting those dollars for enhancing research infrastructure. Faculty reported the equipment, and in some cases, facilities were inadequate. They also reported there was not enough technical staff support to maintain current equipment and facilities. Science and engineering technical support and service facilities are often not adequate to support cutting edge research.

Institutions have very little money available for equipment and much of this scarce equipment money must be used to supply start-up equipment for new faculty. Established faculty must turn to grant support to repair, replace, and expand equipment. Many faculty reported that agencies do not fund requests for equipment which traps them in the cycle of needing equipment to be competitive but not having funds to obtain the equipment. The state also erects barriers in the purchase of equipment. Long delays in getting equipment and difficulty in getting the level of quality

required for research means researchers' productivity (and hence competitiveness) is reduced.

University Issues

Several issues concerning the universities emerged as areas of concern:

* Kansas has not kept up with changes in the scientific enterprise. It has few major research labs that focus the research efforts of teams on a single area. Few Kansas scientists have turned individual success into institutional success.

* While the importance of undergraduate education was not challenged, many commented on the need for greater balance in educational mission. To achieve this balance greater emphasis on graduate education and research is needed. Research activities have born a larger share of recent budget cuts than undergraduate programs. In many cases, faculty are hired primarily to fulfill teaching demands, not to build research areas since strong undergraduate teaching departments cover the breadth of their discipline while strong research departments specialize.

* Those interviewed stressed that the foundation of successful research programs was graduate, especially doctoral and postdoctoral, education and that any improvement in scientific research begins with improving graduate education. Departments that have increased both the number and quality of their graduate students have also increased their research activity. Pressure to fund students often leads to grant applications.

* All three institutions have difficulty recruiting graduate students because of location and lack of competitive support. Assistantships are low by national and regional standards and research assistants do not receive tuition reductions as do graduate teaching assistants. These rules not only reduce the dollar value of graduate support, they discourage student involvement in research. In addition, beginning graduate students, who have not developed skills necessary to contribute to research programs must be carried on grants because of lack of other funding sources, such as fellowships and teaching assistantships.

* Successful grant recipients, like successful scholars, are persistent. Because reductions in funds available for research has increased the competition, young researchers may give up and more senior researchers often give out. Getting a first grant funded and sustaining an established research program requires institutional support. Successful universities minimize the effort that individual researchers and departments must expend upon the routine aspects of grant writing. Kansas institutions need to provide better support.

* Incentives for funded research vary. In general, departments reward the products of research, primarily publications, but not intervening efforts, such as proposal writing and grant submissions. Therefore, researchers who can produce results with little or no external funding rationally bypass grant seeking.

* Although departments can offer little support for funded research through release from teaching and a greater proportion of graduate teaching, grant activity is based primarily on individual faculty initiative, not institutional imperative. Rewards, especially raises, were inadequate to motivate the extra work funded research requires.

* With some notable exceptions, faculty are not active participants in the informal networks surrounding funding agencies. Experienced grant getters recognize the importance of such informal information in the success of any proposal. However, Kansas's universities do not adequately underwrite travel and other expenses at the proposal stage. Respondents stressed that direct contact between researchers and funders must increase. Sending administrative representatives to Washington is not enough. Several suggested that established researchers should take junior colleagues to meet funding agents and that the university must support such travel.

* Kansas institutions do not have adequate internal funds to support grant development, seed grants, or to support research programs between grants. Lack of seed grants makes it difficult to compete for external funds since preliminary data are often required to successfully compete for federal grants.

* Kansas State University reported a need for larger start-up packages for new faculty.

* Wichita State University reported a shortage of faculty.

Departmental Issues

Academic departments are and will remain the primary locus for research activities. Those interviewed felt that departmental norms, expectations, procedures, and capabilities all directly affected the amount of externally funded research. The effects of all other university units are indirect. Key findings included:

* Departments with strong records in funded research tend to hire faculty who hold promise of continuing this tradition. New faculty are encouraged to submit and resubmit proposals. Proposal submissions count during merit review and grant success and potential are carefully considered during tenure decisions.

* At KU, departments with limited grant activity do not place a high priority on proposal submissions and grant potential during hiring and promotion. They focus on the products of research (publications and paper presentations) which discourages funded research to the extent researchers can look to internal funding sources or can produce adequate publications without external funds.

* Departments with limited experience with funded research cannot offer the same level of support for grant development and administration because of that inexperience. This perpetuates the cycle of nonfunding.

* Departments are self-reproducing systems, often hiring to fill vacancies, not to build new and potentially more fundable research areas. For departments with little history of funded research, the conservative nature of academic departments becomes a major barrier to increasing grant activity. Deans often appoint department chairs from within based on departmental recommendations, and who reflect current norms. However, hiring from the outside increases the likelihood of changing departmental norms.

* Departments, because of their narrow focus, cannot, in the words of one faculty, "think big." We often fail to attract the large programmatic grants that are generally beyond the reach of any individual department. In this realm, higher administration (deans, vice chancellors, chancellor, regents) need to lead. Administrative leadership is necessary to push the university system forward in science.

Conclusions

Based upon the assessment, Kansas' three universities must address the following issues to improve science and engineering research capacity:

* Increase the emphasis on graduate, especially doctoral, education to drive the research mission of the university.

* Provide more competitive salaries for graduate research assistants and provide fee waivers for graduate assistants.

* Improve support for technical support and service facilities and for equipment purchase and maintenance. Remove regulations that hamper purchase of research equipment.

* Stimulate grant development by providing more seed money, travel money, and better grant development services that

minimize the effort researchers must expend to obtain grants.

* Reward grant submission efforts as well as the products of research to increase number of submissions;

* Make grant activity an institutional imperative rather than relying on individual faculty initiative;

* Increase the number of faculty who hold promise of developing strong programs of funded research;

* Make faculty salaries more competitive;

* Provide administrative leadership to push the system forward in science and engineering. Large programmatic grants are generally beyond the reach of any individual department and leadership is needed to "think big" and provide resources needed to build areas competitive in national and international arenas and to promote team research.