

## Operational and Fiscal Management of Core Facilities: A Survey of Chief Research Officers

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**Abstract:** *Sharing research equipment and personnel across investigators and laboratories has a long-standing history within research universities. However, the coordinated management of centralized, shared resources (i.e., core facilities) that provide access to instruments, technologies, services, expert consultation, and/or other scientific and clinical capabilities by Chief Research Officers (CROs) represents a more recent shift within the academy. While a number of recent surveys and studies have focused on the experiences of core facility directors and users, there has not yet been a targeted survey of CROs. Partnering with the Association for Public and Land Grant Universities Council on Research, fifty-eight CROs (or their designee) from research universities completed an electronic survey on core facilities (response rate = 35%). Core facilities formally reported to a range of entities within the university (and many to multiple entities), including the CRO office (83%), colleges/schools (67%), institutes/centers (42%), and departments (42%). Forty percent of respondents indicated that their university does not have a formal process to become and/or retain status as a recognized core facility. CROs also perceived that different types of core facilities directors differed in their general effectiveness ( $F(3,179)=6.88, p<.001$ ); professional staff and administrators were rated as significantly more effective at directing/*

*supervising core facilities than were tenure/tenure-track faculty (Tukey's post-hoc;  $p < .005$ ). Core facilities were funded through a variety of mechanisms, with the most common being use fees (96%), central and/or decentralized funding of directors or staff (77%), annual general fund allocation (62%), a designated portion of Facilities & Administration (F&A) reimbursements (46%), and internal grant programs (31%). Funds for purchasing new equipment within core facilities came from a number of sources, with the most common being external grants (87%), central institutional funds (83%), college/school/department funds (73%), use fees (50%), F&A resources (50%), and donations (27%). There are significant challenges to managing and funding core facilities; the present study provides new insights into the various strategies and tactics being taken by CROs to address these real and perceived challenges.*

Keywords: *Research Facilities, Shared Facilities, Research Infrastructure, Research Efficiency, Scientific Research, Clinical Research*

## **Introduction**

The sharing of research equipment, facilities and personnel across multiple investigators and laboratories is common within research universities. At many institutions, and for the purposes of this paper, these shared resources are often referred to as core facilities. In some disciplines (e.g., astronomy and various domains of the biomedical sciences) the sizable expense associated with state-of-the-art equipment, facilities, and trained operators necessitates the centralized operation of shared resources (Farber & Weiss, 2011; Chang, Birken, Grieder, & Anderson, 2015). Indeed, the various federally-funded National Laboratories that exist throughout the United States (e.g., Oakridge National Laboratory, Los Alamos National Laboratory, etc.) perhaps best illustrate the long-standing history of core facilities, which provide access to cutting-edge equipment and technical personnel to accelerate research outcomes and impacts.

Sharing of research facilities, and the resources within them, at modern research universities has tended to occur through ad-hoc and/or historical arrangements, and in many cases they have been managed outside the oversight of the Chief Research Officer (CRO), such as within colleges, schools, departments, and research centers/institutes. However, the coordinated management of core facilities by the CRO office has increased dramatically over the past decade. The need for centralized, higher-level coordination of university research facilities is the result of multiple factors, including (but not limited to) rising research costs, economic constraints, a desire to maximize research efficiency, a mandate to improve research transparency, and the highly competitive landscape of global research and development (Farber & Weiss, 2011; Chang et al., 2015).

While there have been a number of recent surveys and studies on core facility use and management, they have focused on core facility directors, supervisors, and/or users. For example, the Federation of American Societies for Experimental Biology (FASEB, 2017) conducted a survey that focused primarily on core facility directors, professional staff, faculty users, and student users. The FASEB

survey demonstrated a perceived value of core facilities through improved access to advanced equipment and analyses, specialized expertise, cost savings and efficiencies, and increased opportunities for transformative collaborations. Similarly, a 2016 Core Facilities Management Benchmarking Study conducted by iLab Solutions (Agilent Technologies) surveyed 282 core facility directors representing over 50 types of core facilities at 156 institutions (iLab Solutions, 2016). This survey reported that the costs of new technology and lack of sustainable funding are primary challenges and threats to core facilities (iLab Solutions, 2016). More recently, Hockberger, Weiss, Rosen, and Ott (2018) detailed a variety of strategies taken at Northwestern University to 1) improve the coordination between core facility directors and central administration (i.e., CRO office), and 2) support core facilities in a manner that ensures compliance with federal regulations, fiscal sustainability, and alignment with institutional priorities.

Whereas these recent studies provide valuable insights, a comprehensive survey of CROs is warranted given the expanding need for government cost compliance, centralized oversight, and equitable access and resource allocation of core facilities. Therefore, the purpose of this study was to survey CROs on the actual and/or aspirational structure, operational management, and fiscal management of core facilities at their respective institutions.

## **Methods**

This study was conducted in partnership with the Association for Public and Land Grant Universities (APLU) Council on Research (CoR) as part of their new Research Leader Fellow Program. Briefly, the CoR Research Leader Fellow Program was designed to provide training and skill development to APLU administrators who work closely with CROs and aspire to consider a transition into such a role in the future. The authors of this paper represent a subsection of the initial CoR Research Leader Fellow Program (selected in the summer of 2017) that expressed interest in focusing on Core Facilities operation and management as a special project area for the 18-month fellowship.

The Michigan Technological University Institutional Review Board approved the following study procedures. A self-report survey administered using Qualtrics was distributed electronically to CROs within the United States during the spring of 2018. Specifically, an email link to the survey was sent to 148 CROs included in a database maintained by the APLU CoR on May 1, 2018. Three subsequent reminder emails were sent on May 24, June 5, and June 19, 2018. In late May, APLU CoR updated their CRO database, which led to an additional 20 CROs for the June 5 and June 19 correspondence. Of the 168 CROs contacted, 58 completed the survey, yielding a response rate of 35%.

Respondents were instructed that the survey should be completed by the CRO (i.e., Vice President/Vice Chancellor/Vice Provost for Research) or their designee, and that only one survey should be completed per institution. In addition to the survey instructions and the Qualtrics link, the initial email included an attached PDF of the survey so participants could consult with other institutional officials prior to formal submission of the survey responses. This is relevant because participants were informed that certain questions required financial knowledge broken down by

core facility categories, and that these questions would likely require input from the core facility directors and/or financial managers.

The survey questions were conceived and designed by a group of Research Leader Fellows within the APLU CoR. A draft survey was developed in the fall of 2017. Four CROs (Vice Presidents and Vice Chancellors for Research) provided expert review of the survey questions, and a revised version of the survey was presented to the APLU CoR Executive Committee. The APLU CoR Executive Committee approved the distribution of the survey at their Executive Committee meeting in February of 2018. The survey included a total of 41 questions designed to capture key institutional demographics (Carnegie classification, land-grant status, research expenditures, etc.); how core facilities were defined, approved, and evaluated; how core facilities were financially supported; how they were perceived by the CRO and other institutional leadership; and what tools were used to evaluate the success of each core facility. The results section is organized to reflect these key components of the survey. A copy of the survey questions is included as Appendix A.

When appropriate, data were analyzed using SPSS version 25.0 (IBM Corp, Armonk, NY). Two types of statistical tests were performed as appropriate: One-way analysis of variance (ANOVA), and Tukey's honestly significant difference (HSD) tests for applicable post hoc tests. Statistical significance was set a priori at  $p < 0.05$ . Where applicable, results are presented as mean  $\pm$  standard deviation. Word clouds to summarize qualitative responses were created by standardizing plurality and tense. Responses were then put into Wordle<sup>TM</sup> (Feinberg, n.d.). Font size is proportional to the number of times a given word was used in open-ended responses.

## Results

### *Institutional Profiles*

Of the 58 respondents, 46 (79%) held the title of VPR/VCR, four (7%) held the title of Vice Provost for Research, and eight (14%) held another title. Thirty respondents (52%) were from institutions with a Carnegie Classification of Doctoral Universities: Highest Research Activity, 27 respondents (47%) were from Carnegie classified Doctoral Universities: Higher Research Activity, and one respondent (2%) was from a university that Carnegie classified as a Doctoral University: Moderate Research Activity. Fifty-five respondents (95%) were at public institutions, while three (5%) were from private institutions. Over half of the institutions were designated Land Grant universities (31 respondents, 53%) as defined by the Morrill Acts of 1862 and 1890 (or similar legislation). With respect to size of the institutions, there was a wide range in the number of full-time tenure/tenure-track faculty (range = 207 to 2000 faculty; mean =  $993 \pm 457$  faculty) and full-time non-tenure/non-tenure-track faculty (range = 0 to 2000 faculty; mean =  $507 \pm 535$  faculty). Finally, institutions ranged in FY16 National Science Foundation (NSF) Higher Education Research and Development (HERD) expenditures from \$13 million to \$1,194 million (mean =  $\$244 \pm 235$  million).

### *CRO Operating Budget*

Twenty-nine respondents (50%) indicated that the general budget model at their institution was one in which unit budgets were “typically based upon previous year’s levels.” The remaining respondents indicated that unit budgets were “dependent upon revenue generation by the unit such as student credit hours, enrollments, research awards, etc.” (12 respondents; 21%), or “based upon performance funding models such as graduation rates, research expenditures, etc.” (6 respondents; 10%), or “cleared each fiscal year and future funding is based upon annual request” (5 respondents; 9%).

Thirty-three respondents (57%) indicated that the size of the CRO budget was directly linked to F&A reimbursements, while 25 respondents (43%) said it was not. Of the 32 respondents that indicated a direct link to F&A reimbursements in support of research initiatives, 18 respondents (56%) indicated that F&A contributed <50% of the CRO operating budget, whereas the remaining 14 respondents (44%) indicated that F&A contributed >50% of the CRO operating budget.

CRO perceptions of the level of overall budget autonomy and adequacy of resources were queried. When asked “How much flexibility do you have with the VPR/VCR budget?” the following responses were provided: no flexibility (1 respondent; 2%), little flexibility (10 respondents; 18%), moderate flexibility (28 respondents; 51%), considerable flexibility (11 respondents; 20%), and complete flexibility (5 respondents; 9%). When asked “To what extent do you feel the VPR/VCR office is provided with adequate resources when compared to other budgetary units on campus?” the following responses were provided: inadequate (7 respondents; 13%), somewhat inadequate (24 respondents; 44%), adequate (22 respondents; 40%), somewhat plentiful (2 respondents; 4%), and plentiful (0 respondents; 0%).

### *Core Facility Reporting Structure*

For the purpose of the survey, core facilities were defined as “shared facilities and infrastructure (including equipment and personnel) that support research across multiple colleges/schools/units.” Of the 55 respondents who completed this question, 52 (95%) indicated that their institution had core facilities consistent with this (or a related) definition, while three respondents (5%) indicated that their institution did not have facilities that met this definition. Reasons for not having formalized core facilities were either 1) having too little research to justify or 2) having a lack of adequate resources. At this point, the questionnaire ended for the three respondents who did not have core facilities and the remaining 52 respondents proceeded on to the remainder of the survey.

To whom core facilities reported varied across and within institutions. Forty-three respondents (83%) indicated that some or all of their core facilities reported to the VPR/VCR office. Other units to which core facilities reported included colleges/schools (35 respondents; 67%), institutes/centers (22 respondents; 42%), departments (22 respondents; 42%), provost offices (4 respondents; 8%), and other (6 respondents; 12%). Respondents could endorse all options that applied to their institution. The response box for “other” included the Chancellor’s Office, Chief

Information Officer, and the Office of Grant and Contract Accounting.

### *Core Facility Application, Evaluation, and Renewal*

When asked “Does your institution have a formal application process to become a designated core facility?” 20 respondents (40%) indicated that their institutions do not have a formal process. Of the remaining 30, 16 respondents (32%) indicated that they had a formal application process that was managed centrally by the office of the VPR/VCR or provost, and seven respondents (14%) indicated the formal application process was managed by the unit it reported to. The remaining seven respondents (14%) selected “Other” and indicated that the approval was managed centrally through their service center process, through the Office of Grants and Contracting, or by multiple units (i.e. VPR/VCR Office in combination with other units). Respondents were given the opportunity to qualitatively detail their responses; examination of these responses indicated that several institutions that did not have a formal application process were currently working on establishing one. Additionally, one institution uniquely noted a shared governance approval process that required approval from their Academic Senate (in addition to central administration approval).

Results concerning the evaluation and/or renewal process for core facilities paralleled the application process. When asked “Does your institution have a formal evaluation and/or renewal process for designated core facilities?” 21 respondents (40%) indicated that their institution did not have a formal process. Of the remaining respondents, 21 (40%) indicated that they had a formal evaluation/renewal process that was managed centrally by the VPR/VCR or Provost Office, while 7 respondents (14%) indicated that the formal evaluation/renewal process was managed by the unit it reported to. The remaining three respondents (6%) indicated a hybrid system (evaluation/renewal by multiple units) or that evaluation/renewal was managed by the Office of Grants and Contracting. Review of the optional, qualitative responses indicated two themes: 1) three institutions that did not have a formal evaluation/renewal process were working on establishing processes, and 2) the timeframe of evaluation/renewal ranged from one year to as long as five years.

### *Financial Support of Core Facilities*

Figure 1 depicts that core facilities are funded through a variety of sources, including: 1) use fees; 2) central and/or decentralized funding for directors or professional staff; 3) annual general fund allocation; 4) an allocated percentage of F&A); and 5) internal grant programs. Respondents were able to “select all that apply,” thus the total number of responses was not equal to the number of unique institutional respondents. Qualitative responses indicated that other sources included philanthropy, state funding, and personnel time/effort built into grants.

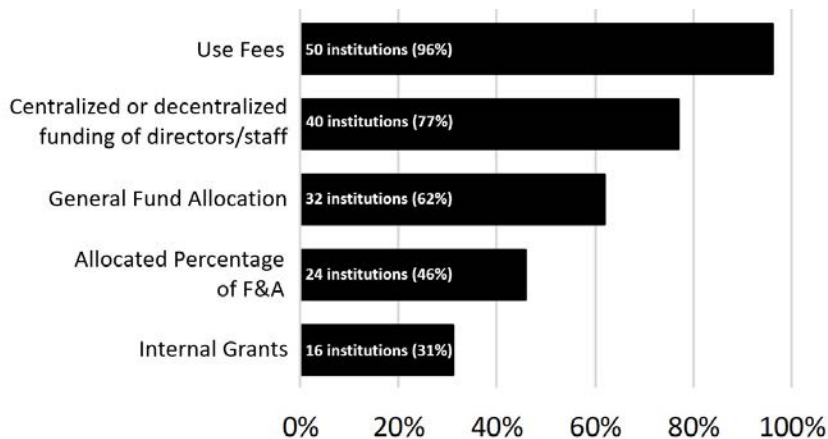


Figure 1. Prevalence of funding sources used to support core facilities.

Given the tremendous heterogeneity in the way in which institutions classified and/or named their core facilities, CROs were asked to indicate if their institution had designated core facilities in the following seven broad (i.e., “common”) areas: 1) microscopy/imaging; 2) microanalytic chemistry and/or molecular; 3) fabrication or microfabrication; 4) animal care; 5) high performance computing; 6) marine or aquatic; and 7) agricultural or field-based. Figure 1 demonstrates that >90% of the respondents indicated that their institutions had designated core facilities related to microscopy/imaging and animal care. Marine/aquatic and agricultural/field-based cores were not reported as frequently as the other “common” core facilities.

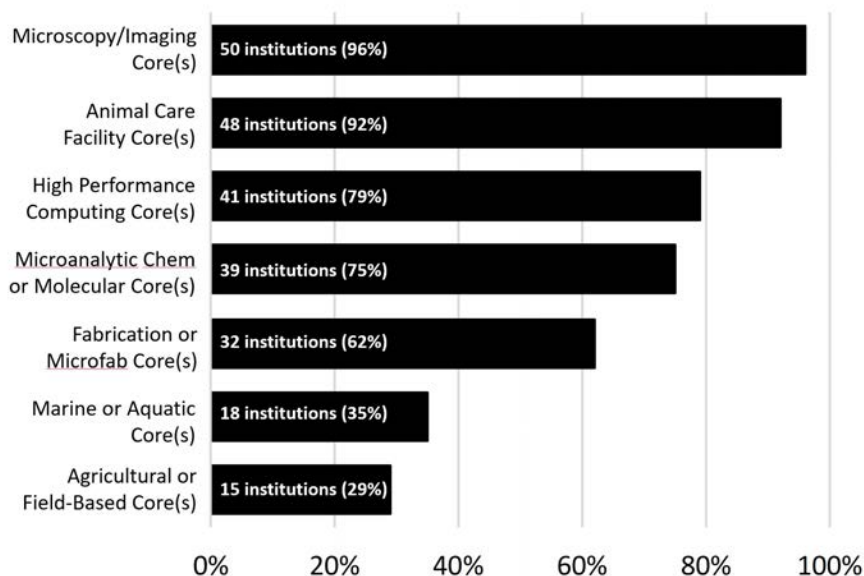


Figure 2. Prevalence of designated core facilities in seven broad areas.

Table 1 includes current estimated financial contributions, as well as aspirational financial contributions, for the seven “common” core facilities. Although there is substantial variability, the percentage of internal use fees was highest for animal care (~44%), microanalytical chemistry and/or molecular (~42%) core facilities, and lowest for high performance computing (~23%). With respect to external use fees, only the fabrication/microfabrication core facilities garnered external use fees that contributed >10% of the core’s budget.

*Table 1. Current Estimated and Aspirational Financial Contributions to Core Facilities*

	Internal Use Fees	External Use Fees	General Fund Allocation	F&A	Internal Grants	Other
<b><i>Current Estimated Financial Contribution by Core Facilities</i></b>						
Microscopy and/or Imaging	35 ± 23%	8 ± 14%	27 ± 27%	14 ± 24%	3 ± 8%	15 ± 26%
Microanalytic Chem and/or Molecular	42 ± 23%	8 ± 9%	28 ± 27%	9 ± 17%	2 ± 5%	11 ± 21%
Fabrication and/or Microfabrication	37 ± 28%	11 ± 14%	34 ± 35%	8 ± 14%	3 ± 10%	7 ± 19%
Animal Care	44 ± 27%	4 ± 6%	27 ± 30%	19 ± 27%	2 ± 8%	4 ± 14%
High Performance Computing	23 ± 26%	2 ± 7%	43 ± 33%	11 ± 23%	8 ± 18%	12 ± 20%
Marine and/or Aquatic	37 ± 25%	2 ± 5%	38 ± 38%	9 ± 20%	4 ± 10%	11 ± 25%
Agricultural and/or Field-Based	37 ± 27%	3 ± 4%	40 ± 27%	6 ± 14%	1 ± 3%	13 ± 20%
<b><i>Aspiration Financial Contribution by Core Facilities</i></b>						
Microscopy and/or Imaging	49 ± 22%	14 ± 15%	16 ± 21%	12 ± 20%	2 ± 7%	8 ± 14%
Microanalytic Chem and/or Molecular	50 ± 20%	16 ± 13%	14 ± 16%	11 ± 17%	2 ± 7%	7 ± 12%
Fabrication and/or Microfabrication	47 ± 21%	20 ± 18%	16 ± 22%	7 ± 10%	1 ± 4%	8 ± 14%
Animal Care	52 ± 24%	9 ± 11%	18 ± 22%	14 ± 17%	1 ± 7%	7 ± 14%
High Performance Computing	35 ± 28%	9 ± 13%	33 ± 32%	9 ± 15%	2 ± 7%	12 ± 19%
Marine and/or Aquatic	47 ± 28%	15 ± 13%	17 ± 22%	4 ± 11%	2 ± 5%	17 ± 27%
Agricultural and/or Field-Based	42 ± 23%	13 ± 14%	26 ± 25%	10 ± 16%	2 ± 4%	11 ± 18%



CROs reported seeking more financial contribution from both internal and external use fees, and less from general fund allocations for all of the “common” core facilities. The goal to shift away from general fund support appears to be most dramatic for marine/aquatic (aspirational reduction of ~21%) and fabrication/microfabrication (aspirational reduction of ~18%). Finally, aspirational contributions from “internal grant programs” was minimal ( $\leq 2\%$ ) for all of the “common” cores.

CROs were also asked “*To what extent do you feel your core facilities are provided with adequate resources for their given mission and responsibilities?*” Ten respondents (21%) indicated resources were “inadequate”, 25 (53%) indicated resources were “*somewhat inadequate*”, 12 (26%) indicated resources were “*adequate*”, and none indicated resources were “*somewhat plentiful*” or “*plentiful*”. When asked how their core facility directors or supervisors would answer that same question, there was general recognition by the CROs that perceptions were likely more negative among their directors/supervisors. Specifically, in predicting what their directors/supervisors would say, 22 respondents (48%) chose “*inadequate*”, 21 (46%) chose “*somewhat inadequate*”, three (7%) chose “*adequate*”, and none chose “*somewhat plentiful*” or “*plentiful*”.

#### *Perceived Effectiveness of Core Facilities Directors*

Figure 3 depicts CRO perceived effectiveness of core facilities directors based upon four common employee classifications, including professional staff, administrators (e.g., associate VPRs, institute/center directors, etc.), non-tenure/tenure-track research faculty (NTTF), and tenure/tenure-track faculty (TTF) . A one-way ANOVA examining perceived effectiveness ratings significantly differed across groups ( $F(3,179) = 6.88$ ,  $MSE = 2.64$ ,  $p < .001$ ). Tukeys HSD revealed that TTF were rated as significantly less effective at directing/supervising core facilities than administrators and professional staff ( $p < .005$ ). No other group comparisons were significant.

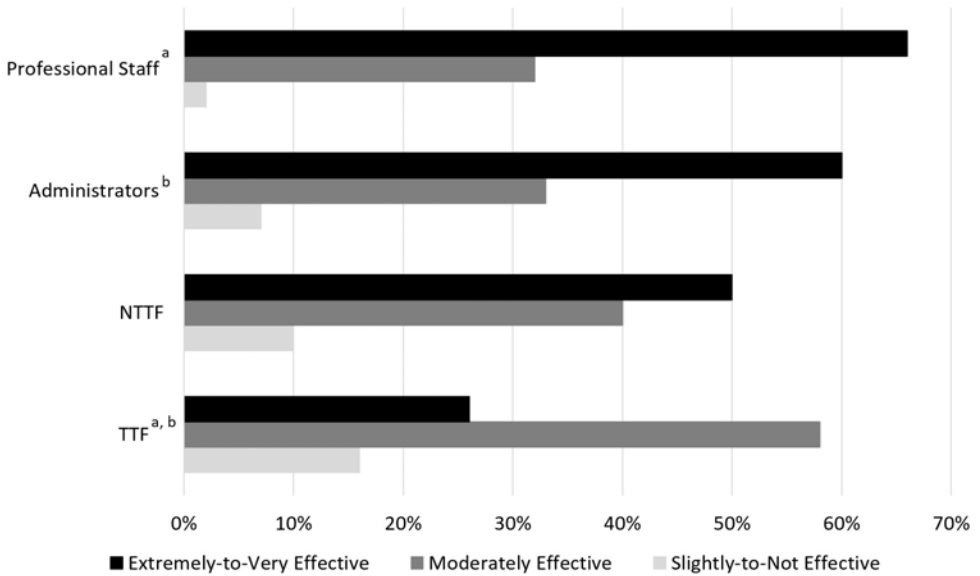


Figure 3. Perceived effectiveness of core facilities directors by job classification. Administrators included associate VPR/VCR, institute/center directors, etc; NTTF, nontenure/tenure-track faculty; TTF, tenure/tenure-track faculty. <sup>a,b</sup>Groups sharing superscripts differed in effectiveness ratings at  $p < 0.05$ .

CROs were next provided an opportunity to list “2-3 key characteristics of effective/highly effective core facilities directors/supervisors.” Figure 4 shows a Word Cloud from the compiled responses, where frequency of response correlates with font size. CROs emphasized the importance of characteristics such as “collaborative”, “expertise”, “skills”, “business”, “management”, “ability”, “service”, “technical”, and “professional”.





## Discussion

The present study is the first to survey CROs on their current and aspirational structure for the creation and management of core facilities. Several key findings emerged from the study. The results emphasize the varying roles of CROs in approving, evaluating, and renewing core facilities including preferred investments (e.g., new equipment). It also provides a comparison of current versus aspirational fiscal management of core facilities, including a breakdown by common core facility categories. One of the most intriguing findings is the perceived effectiveness of core facility directors based upon employee classification with TTF deemed less effective core facility leaders. The characteristics that CROs deemed the key characteristics of effective core facilities directors were identified, as were the criteria by which CROs judged the success of a core facility. These findings are intended to provide a reasonable, yet limited, window of insight into how CROs are attempting to support and fund core research facilities. More importantly, we hope they provide CROs, core facilities directors, and users some potential data for comparison and benchmarking aimed at improving the structure and functionality of their core facilities.

There is a perception among universities that CROs are increasingly involved (or should be involved) in overseeing and allocating resources to core facilities, and this assumption appears supported by the present data. Specifically, the reporting structure, application process, and evaluation/renewal process of core facilities was most often associated with the CRO. Other key units involved in oversight, application process, and evaluation/renewal process were the colleges/schools, centers/institutes, and departments. Indeed, both the quantitative and qualitative data support that this is often a hybrid structure, with multiple units involved in the coordination and oversight of core facilities. To this point, one institution indicated their process required University Senate approval to be a designated core facility. Nevertheless, the data from the current study support that the CRO office appears to be the key unit overseeing core facilities, with input and assistance from other academic units.

Core facilities are expensive. They often require state-of-the-art equipment and facilities, as well as highly-trained personnel to run and maintain federally compliant facilities (Farber & Weiss, 2011; Chang et al., 2015). Moreover, the coordination of multiple users across a variety of units that often span an entire university (and even across institutions) adds a layer of complexity that can require centralized and/or decentralized business/fiscal managers (Hockberger et al., 2018). Given both federal mandates and the costs of maintaining high quality core facilities, we surveyed the CROs with a variety of fiscal questions related to their general operating budget, their core facilities costs (actual vs. aspirational), and their priorities for investments in core facilities.

Given that the majority of respondents were from public universities, in which resources can be scarce, it is perhaps not surprising that nearly 75% of the respondents indicated that resources for core facilities were either “*inadequate*” or “*slightly inadequate*.” The CROs were aware that their perception was more optimistic than they anticipated from core directors suggesting that a more centralized allocation of resources might impose budgetary constraints on those cores even with increased resources.

Prior studies have suggested that funding of core facilities is complex and met through a variety

of resources (Farber & Weiss, 2011; Chang et al., 2015; Hockberger et al., 2018). The present study advances prior work in several ways. First, it provides both quantitative and qualitative data from a CRO perspective, with a variety of funding streams that included (in order of prevalence): 1) use fees, 2) central and/or decentralized funding for directors or professional staff, 3) annual general fund allocation, 4) an allocated percentage of F&A, and 5) internal grant programs. More importantly, the CROs provided actual and aspirational funding levels based upon the various funding mechanisms and the type of core facility. As shown in Table 1, the CROs were queried on seven “common” core facility categories. While all seven categories had the largest percentages of the current fiscal contributions coming from either internal use fees (mean range, 23 – 44%) or general fund allocations (mean, 27 – 43%), there were fairly limited contributions from external use fees (mean range, 2 – 11%) and internal grants (mean range, 1 – 8%). Interestingly, there was a marked and consistent shift in aspirational contributions from external use fees, with targets of doubling-to-tripling current percentages (in some cases even more). Likewise, CROs desired increased fiscal contribution through internal use fees among the seven “common” core facility categories, but this was not nearly as aggressive of a target increase as desired for external use fees. Overall, the data suggest that CROs desire to see more fiscal contributions from internal and external use fees, and a reduced reliance on general fund allocations. Nevertheless, CROs do not expect a “one-size-fits-all” approach, as there is clear heterogeneity in the expectations. For example, CROs desired ~25% from internal/external use fees for high performance computing compared to ~50% internal/external use fee contributions for micro-analytical chemistry/molecular, fabrication and/or microfabrication, and animal care facilities. Also, the high standard deviations within Table 1 suggest large variances in actual and aspirational goals of institutions.

While potentially contentious, the findings related to perceived effectiveness of the directors are novel and may be helpful. Figure 3 shows a clear difference between core facility directors that were TTF when compared to other employment classifications (i.e., professional staff, administrators, and NTTTF). Specifically, ≥50% of CROs indicated that professional staff, administrators and NTTTF were “*extremely-to-very effective*” as core facility directors. In contrast, only 26% of CROs deemed TTF as “*extremely-to-very effective*” as core facility directors. Some of the qualitative responses suggest that while not universal, TTF can be conflicted between core facilities management and their own research/scholarship. Moreover, CROs acknowledged that a “*service*” mindset, coupled with “*business*” savvy are key characteristics of effective/highly effective core facilities directors. This does not mean that TTF should not serve as core facility directors. Rather, what it suggests is that different strategies, training, on-boarding, and/or support mechanisms might be needed when considering TTF for core facilities directorships. As detailed in Hockberger et al. (2018), there are various combinations of centralized and decentralized support that should be considered for any core facility (whether it is directed by a TTF or one of the other categories represented in Figure 3).

Most core facilities obtain equipment from companies that offer service contracts. In some cases, service contracts are very expensive, but necessary due to the expense of the equipment and/or the technical skills required to maintain it. Service contracts were strongly “*preferred*” with microscopy/imaging and micro-analytical chemistry/molecular core facilities. Indeed, only

three respondents (7%) indicated they preferred on-campus service options for their microscopy/imaging facilities. In contrast, ~50% of CROs indicated a preference for on-campus service options for fabrication/microfabrication, animal care, and agricultural/field-based core facilities. These findings again highlight that there does not appear to be a one-size-fits-all approach to maintaining and servicing equipment.

Finally, CROs were surveyed on how they deal with new equipment purchases, and how they would prefer to invest in core facilities if they had designated and/or new resources specific for core facilities. Perhaps not surprising, the top two priorities were “*maintaining/repairing/replacing equipment*” and “*new equipment*.” Regarding the purchase of new equipment, CROs acknowledged that external grants (e.g., NSF Major Research Instrumentation grant), central institutional funds, and unit-level funds (i.e., college/school/departments) were primary resources. Additionally, ~50% of CROs indicated F&A and use fees as sources for new equipment purchases. Surprisingly, only 27% indicated fundraising donations as a source. Given the high expectations at universities to develop, grow, and sustain institutional endowments, CROs might consider strategies for having their core facilities prioritized within institutional fundraising/endowment efforts.

Several of the funding and usage metrics reported in this study are notably variable. This is likely due, in part, to the varying institutional missions. Each CRO is tasked with navigating under various fiscal, political, and governance structures that likely impact support levels for a given core facility. For example, universities with strong engineering programs likely have a longer history (and perhaps more funding) for fabrication facilities than universities focused more heavily on molecular genetics. That said, the results of this survey suggest tremendous heterogeneity in how CROs are supporting core facilities, and should offer hope to those struggling to support areas of targeted growth. We interpret the notable variance as an opportunity to exchange ideas, and to creatively address the local circumstances and priorities at a given institution.

There are several limitations to the present study. First, the limited sample size (n=58) prevented sub-analyses based on institutional profiles (i.e., Carnegie classification, institutional size, etc.). We acknowledge there are likely very different strategies that might be needed for institutions with NSF HERD expenditures in the hundreds of millions or above when compared to an emerging research university at \$50-100 million in expenditures (National Science Foundation, 2017). Nevertheless, we were pleased to have a wide, representative sample of institutions with a respectable 35% response rate. This response rate is admirable when one considers the effort it took to gather the fiscal information and complete the 30-40 minute survey, and we believe it demonstrates the growing interest of CROs in better identifying effective practices for core facilities management and sustainability. Second, this survey was the result of a partnership with APLU. It is not surprising therefore that the majority of respondents were from public universities. Future studies would benefit from greater representation from private research universities. Third, we condensed the “common” core facilities into seven arbitrary categories. The research team debated the pros and cons of more categories to increase granularity versus a longer survey that may reduce response rate. This debate extended beyond the authors, as we sought opinions of several CROs, as well as the APLU CoR Executive Committee.

In summary, the present study represents the first comprehensive survey on core facilities that focused on the perspectives of CROs. Such insight is important and timely given the complex and consistently evolving role of the CRO at research institutions of higher education (Droegemeier et al., 2017). The results suggest that the role of CROs in core facility creation, funding, and management is expanding, making this study both timely and relevant. A higher-level coordination of core research facilities is becoming necessary to improve research productivity, efficiency, and global competitiveness. The findings of this study are intended to help not only CROs, but also core facilities directors and researchers, to identify innovative solutions for supporting and funding core research facilities.

### **Authors' Note**

The authors wish to acknowledge Sarah Rovito (Association of Public and Land-Grant Universities; APLU) for her assistance with the administration of the survey. We also wish to acknowledge the following individuals for their input and feedback during the development of the survey content: Robert Nobles (University of Tennessee), Faith Hawkins (Indiana University), Kevin Gardner (University of New Hampshire), David Reed (Michigan Technological University), Mark McLellen (Portland State University), Janet Nelson (University of Idaho), Mridul Guatam (University of Nevada, Reno), and the APLU Council on Research (CoR) Executive Committee. Finally, the authors wish to thank the Chief Research Officer (or designee) from the 58 institutions that responded to this survey.

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