Planning for Institutional Core Research Facilities in Uncertain Times

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When I began my career at the University of Kansas over 30 years ago, university research core facilities were generally called "core service laboratories". About three years ago during a discussion in one of our staff meetings, the directors of these facilities expressed their displeasure with my continued use of this terminology. They wanted to be referred to using language more accurately reflecting their central role in the university's research endeavor. They were absolutely right. With that discussion KU undertook a renewed focus on "core research laboratories" or "core research facilities".

It is an understatement to note that the vision of core laboratories as "service" units is several generations out of date. Of course, these laboratories do still serve a significant swath of the science, engineering, mathematics, and technology (STEM) researchers at the university. But the operation of these laboratories is far more diverse than the stereotypical "drop a sample off on Monday and pick up a spectrum on Tuesday" mission that was thought to dominate the service cores of the 1970's and 1980's. Most core laboratories now often play the part of institutionally supported research collaborators, available to tailor analytical research solutions, design new instruments, and create novel software applications to address the needs of researchers from diverse disciplines. Frequently, these core research laboratories generate independent intellectual contributions to the problems they address, and consequently need to be acknowledged as co-investigators in proposals and publications. This is a far cry from our dated vision of the role of core service laboratories.

The challenge for today's public research universities is how to create a sustainable system of core research laboratories that serve the largest possible group of institutional investigators. Sustainability in today's context of challenging state and federal budgets implies achieving a balance of the following factors:

1. Cost effectiveness—the institution and its researchers need to obtain the greatest possible research output for the financial commitment provided to the core research laboratory or facility.
2. Sustainability—the institution should seek to invest in core laboratories that have a sufficient client base and mission to offer the prospect of sustainable operation.
3. Adaptability—core research units need to vary their offerings of in-

strumentation and research activities based on investigator need and on the availability of convenient, cost effective alternatives in the private sector.

4. Responsiveness—leaders of core research units need to seek constant input from investigators about emerging trends in institutional research, and areas where core functions could be expanded to support emerging research needs.
5. Engagement—the level of institutional investment in core research units needs to be confirmed through researcher engagement in evaluating their effectiveness and in ongoing management (including expansion and contraction) of the institutional core laboratory and facility portfolio.
6. Outreach—where possible, augmenting internal services by offering unique research services to other universities, research institutions, and private sector partners outside of the university can assist in supporting core laboratories. Achieving a balance of these factors in a core research facility and laboratory program is essential for the vitality of the university research endeavor.

Rationale for building research laboratory and infrastructure cores

The function of core laboratories has always been about creating efficiencies in capital investment and operations that minimize the cost of research services and infrastructure for the institution. While investments in core laboratories frequently focus on stupendously expensive capital equipment (NMR spectrometers, electron microscopes, mass spectrometers, research nuclear reactors, etc.), other significant components of institutional investment must also be factored into an analysis of core laboratory costs. Among these factors are ongoing maintenance of equipment, opportunity costs for the use of space, the cost of utilities, personnel salaries and training, the cost of maintaining compliance with federal and state regulations, and infrastructure for budgeting and account management. Though initial capital costs for the creation of these facilities can be staggering, annual support for personnel-intensive research core laboratories can dominate the longitudinal institutional investment costs.

In spite of these costs, maintaining core research laboratories can enhance the university's research efficiency beyond avoiding duplication of highly expensive capital equipment. Centralizing important, yet non-cutting edge research functions in core research laboratories can ensure that researchers have access to important collaboration partners in areas where it is impractical to hire tenure-track faculty. The expertise found in core laboratories allows faculty researchers to focus their group's activities on aspects of studies that reflect their specialty rather than cross-training researcher's peripheral techniques in a wide variety of disciplines. Finally, centralizing certain research functions in core laboratories and facilities can ensure a uniform approach to critical compliance and quality control functions.

Building a core research laboratory system

It is increasingly clear that Federal agencies also see the advantages of centralizing major core resources on a regional, national and international level. While this has been the case since the 1940's for massive infrastructure projects such as telescopes, particle accelerators, and facilities for supporting nuclear and infectious disease research, NSF and NIH seem to be turning with renewed interest to creating regional resources in high performance computing, microscopy, advanced manufacturing, and other core areas of technology.

KU began to build its core laboratory capacity during the early 1970's. Following passage of an amendment to the Animal Welfare Act (1), the Animal Care Unit became KU's first formal core research laboratory. The addition of analytical cores was supported through NSF funding in the early 1980's, and facilities that support small molecule drug discovery and high performance computing have been added throughout succeeding decades. KU Research currently supports and administers the ten core laboratories outlined below:

- Animal Care Unit—early 1970's
- Instrument Design Laboratory—early 1980's
- Mass Spectroscopy Laboratory—early 1980's
- NMR Laboratory—late 1980's
- X-ray Laboratory—early 1980's
- Molecular Graphics Laboratory—early 1990's
- Biotechnology Innovation and Optimization Center, mid-1990's
- High Throughput Screening Laboratory—early 2000's
- Microscopy and Analytical Imaging Laboratory—early 2000's
- Center for Research Computing—2013

These university core laboratories receive some degree of salary support and are under budgetary supervision by KU Research. Each laboratory has rates for research and service activities reviewed and approved by KU Research, and each lab undergoes formal performance evaluations on a 5-year rolling schedule. The smallest of these units has only two full time staff, while the Animal Care Unit has a total of 10 full time staff for veterinary and animal husbandry services. Overall, KU currently budgets $1.8 million in support of these laboratories. Because these cores were established during different decades and serve different groups around the university, the degree to which KU Research subsidizes their cost varies between 0 to 80 percent. On average, the university provides 60 percent of the laboratory budget. Anecdotally, this percentage appears to be a common average for core laboratory support across the country, though some campuses provide little or no subsidy for their cores and others offer core services at little or no cost. Based on recent discussions among national research leaders, there appears to be little consistency in how research core laboratories are developed and managed across the country.

Rates for research and service activities offered by KU core research laboratories are established through a formal university financial accounting process using data gathered from laboratory operations. KU maintains three rates for most research activities embedded in core laboratories:

- A rate for internal investigators. This published rate does not include F&A cost recovery, because this occurs automatically for expenditures from federal grants held by KU.
- A rate for external academic researchers and non-profit agencies. This rate combines both the internal investigator rate and the accompanying F&A recovery, and adds an additional 5 percent fee for administrative costs.
- An external market rate. This rate reflects the cost of obtaining similar services in the private sector, and is applied to all for-profit entities seeking core laboratory research and services.

Rates are, at most intended to recover operating costs, not to generate excess funding. In spite of the importance of covering operating costs, there are practical constraints on the internal rates the core laboratories can charge, and the level of rate increases they can impose in any annual period. Investigators can and sometimes do shop for the prices of similar services at other institutions. This can impose a practical limit on the price of specific research services. When researchers outsource research services available at their home institution to core laboratories at other institutions, this drives up the cost of providing services to other researchers by decreasing the financial competitiveness of their own core laboratories. In spite of this fact, a large differential between the cost of services at the home institution and those in competing academic laboratories can result in an exodus of business from specific cores. Price increases face a practical limit as well, because the average 4-year Federal grant cycle assumes a reasonably constant rate for access to specific research resources. Finally, Kansas statute also forbids State institutions from unfairly competing with private sector service providers, which explains why core laboratory rates for private sector research partners are pegged to either the external market rate or the total cost of services (whichever is higher).

The roles core laboratories undertake in their work with university researchers has continued to diversify as core laboratory directors see new opportunities to serve as collaborators. KU has prided itself on allowing all trained researchers, including undergraduate students hands-on access to instrumentation. Since some core laboratories are engaging in collaborative research rather than in routine analyses, the ability of students to be hands on users of some core facility resources is changing. Studies that require more intellectual input as the project develops tend to be performed entirely within the unit. Additionally, some of the core research laboratories almost exclusively serve an internal clientele where hands-on involvement by researchers from the laboratory might be appropriate, while other cores work with a diverse range of internal and external investigators.

There are many other core laboratories hosted in various units at KU. Some of these are longstanding cores funded within research units such as the Higuchi Biosciences Center or the Life Span Institute. Others, such as the Protein Production and Protein Structure cores, have been funded through a 15-year maturation period with NIH-COBRE funding.

The expectation is that many of these latter cores will demonstrate their utility and sustainability through building a user base and be assimilated as university core laboratories once they "graduate" from COBRE support. Though KU's central administration establishes rates and sets invoicing policies for other core laboratories, we do not formally oversee their finances or provide direct monetary support for their operation.

Building a culture around the development and use of institutional core laboratories at KU requires several key components. First, there must be an institutional commitment to funding and supporting such laboratories. The university must either have sufficient centralized research funding to sustain laboratory operations, or academic units must band together and engage in priority planning to fund a range of core laboratories. Second, principle investigators must jointly commit to support the core laboratories. This means participating in core laboratory governance and evaluation, working with research leadership when core laboratories are not serving investigator needs, and writing contributions to core support and maintenance into external grants and awards. Matching the financial support KU provides for the institution can continue to support the widest possible range of core laboratory services. Third, in order to optimize laboratory function, the university must have a strategy for gathering formative user input on core laboratory function and longitudinal input on the effectiveness of core laboratories, and must engage investigators in discussions about sun-setting core laboratories when their functions no longer serve the research community.

Suggested best practices for building core laboratories

The following is a concise summary of suggested best practices for creating a robust system of core research laboratories:

1. **Cost effectiveness:**
    - University core research laboratories undergo a monthly (or quarterly) financial review.
    - Subsidize cores only to the extent necessary to maintain competitive costs for services.
    - Subsidies and service rates must be kept in balance—requesting fees for facility usage in research grants leverages institutional resources and expands the number of core laboratories the institution can support.
2. **Sustainability:**
    - Subsidized university cores need to have a sufficient base of clients to project financial stability.
    - The function and client base of proposed cores need to be fully described prior to approval for rate setting.
    - Successful core laboratories depend on building a culture of community responsibility.
    - Rates will not be established for non-university cores when these services are available in a university-subsidized core—dilution of the client base is a recipe for financial failure.
3. **Adaptability:**
    - Using external services that are available in a subsidized core is a signal that the university should not be supporting that core.

- Services should not be offered if they are available from external providers at lower costs.
- Services that are broadly embedded in individual labs generally should not be offered in cores.

4. **Responsiveness:**
   - Institutionally supported core laboratories must be available for all-comers within the university.
   - All university subsidized core research laboratories and their directors undergo a formal internal review every 5 years.
   - Subsidized university cores either need to work for clients or they need to be reorganized so they do work for clients.
5. **Engagement:**
   - All core research laboratories must have a user advisory committee.
   - The director must meet with this group on a regular basis.
6. **Outreach:**
   - Engagement of private sector clients is strongly encouraged for all core research labs—given costs of operation, it is probably essential for some.

Case study: Construction of a new nanomaterials clean room core laboratory in the KU Central District project

In support of a growing sector of university researchers focusing on nanomaterials fabrication for energy conversion, biomedical analysis, and implantable biomaterials, KU made a decision to include a new clean room core facility space in the footprint of the Integrated Science Building in KU's Central District Project, see Figure 1. KU's Central District is a nearly $400 million construction project stretching diagonally from 15th Street and Naismith Drive in the north east area of central campus to 19th and Iowa Streets in the south west. Clean room spaces are among a small group of laboratory spaces—others include animal care space, biosafety laboratory level 3 & 4 spaces, GLP manufacturing spaces, and spaces for human clinical trials—that are among the most expensive spaces for universities to construct and maintain. The cost of maintaining such facilities can stem from hazard management and regulatory oversight of experiments conducted in these units, and, particularly in the case of clean room spaces, from the annual cost of supporting personnel to actively manage and provide oversight of facility operations. A careful plan for the new clean room core was in the university's best interests to ensure the maximal utility and sustainability of the unit.

KU currently has two clean room environments. As shown in Figure 2, one of these is a 3,000 square foot (sf) dedicated-user space in Malott Hall, a 60-year old building on main campus. This space is focused on the development of photophysical devices for energy harvesting. The other is a 2,000 square foot multi-user space focusing on the generation of biosensors for detection and study of cancer and other disease states. KU's Central District project was originally scheduled to host two cleanroom spaces: A new 6,000 square foot dedicated clean room space in the new Earth, Energy and Environment Building replacing the photophysical device space in Malott Hall, and a 15,000 square foot multi-user core clean room space located in the new 180,000 square foot Integrated Science Building. Executing this plan would have left KU with 23,000 square feet of clean room space in three sites on the main campus. Clean room construction can cost up to $1,000 per square foot and cleanroom space of this magnitude approaches that of small-scale commercial production facilities. Given these factors, the cost of construction and operation of the new spaces would have monumental initial and ongoing commitments for KU. Just the cost of maintaining and operating these facilities would likely have topped $4 million per year. Moreover, most universities operating successful clean rooms for basic materials and biomaterials research support at most 5,000 square feet of multiuser space. Based on continuing design discussion and ongoing analyses of researchers needs, KU decided to re-scope the project, focusing on constructing a centralized facility that would maximize clean room functionality for multiple investigators.

The resulting decision was to close the existing satellite facilities and build a single 5,000 square foot multi-user cleanroom space and an associated 2,000 square foot dedicated-user cleanroom space centrally located in the new Integrated Science Building. This strategy would create new, more energy efficient spaces and create a single space for personnel engaged in clean room management. These spaces are sufficient to host the $3.5 million of nano and microfabrication equipment we intend to provide for core facility researchers. We anticipate that this facility will cost a minimum of $800,000 per year to operate.

In light of this cost, we have sought to create a facility that can become a unique regional resource for other academic partners and private sector R&D projects requiring device fabrication in a clean room environment. Among the shared resources contained in this facility, we expect to offer:

- Class 10,000, 1,000 and 100 space
- Photolithography and chemical etching
- Nano-imprinting and embossing
- Sputtering and molecular beam epitaxy
- Device fabrication and wire bonding
- Device characterization and analysis
- Biomaterials and materials sample preparation areas
- "Gray" space for sample and device preparation

We anticipate not only widespread use of this facility by KU researchers, but an aggressive campaign to market this resource to private sector partners.

We believe a wide range of research focus areas will benefit from this state of the art facility, including the preparation of energy harvesting devices, the study of new implantable biomaterials, and the development of biosensors for the detection of circulating markers. To bolster KU's research expertise in some of these areas, we recently hired Professor Steve Soper as a Kansas Foundations Professor. Professor Soper's research, briefly outlined in Figure 3, targets the detection and identification of circulating tumor cells, extracellular DNA, and exosomes as potential markers for metastatic cancer and other human diseases. His research, see Figure 4, uses nano-engineered flow devices to collect and conduct real-time analysis circulating markers at the single cell or exosome level from small samples of plasma. This type of rapid bedside liquid biopsy will dramatically reduce the time required to diagnose and develop genetically targeted treatments for metastatic and pre-metastatic tumors. His research programs will make heavy use of the new clean room core.

Conclusion

At KU-Lawrence, our developing understanding of best practices in the management of our research core laboratory portfolio was of great assistance as we engaged in the conceptualization and design of the new multi-user clean room core facility. We intend to continue working with KU investigators and core laboratory directors to refine these concepts for the operation of all KU core research units.

Acknowledgements

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References

P. L. 94-279, Animal Welfare Act Amendments of 1976

Figure 1. Artist's rendering of the Integrated Science Building in KU's Central District Project

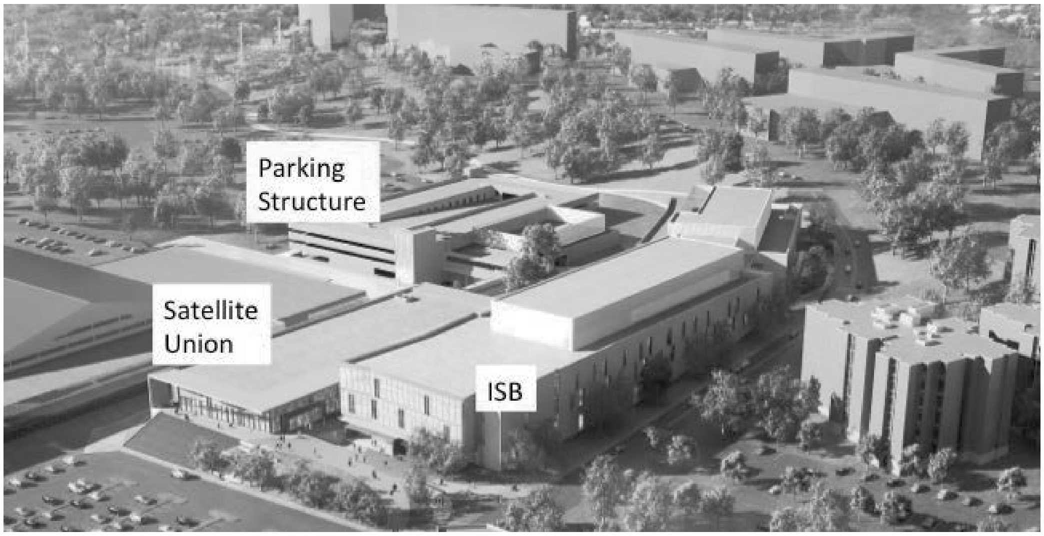

Figure 2. Current and initially planned distribution of clean room spaces on the KU-Lawrence campus as part of the Central District Project. (KU campus map © Google Maps.)

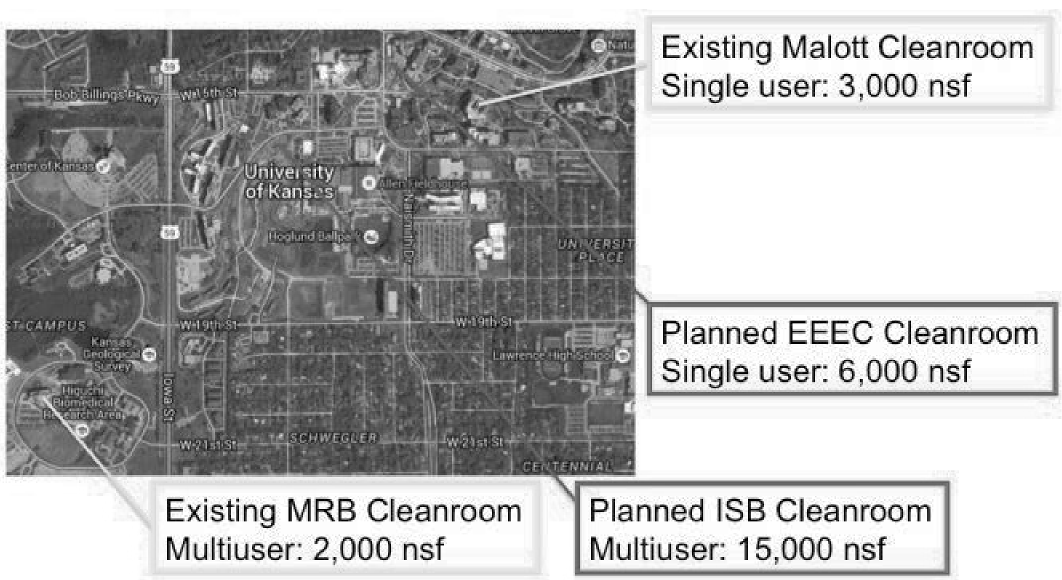

Figure 3. Summary of research themes of KU Foundation Professor Steven Soper

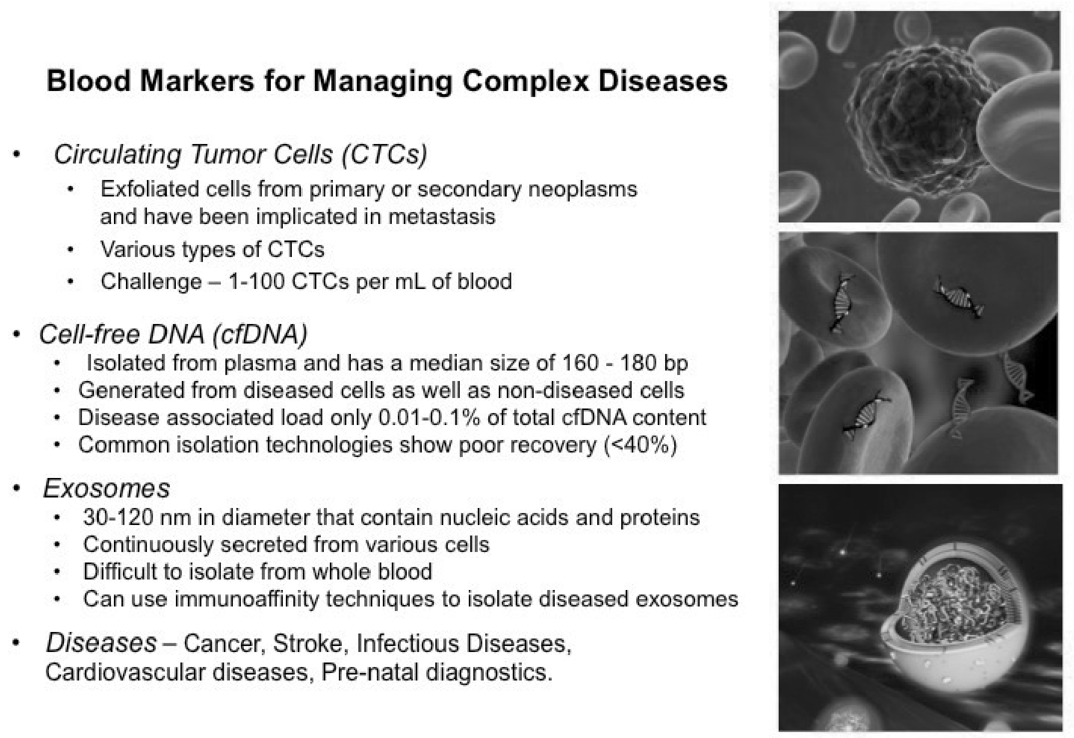

Figure 4. Nano-engineered flow analysis systems created in the Soper laboratory.