Establishing and Managing Multi-Disciplinary Research and Engineering at Small Universities

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Abstract

The technological requirements of the 21st century will often be satisfied through the concept of multi-disciplinary research. Multi-disciplinary research is often the impetus that moves science, engineering and technology forward to facilitate system solutions. A common approach to establishing and sustaining multi-disciplinary research at small and minority universities is through a Multi-disciplinary Research Center (MDRC). The general mission of the MDRC is to: Conduct research in the sciences; Develop technologies and evaluation procedures; Resolve technical and human problems; or Assess the impact of various conditions on life, materials, systems or the environment. Centers also provide various research bases, which are carried through engineering implementation. The first step of establishing a MDRC is to identify a "funding source" with needs in the various areas of local expertise. The second step is to propose a center foundation or organization upon which to build the MDRC infrastructure. Constructing the foundation of an organization, which will convince the funding source of likely success is very important. As with forming any organization, one must consider the political, functional and operational environments concerning the mission, goals and objectives. The leadership traits of the center director must be well communicated throughout the Office of the Director, fostering participatory management and accountability. The strategies used to establish and sustain the NASA-Prairie View A&M University (PVAMU) Center for Applied Radiation Research (CARR), an $11.5M, five-year endeavor are provided.

Section One: Establishing and Managing Multi-disciplinary Research and Engineering

Background

The NASA-PVAMU CARR was established through the competitive process to address the tasks, missions and technological needs of NASA in the areas of radiation research. The CARR was awarded $11.5M over a ten-year period to meet the mission needs of NASA and to develop a broad-based radiation research infrastructure at a small university. In addition, the CARR mission included the development of mechanisms for increased participation by faculty and students of Historically Black Colleges and Universities (HBCU) in mainstream research and to increase the production of underrepresented minorities who are U.S. citizens with advanced degrees in NASA-related fields. The concept of developing a research capability at a small university to compete for research normally awarded to very large universities is quite challenging. University administrators, staff, faculty and students must be convinced that such an endeavor is realistic and must be pursued. Recruiting a team capable of resolving internal and external opposition is no trivial task. A careful and accurate assessment of the various organizational cultures must be made in order to determine the team players. The "funding source" and local decision makers must be convinced to adequately invest in the program or research endeavor. The core team or "superstars" must be carefully selected and willing to accept the charge of making the overall program a success. If not, failure will quickly approach and program termination will be the solution to all who must make the investments to support the program.

Organizational Culture and Structure

Organizational culture is often not given the attention or analytical assessment truly needed. The definition of organizational culture is "the informal set of values and norms that controls the way people and groups in an organization interact with each other and with people outside the organization."[1] Decision makers often influence the organizational culture by imposing various values and norms on selected individuals or groups. On the other hand, decision makers also influence the organizational culture with the absence of such values and norms. Organizations are often categorized with having a strong culture or a weak culture. Strong cultures have cohesive sets of values and norms that bind members together and foster commitment from employees to achieve organizational goals. Weak cultures provide little guidance to employees about how they should behave or respond to certain situations. Often, the formal organizational structure is used to coordinate organizational behavior.[2] Regardless, the important task is to conduct a careful analysis of the organizational culture in an effort to organize for and promote program success. The value of such an analysis is emphasized for the following reasons:

- The culture influences the attitudes, behavior and performance of individuals.
- A weak culture requires an appropriate organizational structure to help coordinate behavior.
- Strong cultures often generate high performance and promote greater success.
- Strong cultures can be built through the organization's socialization process.
- The attitudes and values of the founders or leaders of the organization strongly influence the culture.

Overall, the organizational culture and structure influence individual performance to achieve the desired goals. Culture and structure are very important to foster the level of participatory management and accountability required for the life long success of the MDRC. The management structure must empower and hold accountable the key players or "superstars" within the MDRC.

CARR Foundation Organization

The CARR technical areas, as with any MDRC, bridge relationships between people and technologies, which would not normally coexist. On rare occasions would one expect chemists, biologists, physicists, engineers and material scientists to agree and "join together to form a more perfect union." Such uncommon and diverse research conglomerations are necessary and quite challenging to manage efficiently and effectively. The structural organization for the CARR MDRC is illustrated in Figure 1 - CARR Organizational Structure. By design, the structure establishes communication channels involving internal and external sources of influence, to help resolve the various technical, territorial and political issues, which are inherent within such a diverse and complex environment. On occasions, conflicts arise involving intellectual superiority and technical priorities which must be resolved to resume center operations and research. The communications channels provide access to mediators capable of resolving such issues.

The guidance and cooperation of advisory boards, review committees and advisory panels must be visible within the MDRC. The Center must maintain technical and strategic alignment with various sponsor organizations or funding sources. As we proceed further into the information age, technological and material development will foster continuous change within various components of our society. Somehow, the Center must be "plugged in" or connected in such a way to receive pertinent information as it becomes available or at the earliest opportunity. The key roles of the Advisory Boards, Technical Review Committee and Technical Advisory Panel are provided below.

Executive Advisory Board

The Executive Advisory Board (EAB) consists of management executives from industry and other academic institutions. The EAB participates in the strategic planning for the MDRC with the Executive Director and selected members of the Office of the Director. The EAB also serves as an extension of the MDRC to help identify additional funding sources, research opportunities and academic development strategies which may further benefit the Center and the university.

Technical Advisory Panel

The Technical Advisory Panel (TAP) is a long list of renowned technical experts of the various disciplines within the MDRC. The TAP members are from academia, industry, research centers and national laboratories. The TAP provides technical support and assistance within the respective areas. The members review technical papers and reports and also help identify additional funding sources.

Technical Review Committee

The Technical Review Committee (TRC) is primarily composed of carefully selected members from the sponsor organization or funding source. A judicious mix of technical and managerial representatives must be assembled to support and evaluate the capabilities of the MDRC. The TRC is the primary evaluator concerning capability and development.

PVAMU-NASA
Center for Applied Radiation Research (CARR)

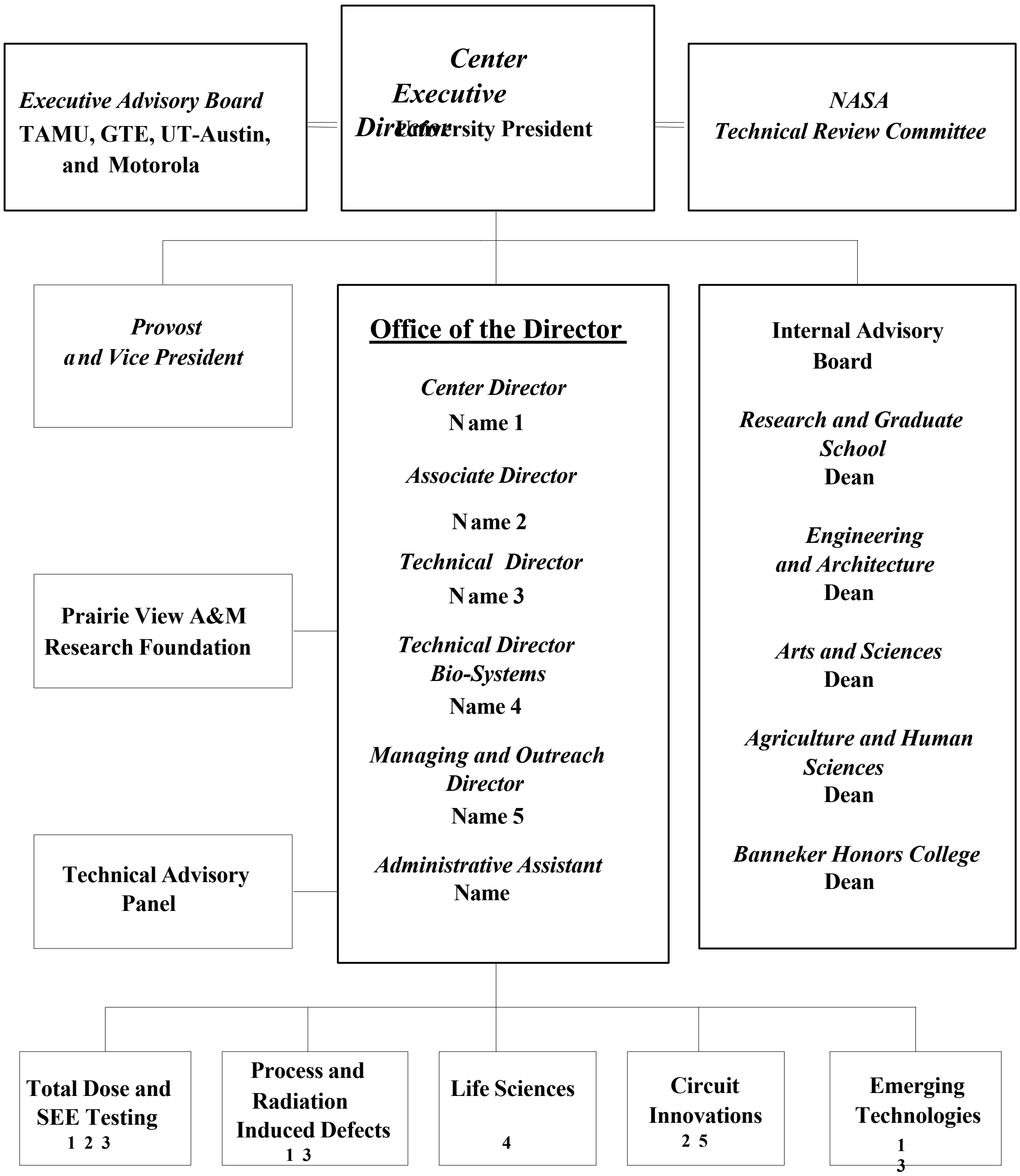

Figure 1. CARR Organizational Structure

Internal Advisory Board

The Internal Advisory Board (IAB) consists of the primary university decision makers concerning personnel allocation and real estate management. People and places for research are of paramount importance. The IAB for the CARR MDRC consists of the deans of the participating university colleges and has proven to be vital for negotiating space and other resource allocations. In addition, the IAB has the critical role of regulating the long-term growth and development of the university infrastructure, which is a major goal and primary purpose of the MDRC. The IAB must ensure that the MDRC promotes the overall growth and development of the university and becomes a permanent entity within the campus infrastructure.

Prairie View A&M Research Foundation

The availability and integration of a local Research Foundation is important for the efficient management of financial matters. The MDRC funds a percentage of over 15 faculty and staff salaries and an average of 35 student researchers on an annual basis. In addition, approximately one hundred fifty orders for research supplies and equipment are placed annually. Such an increase in payroll, acquisition and financial reporting activities may impose an enormous burden on the local university staff. It is strongly recommended that additional staff or a separate financial management agency be utilized to execute the various financial activities.

Operational Environment

The strategies used to integrate faculty, students and resources across a multicultural and very diverse environment must be carefully planned. The organizational structure of the CARR MDRC was planned to help facilitate faculty and student integration within the center and to help facilitate the extension of research activities to the classroom. The Office of the Director was carefully organized to gain the visibility and personnel attributes needed for the overall success of the MDRC. Each member was selected based on technical and managerial expertise, not to exclude the personal energy level and social skills. The process of building and conducting operations within a MDRC requires an enormous amount of energy coupled with the ideal personalities. The group must operate as a cooperative and professional team, from the director to the administrative assistant. The director exemplifies the values and attitudes, which must permeate through each member within the office. Each member of the Office of the Director, faculty investigators and research staff must be committed to uphold the values and attitudes expressed by the director. The success of the CARR has been a direct result of the operational mindset of the director. The director has invested a lot of time mentoring on how to achieve results, while establishing a very efficient operating environment throughout the center. The director empowered the members of the Office of the Director with knowledge, authority and resources to carry out the day-to-day requirements of the center.

Management Strategies

The management strategies within the MDRC must shape the operational environment and maintain the visibility required to foster success. Current literature precisely documents the multitude of managerial roles and skills required for the success of an organization.[3] Furthermore, the concept of engineering management is well developed and highlights various methods and characteristics required of successful managers.[4] Another aspect of the MDRC environment, is the dynamic role requirements of key players, as managers today and engineers tomorrow. A detailed discussion of the transition to engineering manager and the role differences between managers and engineers is also available.[5] Regardless of the approach, the overall management strategy must focus toward the following major accomplishments:

- Management by Objectives (MBO), a goal-setting process, is a very sound initial approach.
- The Center Director must establish the values and attitudes associated with the management styles.
- Key players must emulate the trends of the director and be empowered to execute specific tasks.
- The Office of the Director must demonstrate appreciation for excellence in key investigators and student researchers.
- Total Quality Management (TQM - continuous improvement) must be a part of all center operations.
- Boards and Committees must meet periodically and be accountable for the respective responsibilities.
- Goal setting and job design must be used as motivational tools throughout all aspects of the Center. The basic functions of management are always vital: Planning, Organizing, Staffing, Motivating, Communicating, Measuring and Correcting. A key tool designed to help implement CARR management strategies is illustrated at Figure 2 – CARR Task Sheet.

Educational Benefits

The educational benefits extend to students, faculty and the university. The multi-disciplinary research and engineering integrate various disciplines for students and faculty to explore as a system or environment. The CARR influenced several new initiatives, which are now new components within the university academic inventory.

- Two new classes were developed – "Space Science" and "Intro to Nuclear Engineering."
- Faculty of various disciplines team together and pursue more diverse research ventures.
- Students are involved real world problems and help pursue solutions.
- The diversified research areas help to justify the Ph.D. in electrical engineering, which commences during the fall 2003 semester.
- Several new graduate classes in electronics, materials and properties are being developed to better integrate the various engineering disciplines

The CARR Task Sheet is used as a local contract to motivate investigator and student researchers. By documenting goals, establishing specific tasks and listing deliverables, the director and other key investigators can review and evaluate all activities within the center. Students and research advisors are required to give periodic updates to an audience of center personnel. Monthly meetings involve faculty, staff and student researchers to help maintain the visibility needed of the various research functions within the center. The Internal Advisory Board meets once an academic semester to resolve issues and conduct short and long range planning. The Technical Review Committee and selected members of the Technical Advisory Panel meet annually to assess the overall performance of the center and to evaluate the progress toward the long range and strategic goals. The Executive Advisory Board meets annually with the university president to ensure that the strategic plan of the MDRC is a viable subset of the strategic plans for both the university and sponsoring agency. The various meetings are documented for review and further planning purposes.

CARR Task Sheet
Coordination Date: September 2002

Name: John Doe **Research Advisor**: Dr. John Doe, Sr.
Phone: 857- 1234 **Phone**: 857- 1234
Schedule: Monday through Friday; 10:00 - 2:00
Dates: September 2002 – May 2003
Status: Junior EE Major: Graduation - May, 2003
Research: CARR Common/General Operations

Goals: Manage and maintain computers and computer networks in support of CARR. Ensure all computers and computer networks are operational and accounted for. Acquire the knowledge and skills required to serve as a system and network administrator.

Tasks:
1. Update research advisor daily concerning the status of computer resources.
2. Assist in maintaining the CARR network and development/design systems.
3. Perform maintenance and repair for PCs no longer under warranty.
4. Coordinate network and system repair activities as required.
5. Establish a list of software installed for each PC, system, and network by SN.
6. Conduct daily checks/inspections of computer resources in rooms 213 & 206.

Deliverables:	**Dates**:
1. Computer software listings - Posted 5x7 cards/sheets:	25 Oct 02
2. Computer resource inventories w/SN: 201, 213, 206, etc.	31 Nov 02
3. Computer network diagrams w/software listings: 213, 206	2 Apr 03

Coordination:

______________________________ September 2, 2002
Research Assistant Date

______________________________ September 2, 2002
Research Advisor Date

______________________________ September 5, 2002
Director, CARR Date

Figure 2. CARR Task Sheet

Section Two: Life Cycle Support

The life cycle support concept within a Multi-disciplinary Research Center (MDRC) is based on the premise that equipment, systems and personnel exist on a life cycle. Life Cycle Support is centered on the futuristic approach to survival within the MDRC, along with expanding a short-term research initiative to a permanent infrastructure. Upgrades, retrofits, technology insertion, retraining and replacements are all activities used to address the life cycle issue. The cost to support an item or system over the estimated life span is often more expensive than the cost to acquire the item. If life cycle support is not provided, faculty and student researchers may be dependent upon equipment or systems, which are not properly maintained because of the lack of resources for maintenance, repair parts or expendable inventory. The goal of the paper is to emphasize that life cycle planning must be a part of the acquisition process and to exemplify strategies needed to generate the capital required for survival. The primary strategy is "Integrated Logistics Support" – a process of defining, designing, acquiring and providing the required support for the equipment or system during the early stages of the life cycle.[6] The highlights include; migrating the MDRC to a permanent organizational structure, identifying resources with capital producing potential, and balancing resources between current commitments and attractive new opportunities.

Generic Life Cycle Model (Cradle-to-Grave)

The life cycle commences with the recognition of a need or deficiency and the conceptualization of a product or system, which will satisfy the need or correct the deficiency. The most common life cycle application concerns products, projects or systems, which have definite, start and end stages. The generic model of the product or system life cycle consists of the following phases; (1) Conceptual (Research), (2) Definition, (3) Design, (4) Development, (5) Production, (6) Operation and (7) Phase-out.[7] Each phase has a selected series of tasks or objectives which are relative to the product or system. The MDRC is considered a complex system, which follows the generic model from the conceptual phase to the operation phase. The objective is to avoid the phase-out phase and have the MDRC serve as a permanent entity within the university infrastructure. This endeavor is not easy, since most centers or research initiatives are funded for a specified number of years, based on the availability of funds. Often, universities are required to provide matching funds and facilities as a part of the competition for the research award. This approach is used to ensure that the university is committed to supporting the research initiative for the specified time period and commences the initial phases of the life cycle support planning.

Life Cycle Support Planning

Life cycle planning at the conceptual phase is very critical for the operation and survival of complex systems. The MDRC is composed of numerous highly sophisticated items of equipment. In addition, several experimental and analysis processes are conducted on a continuous basis. The goals of Life Cycle Support Planning are to maintain the equipment at "state of the art" conditions and to ensure that adequate materials, supplies and resources are available to support the planned volume of operations and activities. The initial activities of the life cycle support planning process must begin with the development of the research proposal and include the following:

- Listing of personnel resources and the percentage of time in support of the MDRC.
- Comprehensive list of known equipment items to support the MDRC.
- Outline of the proposed operations, experimental procedures, and research activities.
- Space requirements for laboratories and any conditioning systems for air, water, etc.
- Facility preparation requirements for very large, specialized, heavy or hazardous equipment.
- Special operations or activities – outreach, recruiting, conferences, affiliations, collaborations, etc.

The above items are required to establish the initial budget for the MDRC over the specified period of time. The mistake often made is that the life cycle of each component is not considered early on or is neglected because of the true cost of the MDRC or system. The concept of Integrated Logistics Support was developed years ago to help program and project managers develop a more accurate cost and support system required over the system life cycle.

Integrated Logistics Support

The Integrated Logistics Support (ILS) concept was developed by the Defense Systems Management College in Alexandria, Virginia in response to the Defense Acquisition Improvement Program. ILS is defined as a discipline, unified, and iterative approach to the management and technical activities necessary to: (1) Define the support, (2) Design the support, (3) Acquire the support and (4) Provide the support. The fundamentals of ILS establish the framework for engineers and program managers to design and incorporate a complete support system at the initial phase of the program or project.[8]

The MDRC must utilize the ILS fundamentals as early as possible, in order to provide an accurate account of support requirements. It is very difficult for the university or sponsor to identify additional funding for a project after the budget is final. The late identification of substantial dollar requirements places the center or program at risk for early termination or entices decision makers to try and "find the dollars." In such situations, the university and sponsor could view the early termination of the center or program as a "savings" and defer the goals and objectives to latter years. As a minimum, the MDRC should include the life cycle of the following ILS elements:

- Facilities.
- Man Power and Personnel.
- Training and Training Support.
- Maintenance Planning.
- Packaging, Handling, Storage and Transportation.
- Computer Resource Support.
- Technical Data.
- Supply Support.

- Support Equipment.

In addition, there are additional requirements needed to interface the ILS elements within the overall center operations and life cycle. The definition and design of the support elements and the integration processes for the MDRC form a great portion of the Life Cycle Support Plan.

Life Cycle Support Plan

The Life Cycle Support (LCS) Plan is a document, which outlines the requirements, procedures and strategies to support the MDRC or system throughout the life cycle. There must be a well-defined approach for the MDRC to become a permanent entity within the university infrastructure. The university system or controlling agency must be convinced that the center fulfills a major deficiency within the current educational process and is worthy of funding. A noteworthy approach is to illustrate how the center is capable of supporting itself through various inherent attractions to students or outside sources seeking the use of the center's capabilities. The initial sections of the LCS Plan should document the ILS requirements. In addition, the center should document the preliminary analyses of the following areas: (1) Capital Producing Potential, (2) Balancing Between Commitments and New Opportunities and (3) Transition to a Permanent Organizational Structure. A model of the CARR LCS Plan is illustrated at Figure 3 - CARR Life Cycle Support Model. The model provides the conceptual view of the approach taken to establish and sustain a long-term research center. The input is CARR funding and the output CM^3 Growth.

1. Center for Materials, Microdesign and Microfabrication (CM^3) established by the Texas A&M System Board of Regents.
2. CM^3 is the permanent organization for CARR.
3. Establish CARR/CM^3 accounts for Life Cycle Support.
4. Evaluate capital producing capabilities:
   * Professional Services.
   * Radiation Testing.
   * Material Characterization / Surface Analysis.
   * Simulation Services.
   * New Research and Service Opportunities.
   * Expansion of current capabilities.
   * Incorporating special purpose teams.
5. CM^3 as the incubator of Small Business Innovative Research (SBIR) initiative.

Figure 3. CARR Life Cycle Support Model

Capital Producing Potential

The MDRC develops capabilities to satisfy various technological needs or evaluate potential solutions to specific problems. A strategy of the center should be to conduct a market analysis of the various capabilities to assess the respective market values. The next step is to advertise such capabilities to potential customers. The process will identify the potential of the center to produce capital, which helps sustain the center throughout the life cycle. The CARR MDRC utilizes its radiation exposure and testing capabilities as a capital producing source.

Balancing Between Commitments and New Opportunities

Once the MDRC is established, research investigators are challenged with fulfilling the current commitments and utilizing new research opportunities to help sustain the center. The tradeoffs become getting the job done or ensuring there is a job. A judicious mix must be carefully established to help maintain the performance expected of the center and to continue to add more value to the overall center system.

Transition to a Permanent Organizational Structure

The strategy to become a permanent entity within the university or organizational structure should be developed as early as possible. The overall center objective must focus on a problem or deficiency, which will exist in perpetuity. Thus, the justification for a place within the organization will be a necessity.

Conclusions

In conclusion, the complexity of the MDRC mandates the appropriate organizational structure and culture for long-term survival. The center director must establish and exemplify the values and attitudes needed to promote success. The Office of the Director must maintain a continuous effort to instill accountability and participatory management throughout the MDRC. Recognition and visibility are of paramount importance to motivate such a diverse conglomeration of researchers. One of the most important tasks within the MDRC environment is to select the best person for a specific job and not make selections on the pretense that any intelligent person should be able to accomplish the task. The MDRC appears to be the objective research structure of the future. It will be used to develop the products, technologies and procedures needed to meet the challenges of the 21^{st} Century. Life Cycle Support Planning within a MDRC has several major points, which must be considered. The approach to the process can be easily modified as appropriate. The suggested key points are listed below:

- The LCS planning process should begin at the conceptual or proposal stage.
- The Integrated Logistics Support Elements should be well defined and assigned cost values.

- A Life Cycle Support Plan should be developed as soon as possible, as a working document.
- The MDRC must evaluate its capital producing potential and identify customers for services.
- A judicious balance between current commitments and new opportunities must be established.
- The MDRC should develop a transition strategy to become a permanent organizational structure.

Acknowledgement

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Biography

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