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Collaborations Beyond the Library: Bibliometric Analyses to Support Engineering Research, Innovation, and Diversity

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As Director for Research Impact & Intelligence, I collaborate with campus stakeholders to translate information to insights. We utilize bibliometric, impact, institutional, funding, and industry data from sources such as Scival, Scopus, Web of Science, Mergent, NSF HERD, IPEDs, Funding Institutional and employ a variety of visualization tools such as Tableau and VosViewer to help identify research competencies, to understand collaboration networks and potential partnerships, and to demonstrate impact.

Collaborations Beyond the Library: Bibliometric Analyses to Support Engineering Research, Innovation and Diversity

Abstract:

A new library department was formed to focus on growing university research impact and delivering data-driven research intelligence. The department collaborates with multiple units across campus, including with the College of Engineering via the department's Engineering Collections and Research Analyst. All collaborations stem from the need for data-driven decisions for determining inter- and intra-institutional strengths and for discovering potential and existing research partnerships. This paper focuses on key collaborations with campus partners relevant to engineering research, innovation, and diversity efforts at Virginia Tech, providing processes and examples in each area. Examples include: an analysis of institutional degree data to determine competency related to the CHIPS and Science Act; prospective aerospace company collaborations; and research alignment analysis with HBCUs and other minority serving institutions. Each example covers tools, alternatives, and processes used to generate these analyses with end products presented to collaborators. Overall, the collaborations have been successful and are growing, which prompted the need for a new department, with wide support within the library and across campus.

Keywords: Bibliometrics, Innovation, Academia-Industry Partnerships, Minority Serving Institutions, Cross-Campus Collaborations

1. Introduction

In late 2022, the University Libraries at Virginia Tech developed a new department, Research Impact & Intelligence (RII), to help all stakeholders understand and grow its global impact and reputation. Like most institutions, Virginia Tech increasingly needs data-driven reports to be more effective and competitive. The department's main priorities center on developing bibliometrics and altmetrics based impact reports for individuals and departments, curating the scholarly record via the Virginia Tech's Research Information Management System, and enhancing reputational support through scholarly profiles. Additionally, the team delivers data-driven competitive research intelligence reports aimed at understanding internal and external research strengths and identifying potential academic, corporate, and government partners. For this purpose, the department employs a variety of tools including bibliometrics, funding and patents databases, institutional benchmarking tools, and technology market reports.

The department's beginnings started with a collaboration between the Strategic Research Librarian and the Innovation & Partnerships office (the business development and tech transfer office). Also in parallel with strategic research, the Research Impact Librarian was working with various colleges and individuals on campus, including the Office of Research, which often overlapped or was complementary with the Strategic Librarian's work. Because Innovation & Partnerships reported to both the Office of Advancement and the Office of Research, new connections developed and demand for work blossomed. Much of the work revolved around engineering departments, but also included other STEM related institutes and departments. It became clear through campus interactions, tech and industry conferences, and demand for such analysis that stakeholders across campus are hungry for data-driven expertise.

Virginia Tech is an R1 (Carnegie Classification-Very High Research Activity), land grant institution with a large engineering program and has maintained a dedicated engineering subject librarian position for more than two decades. When the previous engineering librarian retired two years ago, administrators decided to reimagine the position to incorporate engineering research intelligence work into the liaison role and rename the title to reflect the engineering analyst role. This new liaison role allows the Engineering Collections & Research Analyst to spend time directly interfacing with departments to complete analysis and assessments, enhancing liaison relationships, and using subject-specific knowledge to support RII.

To meet demands, strengthen human resources, and leverage skill sets the Research Impact & Intelligence department was formed and the Provost's Office is funding an additional position for the team. RII collaborates with principal investigators and delivers competitive intelligence reports on several grant proposals, and has already collaborated across many campus units as can be seen in **Figure 1**. The Research Impact & Intelligence department represents a relatively new type of department for academic libraries and presents opportunities for librarians to actively participate in research support via analytical roles and capitalize on long-standing skills like database searching and bibliometric analysis.

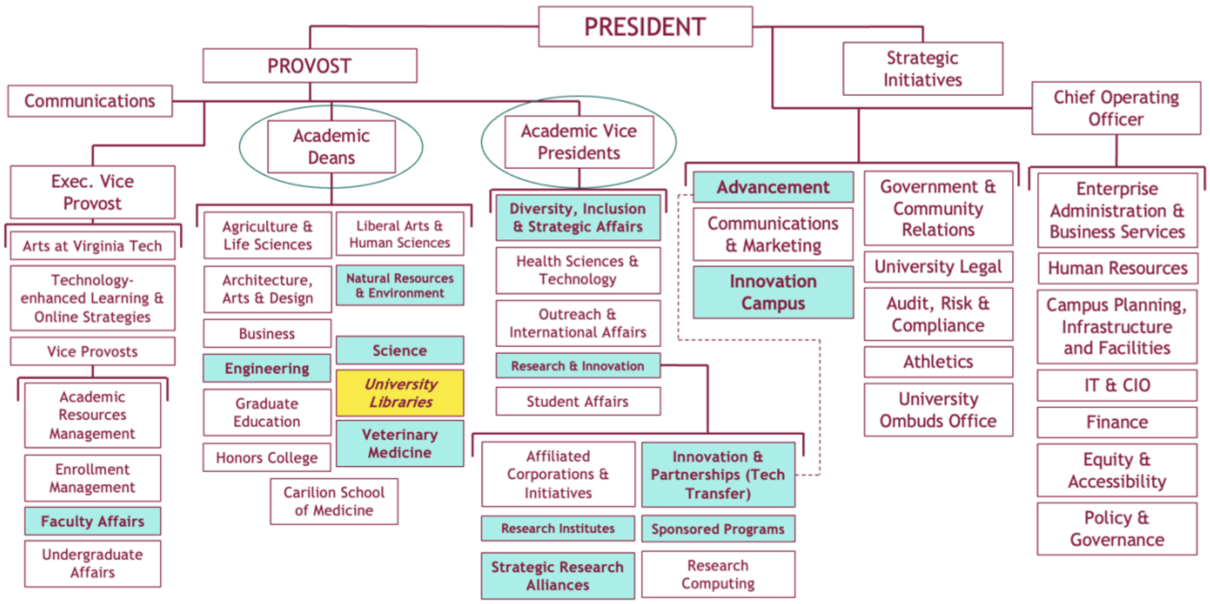

Figure 1: Institutional organization chart highlighting (teal) collaborations as of January 2023, primarily with those in the Office of the Provost.

2. Literature Review

While this review does not aim to be comprehensive, it does aim to provide a high-level overview representative of recent trends in academic library roles in relation to supporting research. Specifically, this is focused on supporting research through research intelligence services that employ: bibliometrics, federal funding benchmarking, proprietary and free database searching, synthesis and analysis around research topics to aid in strategic decision making, and impact services and reputational management.

In its 2020 report, ACRL Research Planning and Review Committee summarized that major trends include: learning analytics, the influence of machine learning and artificial intelligence on technology, the impact of big deals cancellations on open access and transformative publisher agreements, research data maturation and the ethical need to incorporate the GO FAIR Initiative, social justice roles including critical librarianship and critical pedagogy, incorporating increased use and licensing of streaming media, and finally, library space as a place for supporting student well-being [1]. Earlier in a 2017 environmental scan by the same team, the concept of "research evaluation" was discussed as the topic continues to develop rapidly. However, the authors did not articulate any opportunities around research intelligence as a data-driven service; rather, the focus rested on opportunities around advising and educating others to view research metrics more comprehensively rather than on a narrow set of metrics. No mention was made of actively participating in a service to aid in strategic decision making, nor building teams around such services [2]. On the other hand, a more recent report from the often-consulted Ithaka S+R team state in "It's Not What Libraries Hold; It's Who Libraries Serve," that academic libraries must “center on the user” and “must be completely re-architected to provide modern *business intelligence capabilities* for individual libraries as well as their consortia” (emphasis added) [3]. Later, in a 2021 environment scan by ACRL, the report fleshed out new and growing opportunities in research support services [4]. They explain that many researchers have less time for administrative tasks, data management, but a growing appreciation for open access. The authors make the case for enhanced research data services including assisting with finding funding, research data management, research information management, impact reporting including societal impact indicators, supporting open access and open science, and providing research analytics [4]. In a similar vein, a recent Ithaka S+R faculty survey found that “the majority of faculty are not receiving any support throughout their publication process from their college or university library, scholarly society, university press, or other service provider” [5].

While a good deal of recent research points to research support as an area of importance for academic research libraries, significant attention is paid to the role of data management and data scientists. In 2019, Koltay called for supporting Research 2.0 via research data management, further stating RDM services are “becoming increasingly important” and that academic libraries must “recognize that they are part of a suite of services that meets (faculty) needs” [6]. However, no mention of research intelligence or impact is included. Yet, others believe impact services present an additional area of opportunity to support research. Like many opinion pieces before it, Tavernier and Jamieson of Indiana University say in their 2022 article that the value add for research impact services does “help faculty see the full significance of their work, equip them with tools to demonstrate and advocate for the value of their scholarship, and often provide unexpected insights” [7]. Further, a 2020 ARL Library Impact Practice Brief outlines in great detail why impact services and services including bibliometrics and competitive intelligence add value to academic research libraries and their respective institutions [8].

Finally, the OCLC Research Library Partners webinar series has been an important source for discovering North American academic library teams engaged in work at the intersection of research data management, impact services, and competitive intelligence. The webinar series has introduced such initiatives at Syracuse University, University of Pennsylvania, University of Waterloo, Carnegie Mellon University, Rutgers University, University of Illinois, Virginia Tech, and the University of California at Los Angeles [9]. Peer-reviewed articles published in the last five years reveal a small, but growing number of teams offering similar services, although most exist outside of North America [10]–[14].

3. Collaborations Project Requests - Process Overview

Our Research Impact & Intelligence (RII) department fields numerous requests per year from academic departments/colleges, the Office of Research, and Innovation & Partnerships (the tech transfer and business development office). Depending on the request, RII uses a variety of tools and data sources including academic databases, research analytics tools, specialized software, federal funding data sources, and market research reports. RII's projects range from quick data pulls to long-term involvement on NSF grants, but the key for any request is to thoroughly understand what the needs of the collaborator(s) are, and timeline for the resulting project. Depending on the request, RII may meet with the campus partner directly (most common), or for existing relationships and quick projects, email or other asynchronous communications may suffice.

Once the project's scope and deliverables are decided, RII picks the most optimal tools available to complete the work. As RII is part of an R1 institution, adequate funding exists for specialized assessment tools and data sources such as subscriptions for Tableau, Dimensions, and SciVal. However, RII also employs a variety of free or less expensive options including VOSViewer, ASEE's Engineering Data Management System (EDMS), and data from NSF or NIH. A full list of RII's current tools and data sources used can be found in **Table 1**.

Table 1: Tools and databases regularly used by RII for projects as of January 2023.

NAME	USAGE	FREE?	WEBSITE
FUNDING INSTITUTIONAL	Funding Data	No	fundinginstitutional.com
SCIVAL	Bibliographic Data	No	scival.com
SCOPUS	Bibliographic Data	No	scopus.com
WEB OF SCIENCE	Bibliographic Data	No	webofscience.com
SUBJECT DATABASES	Bibliographic Data	Some	(multiple)
DIMENSIONS	Bibliographic Data	Yes, basic	dimensions.ai
ALTMETRIC EXPLORER	Bibliographic Data	Yes, basic	altmetric.com
USASPENDING.GOV	Funding Data	Yes	usaspending.gov
NSF NCSES	Institutional & Funding Data	Yes	ncses.nsf.gov
NIH REPORT	Institutional & Funding Data	Yes	report.nih.gov
NCES IPEDS	Institutional Data	Yes	nces.ed.gov/ipeds
ASEE EDMS	Institutional Data	Yes	survey.asee.org
ACADEMIC ANALYTICS	Institutional Data	No	academicanalytics.com
TABLEAU	Data Visualization	No*	tableau.com
VOSVIEWER	Data Visualization	Yes	vosviewer.com

*Some options available for lower cost depending on organization

The examples provided in this publication highlight collaboration projects that have involved engineering areas, an area which the Engineering Collections & Research Analyst at Virginia Tech has fielded since July of 2022. Each project started with a faculty and/or staff member reaching out to RII for support with their ongoing work. After an initial meeting to decide project scope and feasibility, databases and tools were selected to complete the work. For more involved projects, there were also mid-project check-ins before delivery of work. At the conclusion of a project, the work was presented to the requestor to thoroughly explain the research intelligence being provided, and to provide access to any dashboards, slides, or other outputs developed during the project.

4. Collaboration Requests

A. Blue Origin: Company Quick Survey

This request for collaboration began with the Innovation & Partnerships office reaching out to RII in order to determine how our institution could become more involved with Blue Origin - essentially answering the question: where might our research align with Blue Origin? The Innovation & Partnerships office only needed a basic overview, but needed it quickly (within a week) to align with campus visit schedules.

Blue Origin as a company was considered a priority connection given its reputation as one of the top companies for spacecraft development, specifically known for their human spaceflight missions in recent years. As Virginia Tech has an aerospace department (Kevin T. Crofton Department of Aerospace and Ocean Engineering) with a growing space area, connecting with Blue Origin would prove highly beneficial for that department and any technology developed would reflect on the university at large.

Initially, the search for research alignment began with the engineering librarian checking SciVal and Scopus for Blue Origin as a research entity to determine if it existed in the database; if so, this would provide most publications associated with their company. Unfortunately, this did not exist (and still does not as of early April 2023), so more options were needed. Next, Scopus and Web of Science were searched for “blue origin” in their default search options (title, abstract keywords for Scopus and all fields in Web of Science). In October 2022 this yielded 112 results in Scopus and 89 in Web of Science, which were lower than expected considering Blue Origin as a company is not new at over 20 years old.

Next, the engineering librarian turned to disciplinary databases – the American Institute of Aeronautics and Astronautics’ Aerospace Research Central (AIAA ARC) and NASA’s Technical Report Server (NTRS). These databases yielded considerably more results than Web of Science at 297 for AIAA ARC and 270 for NTRS (October 2022), which is likely due to the inclusion of the ability to search full text in both of these databases. Specifically, AIAA ARC searches full text, titles/subtitles, abstracts, authors, ISSN, ISBN and DOI, while NTRS searches title, abstract, author and full text. There were also options in both of these disciplinary databases to select Blue Origin as an affiliation through the advanced search or filtering options, although in AIAA ARC this reduced the results drastically and NTRS had multiple "Blue Origin" affiliations listed. As these two disciplinary databases can search full text, they were considered to provide more possible keywords to use in this request, especially as they use more specific technical terms for space exploration.

Next, topic listings from both AIAA ARC and NTRS (keyword filters), Blue Origin's website, and relevant aerospace department research pages were identified and documented (**Table 2**). AIAA ARC and NTRS both had longer keyword/topic lists than what was used in this project as not all keywords were only relevant to developing spaceflight vehicles (such as NTRS's "Engineering (General)" that was the fifth top area not included in the table).

Table 2: Identified topics/keywords by source to develop a new SciVal Research Area.

Aerospace Department	**Blue Origin**	**AIAA ARC (43 or more publications)**	**NTRS (top 4 areas by number of publications)**
Space Situational Awareness	Reusable rockets	Space Science and Technology (137)	Lunar and Planetary Science and Exploration (48)
Space Mission Modeling & Simulation	Human spaceflight	Planetary Science and Exploration (97)	Spacecraft Design, Testing and Performance (31)
Proximity Operations	Systems	Space Agencies (84)	Spacecraft Propulsion and Power (23)
Spacecraft dynamics and control	Flight Sciences	Space Exploration and Technology (81)	Space Transportation and Safety (21)
Spacecraft advanced propulsion techniques	Propulsion	Space Missions (81)	
	Mechanical Engineering	NASA (70)	
	Manufacturing	Human Spaceflight (64)	
	Software Development	Space Systems and Vehicles (64)	
	Materials & Processes	Rocketry (62)	
	Avionics	Space Systems (58)	
	Quality Assurance	Spacecrafts (56)	
	Test	Rocket Engine (55)	
	Technical Design	Space Launch System (55)	
	Machining and Fabrication	Aeronautics (50)	
	Analysis	NASA Programs (49)	
	Data Science	Launch Vehicles (47)	
	Mission & Flight Operations	Satellites (44)	
		Combustion Chambers (43)	

These topics were then used to help build a relevant research area in SciVal from "topic clusters," which are a collection of related publications (such as Explosives, Propellants, Detonation - i.e. includes rocket engines and propulsion, see full list below in **Table 3**). Although this was a quick first pass, this created research area could then be used to see who at our institution is publishing in areas relevant to Blue Origin.

Table 3: SciVal Research Area Topic Clusters selected to generate institution publication list.

SciVal Topic Cluster	ID #
Explosives; Propellants; Detonation	TC.464
Orbits; Spacecraft; Satellites	TC.493
Human Engineering; Ergonomics; Automation	TC.588
Systems Engineering; Design; Models	TC.631
Optimization; Uncertainty Analysis; Reliability Analysis	TC.683
Global Positioning System; Satellites; Navigation	TC.712
Hypersonic Aerodynamics; Hypersonic Flow; Reentry	TC.854
Weightlessness; Space Flight; Manned Space Flight	TC.935
Space; International Cooperation; Space Research	TC.1303

Provided outputs to the Innovation & Partnerships office included a list of publications and the top two authors from our institution in the developed research area. The Innovation & Partnerships office then could use these names and publications to prioritize who should meet with Blue Origin to accelerate the collaboration.

Later after the conclusion of this request, further investigation of Scopus for specific searches like this company request was conducted. Broadening the search in Scopus to all fields does yield more results (more than 400 as of April 2023), however it did also include some (less than 20) irrelevant results related COVID-19 or policing. In addition, by checking specific field searches, these increased results seem to be primarily from reference searching (over 300). Affiliation and funding information do also yield some results (68 and 34 respectively), which could be included with the title, abstract, keyword standard search in the future for specific searches such as this one instead of the all fields option.

Alternatives for Similar Company Assessments

For a company like Blue Origin that has a narrow focus, disciplinary databases can provide excellent results comparable with interdisciplinary databases that can be too expensive for some institutions (including Scopus and Web of Science). NTRS is completely free, while AIAA ARC, like IEEE Xplore is available to view citations and abstracts, but not articles (unless they are open access). An alternative to identify publications for one's institution is to follow a similar process (key word identification) to build up the topic into a longer search string for any database of choice, either using a filter or included analytics tools.

Once there is a list of results, these can be analyzed in the free tool VOSViewer or another process of choice depending on the available tools at an institution. VOSViewer has a number of different visualizations available with multiple options to save and share static and non-static versions. The example below in **Figure 2** is for an author collaboration network generated in VOSViewer, which can be useful in identifying top authors who might serve as an optimal connection when communicating with a company. Especially in cases like this example to increase engagement, it is ideal to find a researcher who is well-connected and might lead work going forward.

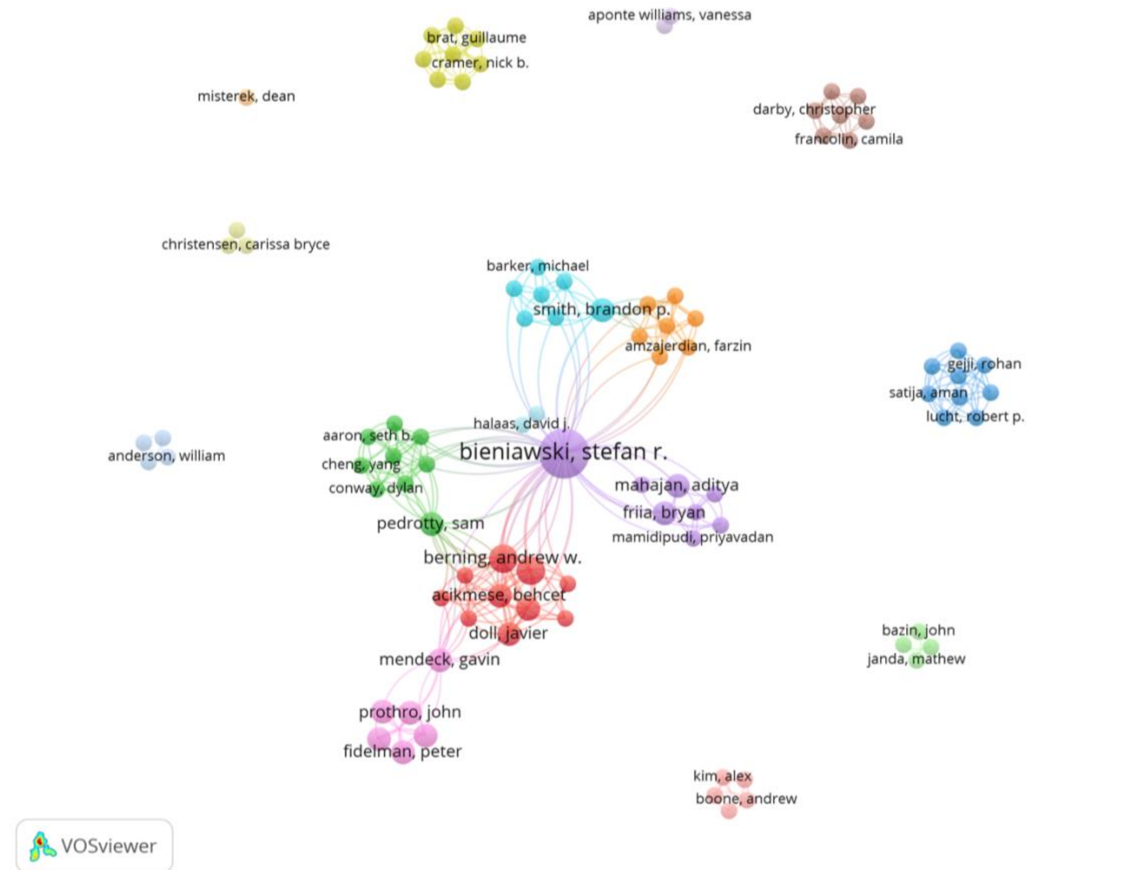

Figure 2: Citation data from AIAA ARC imported into VOSViewer to generate author collaboration visualization, showing connected authors for the publications (non-static version available here: tinyurl.com/2ady4vl2).

B. CHIPS: Graduation Numbers to Contribute State-Wide

This request also originated from the Innovation & Partnerships office with the goal of understanding how our institution might be adding to the industry for the CHIPS (Creating Helpful Incentives to Produce Semiconductors) and Science Act [15]. The requestor mentioned wanting to see data that might show why our institution is well-suited and ranked highly for contributing to the CHIPS and Science Act.

The CHIPS and Science Act which was passed last year prioritizes semiconductors and growing additional quality STEM jobs. The query came to RII as a quick request, but a detailed analysis was needed due to coming meetings with the governor of Virginia. Ideally, the Innovation & Partnerships office wished to have data visualizations that would show why our institution should be prioritized over others. Such prioritization would support broad innovation activities throughout our university via additional funding as well.

This request required longer discussions on project scope than the Blue Origin example given above in that the requestor had a variety of ideas on how to accomplish their goal, some of which were not feasible for showing competence in this area. For example, they were looking to show our institution as being ranked as a department, but did not consider that there are multiple ways to assess this (e.g. by faculty, students, grants, and more). After evaluating their ideas and offering solutions, it was decided to assess degree conferral rates for our institution compared to others, especially the Association of American Universities (AAU) institutions and our academic conference. Comparing to AAU institutions was critical to the requestor as our institution aims to become an AAU member in the next decade. Last, since there are many engineering fields that could be related to the CHIPS and Science Act, it was also decided to include all fields over the past five years, but to allow for filtering or multiple views thus allowing a user to assess individual engineering fields.

For this request, there was little searching in a standard bibliographic sense, but instead the focus centered on the relevant data to pull from the Engineering Data Management System (ASEE's EDMS) [16]. In this case, the "ASEE Degree Totals by Discipline" data was utilized to complete this request as it contains the following: institution names (by selected group - Ivy League, AAU, All US Engineering Schools, etc.), totals for all levels of degrees (bachelor's, master's, doctoral), selected years, and engineering disciplines. Once the relevant data from this EDMS was downloaded for AAU, our institution's academic alliance (ACC), and our state's engineering schools, these were ready to be used in a visualization tool of choice – Tableau.

One disadvantage to the ASEE data is that some data is missing or likely to be incorrect due to the wide deviations shown, which is seen most often in 2019 or 2020 due to the global pandemic disrupting usual reporting processes (2019 data would have been reported in 2020 for example). For instance, if university M graduates close to 1,000 students with bachelor's degrees every year except 2019, but was listed to have none in 2019, this is likely an erroneous data point. Some universities also had the opposite case where one year might have several times more graduates than other years around it. Fortunately, in Tableau these can be excluded and are documented by a filter mechanism when a user chooses to exclude a data point.

After some minor file conversions and data shaping in Excel, the data was ready for visualization in Tableau. There were multiple options that could work for this data, but as this was a quick request, a standard line chart was used along with highlighting our institution in a different color to show how many engineering graduates we produce compared to other institutions (bachelor's degrees example in **Figure 3** below).

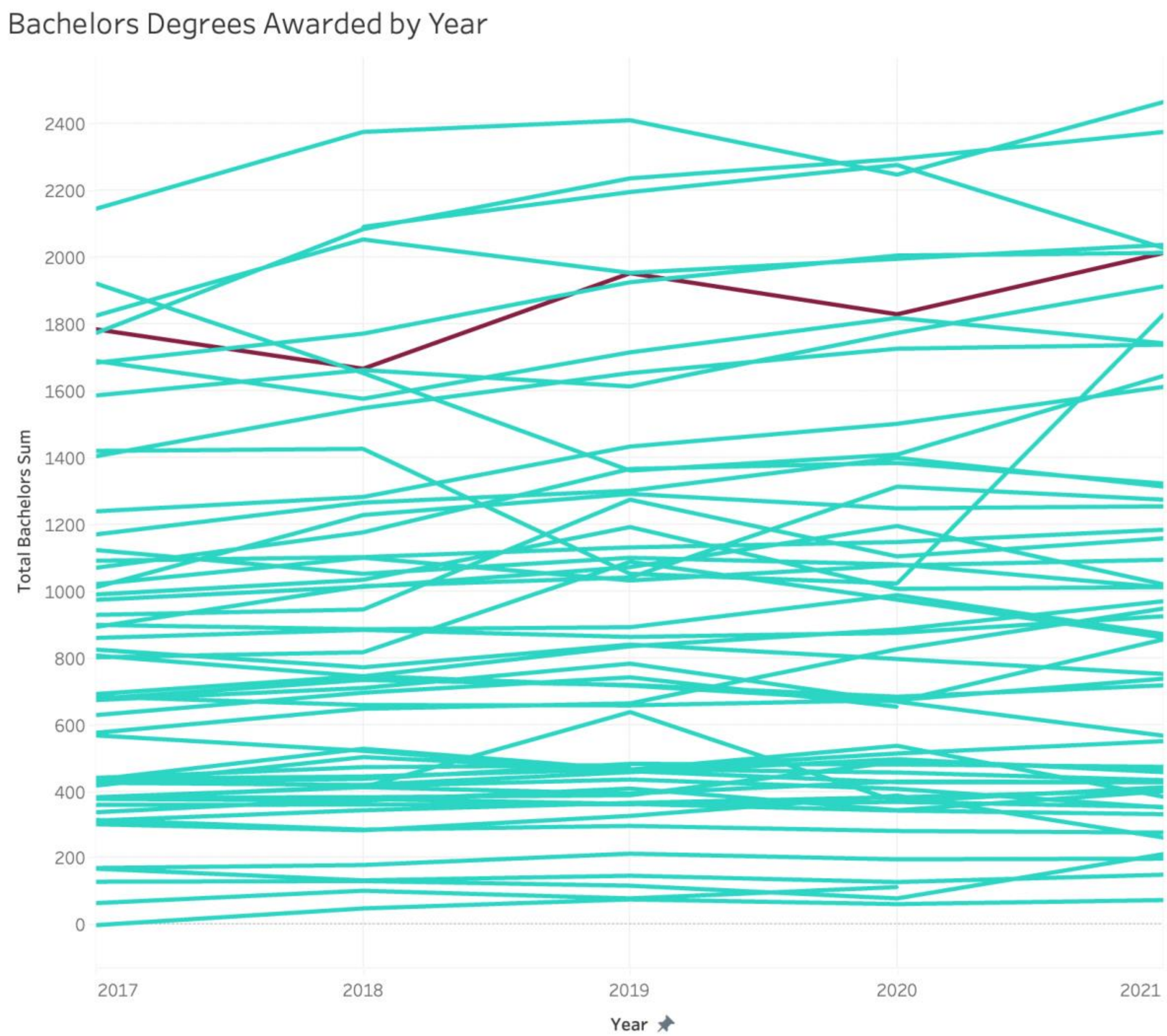

Figure 3: Screen shot from Tableau of bachelor's degrees awarded over time for AAU institutions (teal) compared to Virginia Tech (maroon).

From even a brief look at the data, it was clear that our institution was first in our state and a close second in our academic alliance for numbers of bachelor's degrees (first was Georgia Tech), but we were falling behind in the number of masters' degrees. Doctoral degrees were similar to bachelor's, but the difference was not as significant in our conference and our institution could be overtaken in future years. The data visualizations were also set up such that individual engineering fields could be compared across institutional groups, such as electrical or computer engineering, both of which are highly relevant to the CHIPS and Science Act. The original requestor found even these quick assessments to be helpful for the upcoming meeting with the governor, and requested adding all available academic conferences to enable comparison country-wide.

Although the requestor did not end up needing additional data, this work was continued to finish the project as comparing degrees countrywide could be of use to other campus partners. After adding more academic alliances, additional visualizations were added to allow comparison of these alliances overall and the number of granted degrees per institution, with options to filter by discipline or institution as shown in **Figure 4** below.

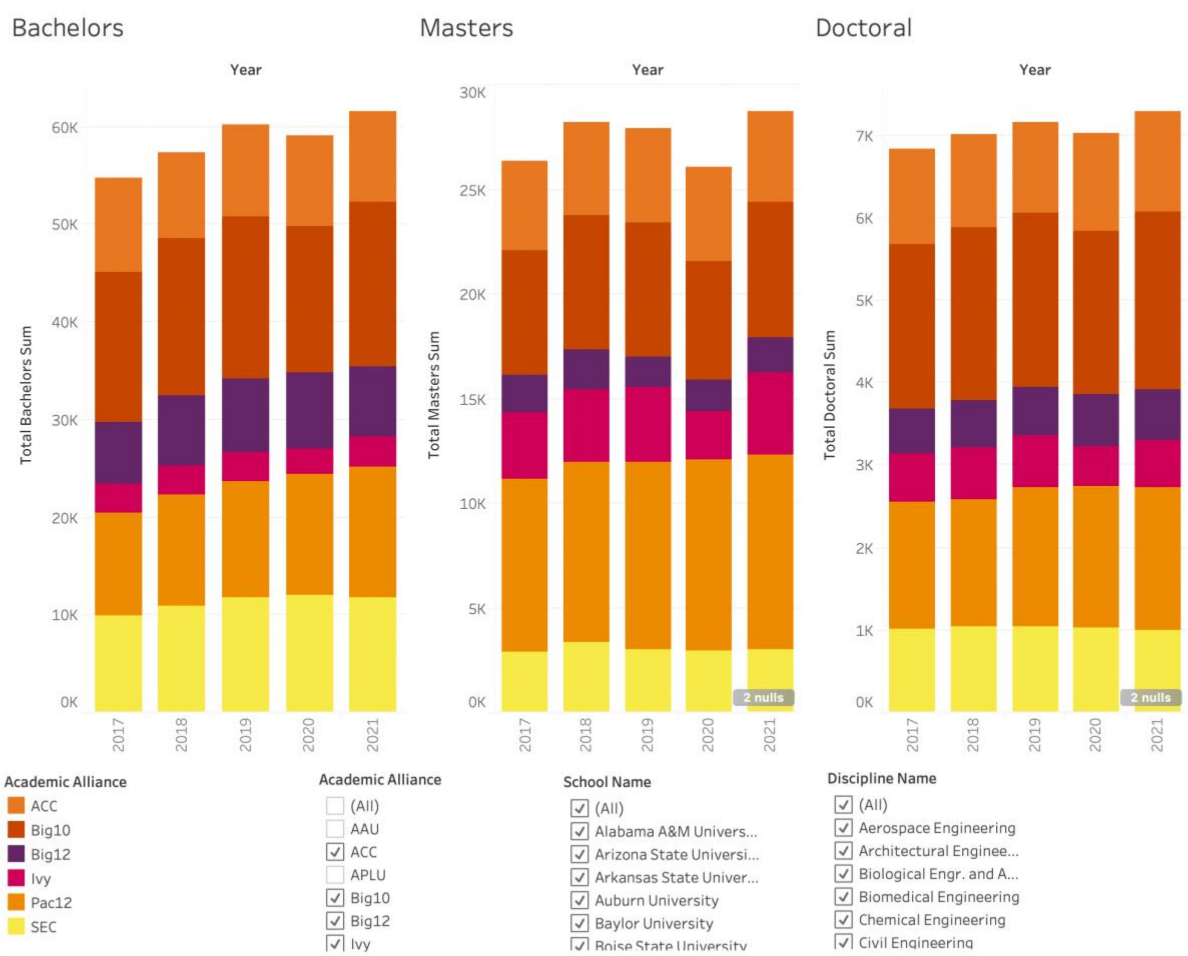

Figure 4: Degree numbers for all large academic alliances from 2017 to 2021 for bachelor's, master's, and doctoral degrees. Nulls represent missing data, which is excluded from the charts.

It is not surprising that the Big10, for instance, lead in producing engineers across disciplines, although they do not produce as many master's degree graduates as the Pac12. From our university's perspective that it is producing too few master's degrees, opportunities may exist to learn from universities in the Pac12. All of the visualizations were added to a shareable dashboard for future use. Screenshots of each dashboard slide are included in the **Appendix**.

Other options for visualization of ASEE data

For the case of this data and the needs of the Innovation & Partnerships requestor, Excel plots might be an option if an institution cannot fund Tableau. Excel's main disadvantage is that many individual graph plots would need to be developed, while Tableau allows for live interaction and filtering, thus allowing for many views of the same data. Also, different reports can be generated to view overall degree numbers for all disciplines as an aggregate or totals per discipline. A similar data visualization tool option is Microsoft's Power BI, which also allows for time savings compared to Excel, and is significantly less expensive than Tableau.

Below is an example benchmarking our institution with AAU institutions, as visualized in Excel (**Figure 5**). This does use data from "ASEE Degree Totals by Institution" (instead of "ASEE Degree Totals by Discipline" used above) that does not split by discipline. This saves time rather than manually combining them in Excel, as would be required if using the original data. More data plots could be produced for each engineering discipline or specific academic conferences, although this process would certainly take a significant amount of time to complete in Excel. As each comparison would require a different plot if not using an interactive data visualization tool, the number could quickly become unfeasible; however, the requestor could just specify which should be prioritized, reducing the number needed. Another option might be the use of R or Python for those familiar with coding in these free languages, and some code might be reusable, reducing time for each request.

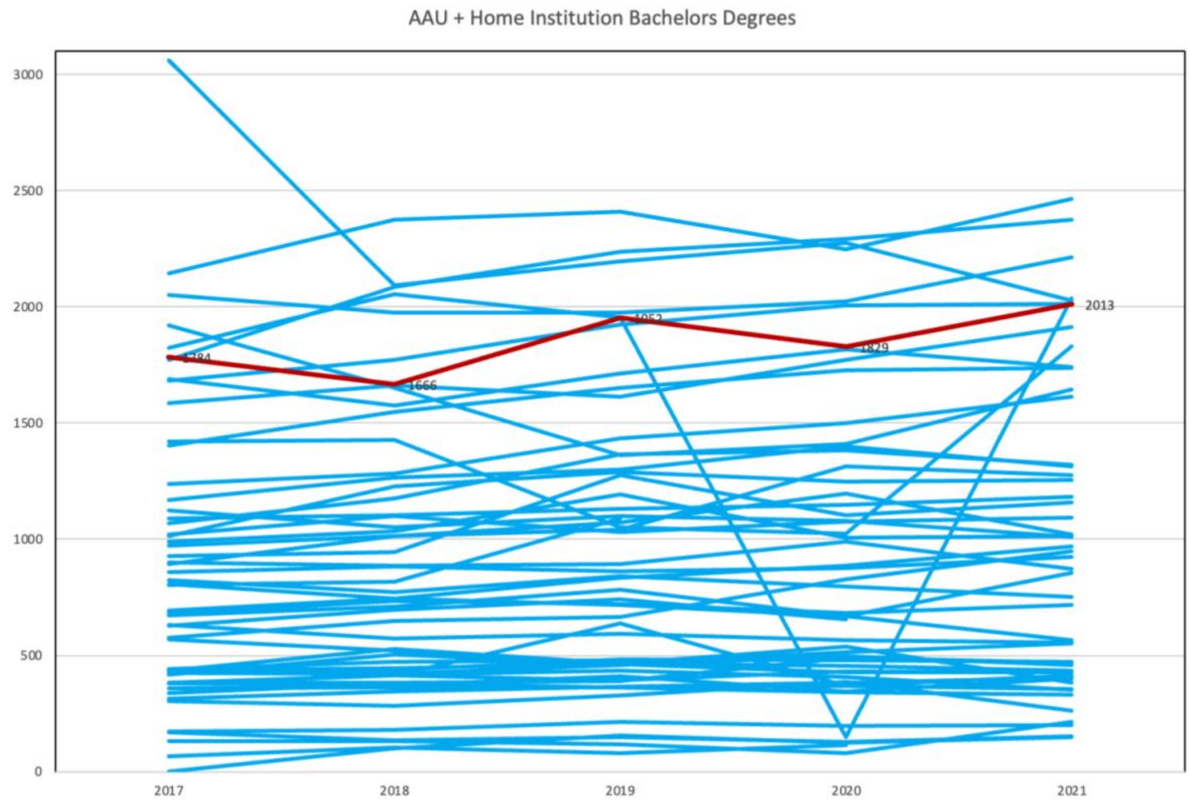

Figure 5: Replication of earlier figure showing Virginia Tech (dark red) compared to AAU institutions (blue). The data point above 3,000 in 2017 and significant depression point in 2020 are likely reporting errors that are documented and excluded in the Tableau version.

C. HBCUs: Future Collaboration Potential

Beyond benchmarking, requests often center on identifying potential partners. This request originated from an institution-wide effort to partner more often with Minority Serving Institutions (MSIs), specifically Historically Black Colleges and Universities (HBCUs). The team within the Office of Research and Innovation reached out to RII with a request to generate a set of slides to aid understanding of specific HBCUs' research strengths in engineering, computer science and physics. As the project progressed, the end goal became to develop a Tableau dashboard that researchers could use to identify possible future research partners at HBCUs.

The initial request to develop the set of slides focused on HBCUs of known interest to the requesting team: Howard University, North Carolina A&T State University, Prairie View A&M University, and Norfolk State University (all within the top 15 HBCUs by scholarly output per SciVal). Data was gathered from SciVal for these institutions to examine their top researchers, existing joint publications, and research strengths. These findings showed which engineering and computer science areas were strongest at the examined institutions. For example, North

Carolina A&T was found to have three shared research areas with our institution within both top ten lists: computer vision algorithms and models, battery technologies, and transportation models. There were also four additional areas that would be of interest to our institution that were not in our top ten, but still demonstrated partnering potential for our existing programs in civil engineering (pavements and asphalt), industrial engineering (supply chains), mechanical engineering (additive manufacturing), and electrical/computer engineering (semiconductor quantum technology). This information on shared research areas was complemented by collaboration information, showing our institution was fifth out of North Carolina A&T's top collaborating institutions with 11 joint publications since 2017. This type of data was presented to the requesters for all four institutions, which prompted them to request similar information for more institutions such as Texas Southern University. The requestors also were interested in having more interactive visualizations within a couple months that would cover all top HBCUs, especially those interested in becoming R1 institutions in the coming years.

To develop interactive visualizations in Tableau, data was gathered on research expenditures from the annual Higher Education Research and Development Survey data, (NSF HERD), and publications from SciVal. The NSF HERD data found in Tables 32 and 33 for 2021 covers all HBCUs, providing research expenditures for a specific fiscal year by fund source (federal, non-profit, state, etc.) and field (engineering, medicine, physical sciences, etc.) [17]. The publication data (2017-2022+) from SciVal included authors, research areas, and research fields, and collaborations for all HBCUs or by individual institution. Both sources (NSF HERD and SciVal) include data access and download as Excel files, which can be used directly in Tableau or with prior data shaping similar to the ASEE degree data example above.

Four visualization slides were developed in Tableau to show the strengths of a selected HBCU and their top funded areas (see the **Appendix** for screenshots), and also includes a slide detailing the dataset sources used. The first visualization slide serves as a landing page for the dashboard and provides an overview of a selected HBCU, providing their overall research field strengths, top authors and collaborations with color and size indicators to enable quick assessments by users. The collaborations also include the status of the collaboration in terms of decreasing or increasing number of publications over time. For example, as seen below in **Figure 6**, if Texas Southern is selected, the dashboard visualization shows the top collaborations with most having consistent publications per year over time, although some have increased or decreased. The second slide focuses on research expenditures, which also gives information to the user about their research strengths, since if a specific field has low research expenditures, the institution is not likely to be available for a collaboration due to few researchers in that field. The third visualization slide provides the option to see publications by field and subfield so that a user can find if an institution is strong in a particular area (such as mechanical engineering within engineering). The fourth visualization slide focuses on specific research areas, which includes an option for users to search or browse for areas of interest (i.e.

additive manufacturing). Finally, the dashboard ends with the important practice of including developer and detailed data information, such as when the data was last updated.

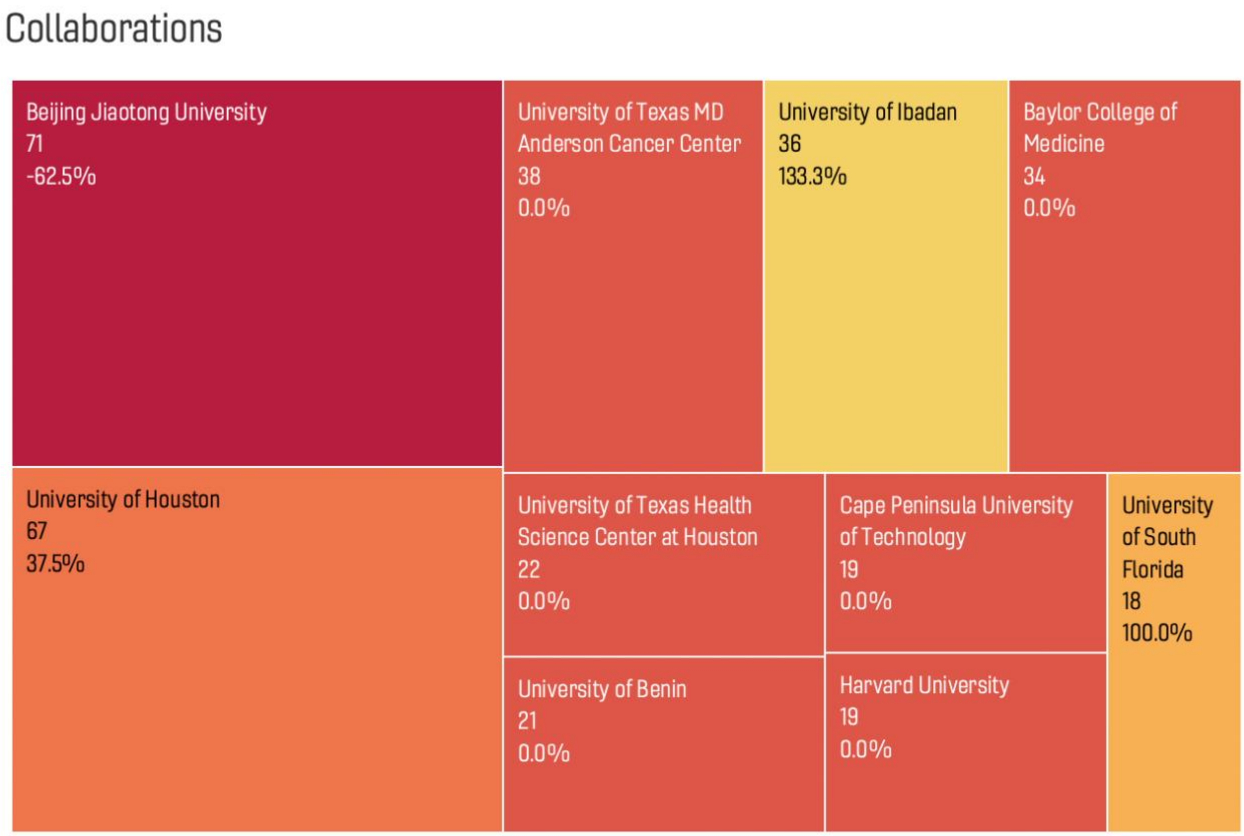

Figure 6: Screenshot of the collaborations component of the HBCU dashboard. Top ten collaborating institutions for Texas Southern University showing collaborations weakening with Beijing Jiaotong University (decreasing by over 60%) and increasing the most with the University of Ibadan (133%).

As each part of this data had more fields than the ASEE degree data and more time was available to spend on the visualizations, discussions were needed within RII to fully develop the dashboard. The data could also sometimes include all HCBUs or in other cases, it would be specific for one institution. This variety in data required a different approach for each part of the dashboard, and decisions as to which institutions should be prioritized for inclusion in the dashboard initially. This initial dashboard was then presented to the requesting team, which was highly successful, and prompted discussions as to more data to include (such as patents) and how to provide more details for researchers using the dashboard. Work on this HBCU dashboard is continuing (patents data added in April 2023), and it will likely see university-wide usage at our institution.

Alternatives for Finding HBCUs for Collaboration

Although the research expenditures data from NSF is free and always available, SciVal and Tableau both require significant funds to provide access, and possibly even more funding to train users in order to develop a dashboard. As discussed above in the ASEE degree data example, there are other options for visualization, and for publication data, Dimensions is an alternative option, even if using the free version. One possible pathway to complete this type of request is to focus on specific institutions of interest such as those located geographically nearby instead of all HBCUs. Using tools such as the COLLEGENavigator database by the National Center for Education Statistics (NCES), HBCUs in a specific state can be located [18].

For example, an institution in Texas might be seeking collaborations with an HBCU in quantum cybersecurity applications. COLLEGENavigator can provide a list of HBCUs in Texas (see **Figure 7** below), which might be narrowed to Texas Southern University due to geographic or other considerations (such as existing contacts).

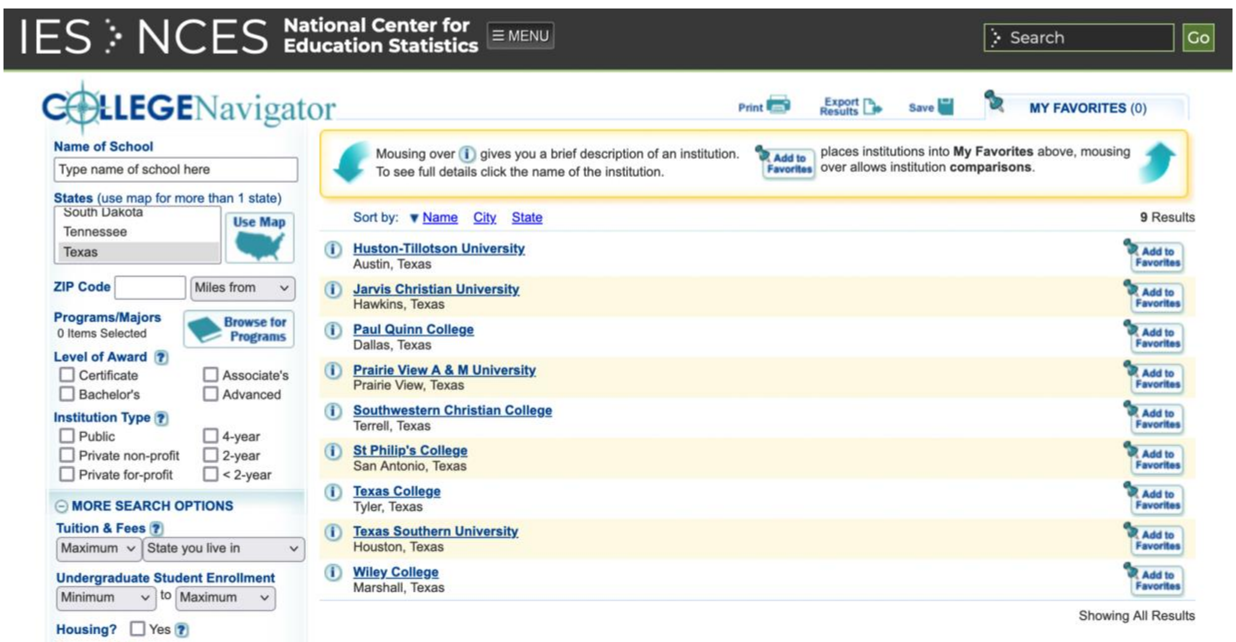

Figure 7: Screenshot of NCES page for locating colleges and universities, filtered for HBCUs and the state of Texas.

Next, Dimensions can be searched for "quantum," filter for a specific time frame (such as the past year - 2022), and use the "Research Categories" browse option to select "4604 Cybersecurity and Privacy." Up to 2,500 results can be exported to a csv file with a free account, which can be analyzed as desired, or simply searched for the relevant institution as the results do list the institutions for each publication. After searching these results, one publication is found with an affiliation at Texas Southern, which can be checked in the author list in a database (IEEE Xplore) [19]. Although this process would need to be applied one-by-one for researchers seeking this information, it could be effectively managed with a consultation-type service, and would provide initial contacts to expand institutional research collaborations for HBCUs and more.

5. Conclusion

Overall, integration of the engineering librarian (Engineering Collections & Research Analyst) into this work has been highly successful for RII. Particularly for an R1 institution like Virginia Tech with most institutional priorities involving the College of Engineering, making it critical to the success of RII's work to involve the engineering librarian. As can be seen in the examples presented in this publication, each required knowledge of engineering to complete: Blue Origin – disciplinary databases and knowledge, CHIPS and Science Act – understanding of the engineering profession, and HBCUs – project started with an interest in computer science and engineering connections. As RII's work continues in collaborating across our institution, it is expected that the Engineering Collections & Research Analyst will be a key member for RII, providing the needed disciplinary expertise and technical background for all future engineering research analysis projects.

As the Research Impact & Intelligence department's reputation for excellent work has spread, requests have become so numerous and involved that RII has begun to turn away collaborators, based on priorities. Additionally, the department is working on policy documentation to provide to potential collaborators regarding our levels of partnerships and expectations. The policy will echo statements from a document written by the Evidence Synthesis Coordinator, who is also experiencing similar demand and success. The department's members believe many academic libraries can build similar teams such as these and serve as research support liaisons to offices of research, institutional effectiveness, corporate business development, department and college level administrators, and provosts. Members believe, too, that those library personnel trained in bibliometrics are particularly well-suited because of their understanding of the responsible use of metrics, helping to lead their institutions to the future of library and campus unit collaborations.

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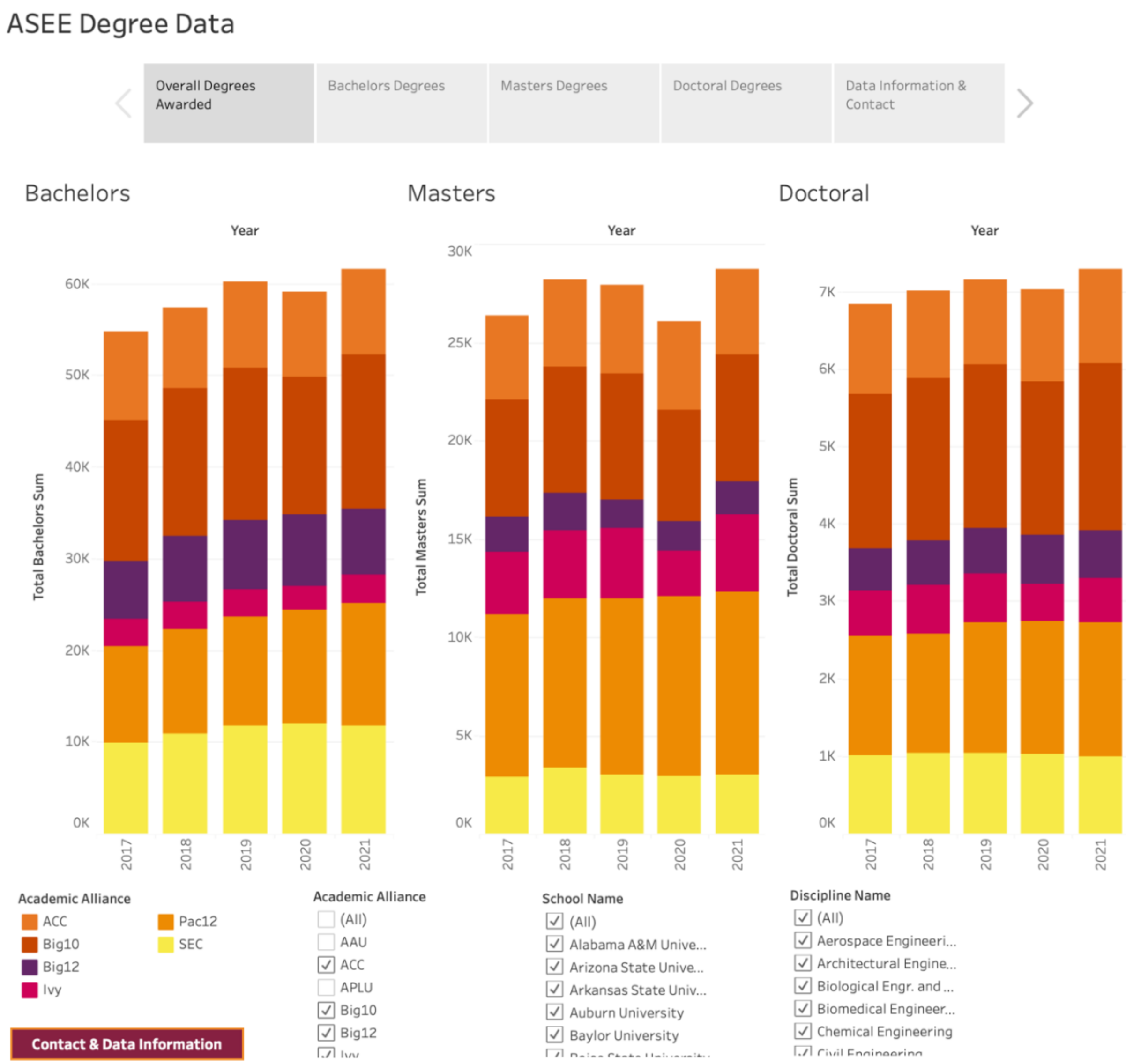
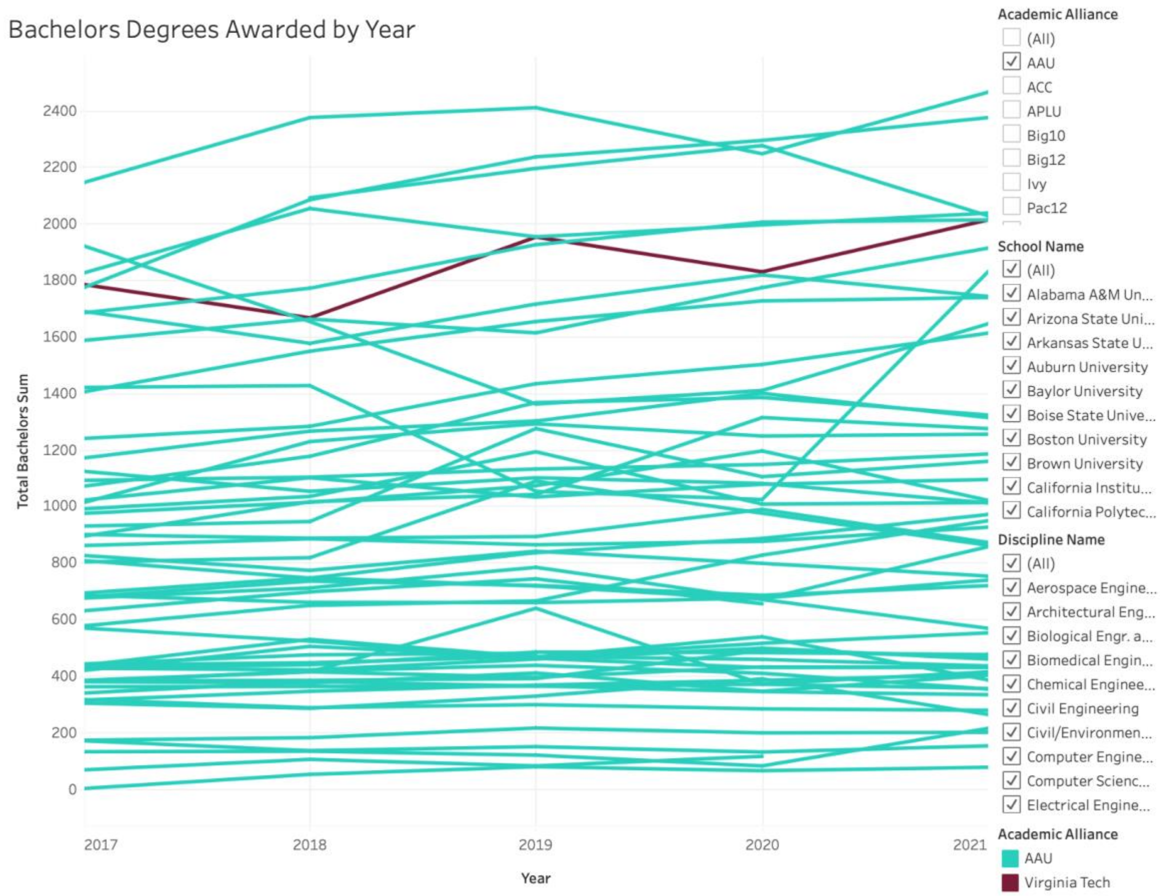
Appendix: Tableau Dashboards - Screenshots

ASEE Degree Data Dashboard



ASEE Degree Data

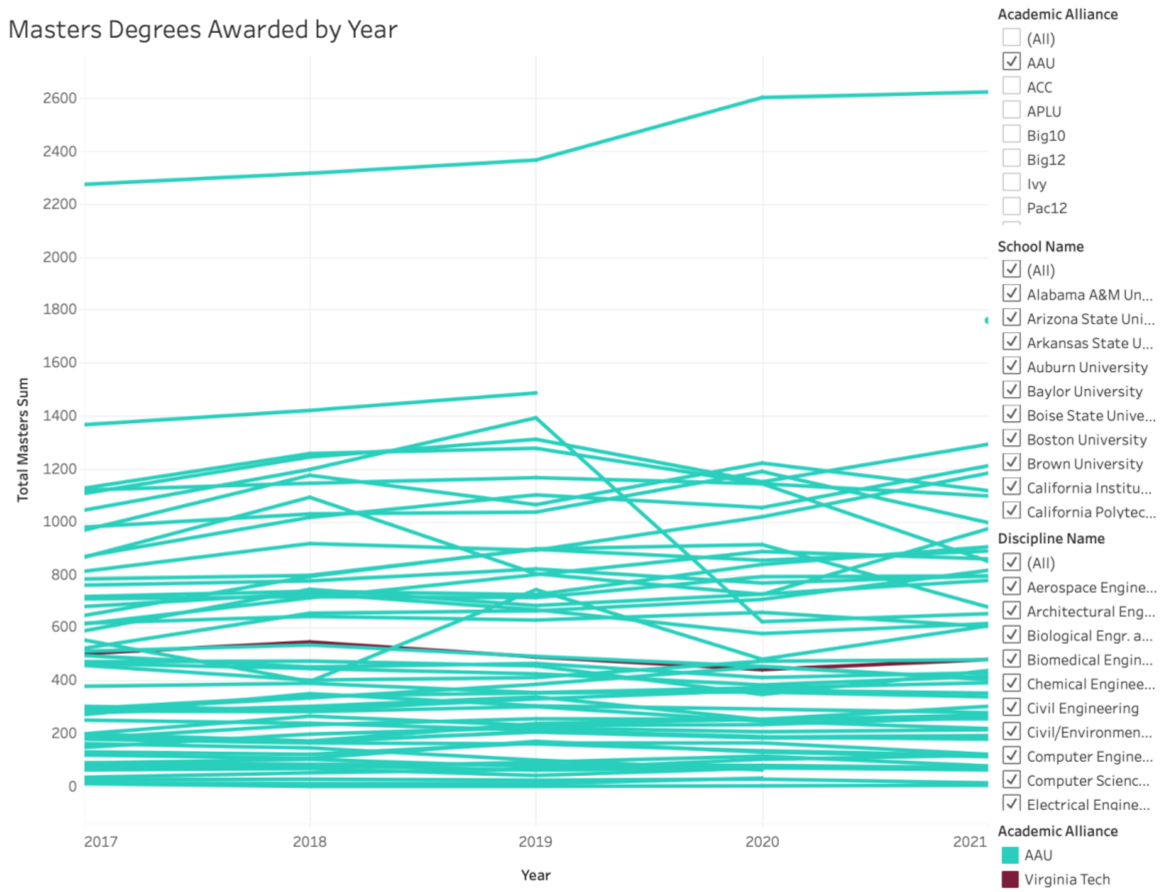
Overall Degrees Awarded | Bachelors Degrees | Masters Degrees | Doctoral Degrees | Data Information & Contact



Contact & Data Information

ASEE Degree Data

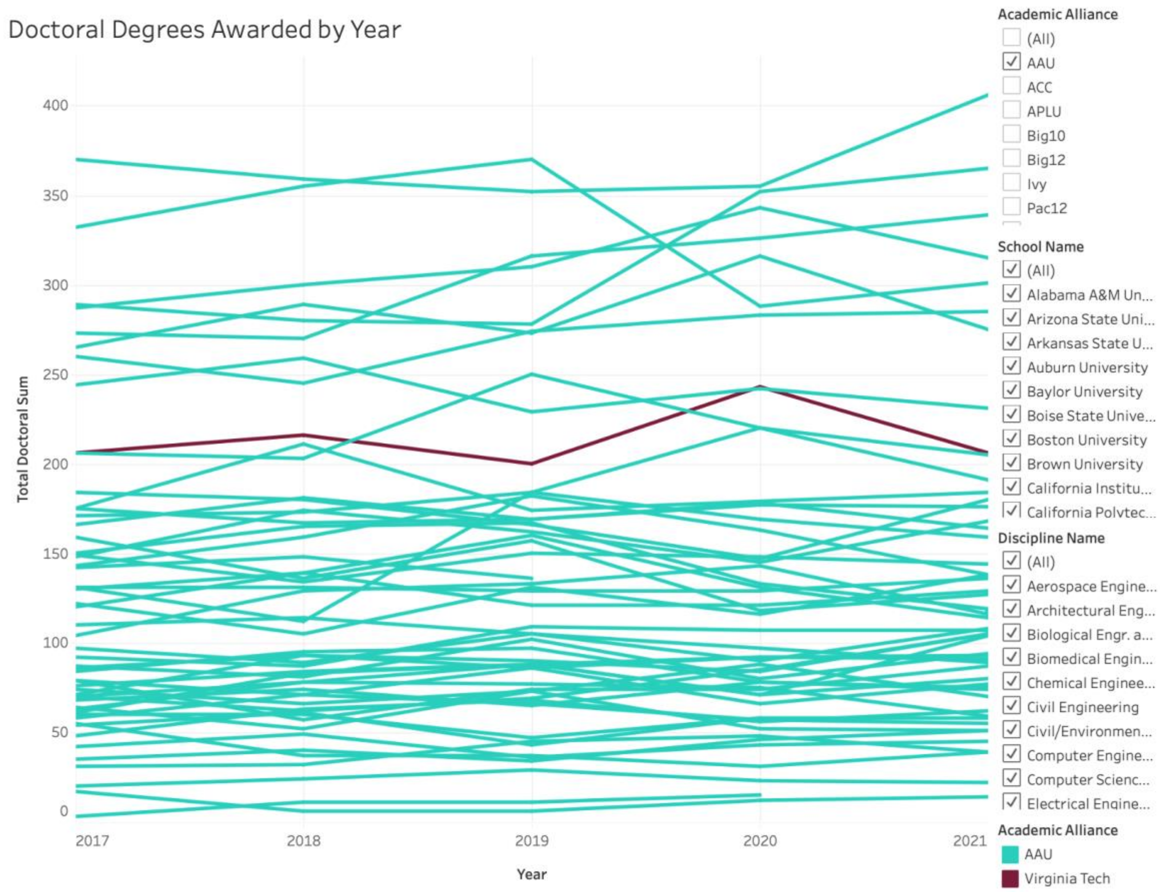
Overall Degrees Awarded | Bachelors Degrees | Masters Degrees | Doctoral Degrees | Data Information & Contact



Contact & Data Information

ASEE Degree Data

Overall Degrees Awarded | Bachelors Degrees | Masters Degrees | **Doctoral Degrees** | Data Information & Contact



Contact & Data Information

ASEE Degree Data

Overall Degrees Awarded | Bachelors Degrees | Masters Degrees | Doctoral Degrees | Data Information & Contact

Contact & Data Information

For more information or further analyses:

Sarah Over, PhD
Engineering Collections & Research Analyst
mailto:sover05@vt.edu
For other projects, reach out to:
mailto:researchintel@vt.edu

Data Source Information:

ASEE Engineering Data Management System: ASEE Degree Totals by Discipline Report

- Academic Alliances & Categories included: ACC, Big 10, Big 12, Pacific 12, SEC, Ivy Leauge, Virginia Engineering Schools; plus AAU (Association of American Universities) and APLU (Public and Land-Grant Universities)
- Degree Disciplines included:
  + Aerospace Engineering
  + Architectural Engineering
  + Biological Engr. and Agricultural Engr.
  + Biomedical Engineering
  + Chemical Engineering
  + Civil Engineering
  + Civil/Environmental Engineering
  + Computer Engineering, Computer Science (inside engineering)
  + Electrical Engineering
  + Electrical/Computer Engineering
  + Engineering (General)
  + Engineering Management
  + Engr. Science and Engr. Physics
  + Environmental Engineering
  + Industrial/Manufacturing/Systems Engineering
  + Mechanical Engineering
  + Metallurgical and Matrls. Engineering
  + Mining Engineering
  + Nuclear Engineering
  + Other Engineering Disciplines
  + Petroleum Engineering

Last updated: 2023/02/09
Coverage: 2017-2021

Data Points Excluded & Rationale:

Bachelors Degrees Awarded:

Georgia Institute of Technology, 2017 - 1k higher than all other years (around 3k vs 2k)
Pennsylvania State University, 2020 - only 148 degrees compared to around 2k in other years
University of New Orleans, 2018 - 0 degrees compared to 150+ in other years

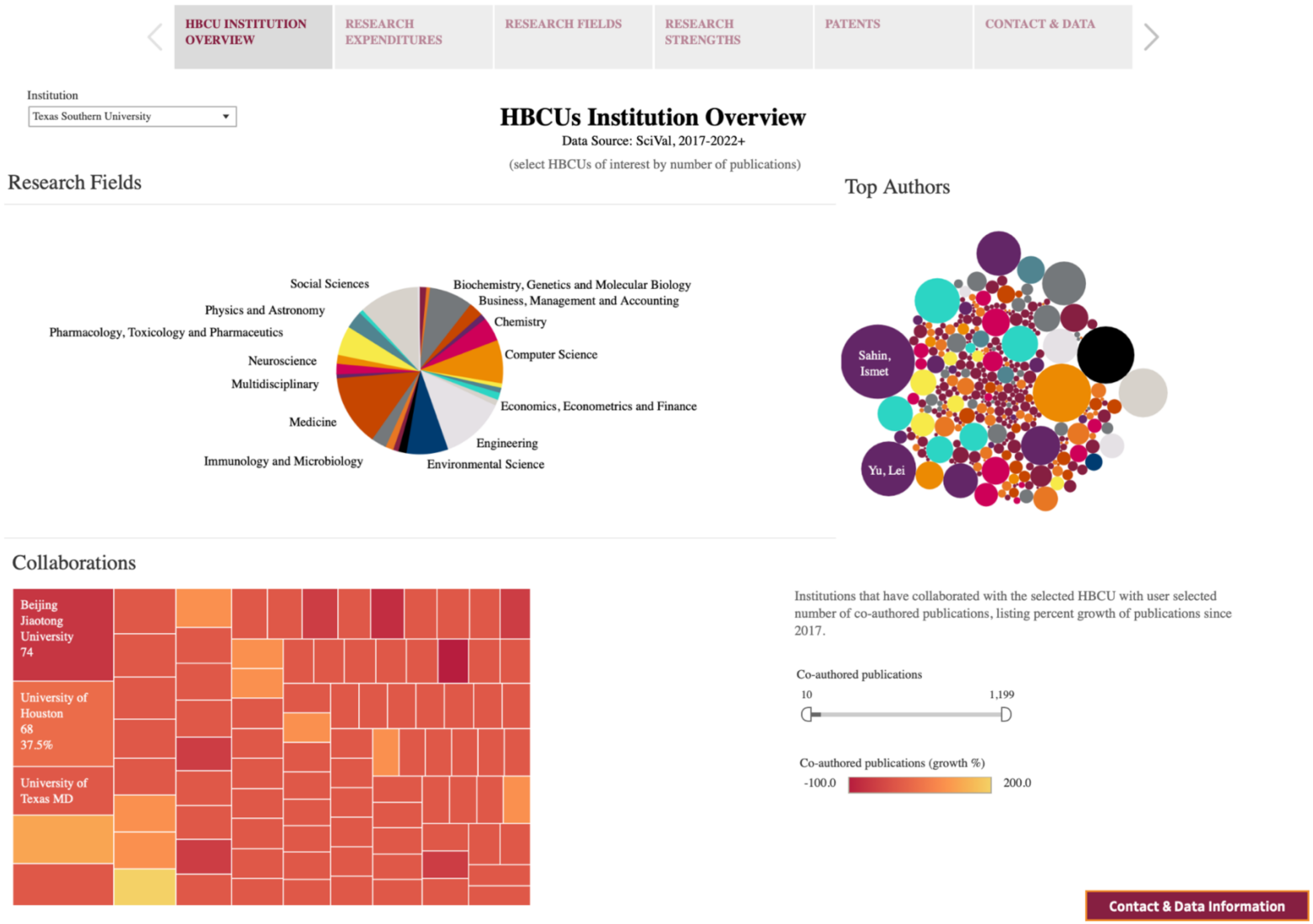
Masters Degrees Awarded:

Northern Illinois University, 2019 - 32 degrees compared to 100+ in other years
Pennsylvania State University, 2020 - 3 degrees compared to over 300+ in other years
Texas Tech University, 2019 - 0 degrees compared to 150+ in other years
University of Alabama at Birmingham, 2019 - 0 degrees compared to 150+ other years
University at Buffalo, SUNY, 2019 - 0 degrees compared to 600-800+ in other years
University of Idaho, 2020 - 195 degrees compared to 100 or less in other years

Doctoral Degrees Awarded:

Pennsylvania State University, 2020 - 0 degrees compared to 170+ in other years
Texas Tech University, 2019 - 0 degrees compared to 60+ in other years
University at Buffalo, SUNY, 2019 - 0 degrees compared to 75+ in other years
University of Idaho, 2020 - 143 degrees compared to 15 or less in other years
University of South Alabama, 2019 - 35 degrees compared less than 5 in other years

HBCUs Dashboard

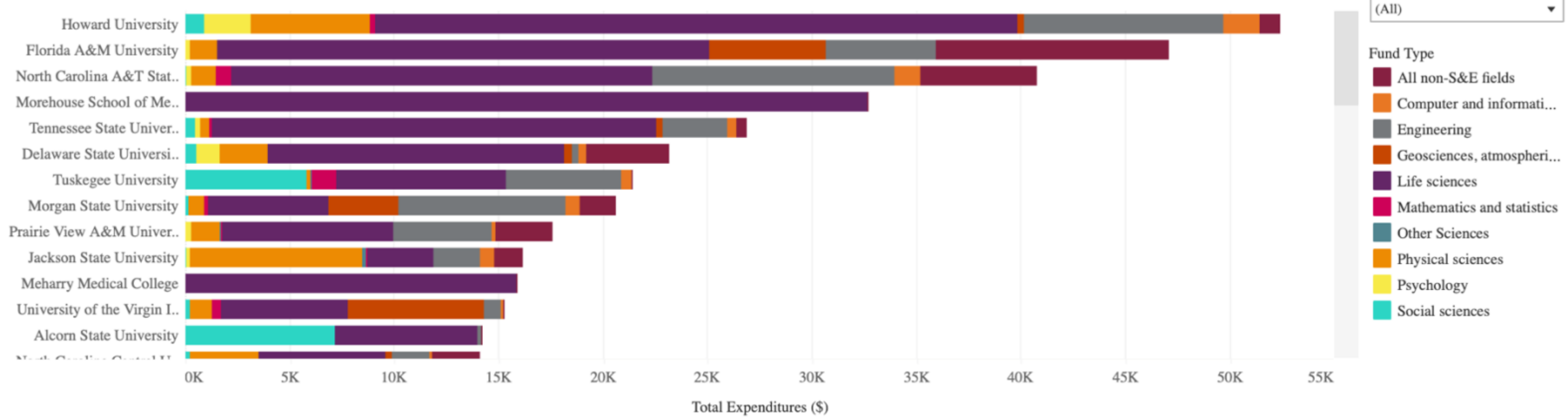


HBCU INSTITUTION OVERVIEW | RESEARCH EXPENDITURES | RESEARCH FIELDS | RESEARCH STRENGTHS | PATENTS | CONTACT & DATA

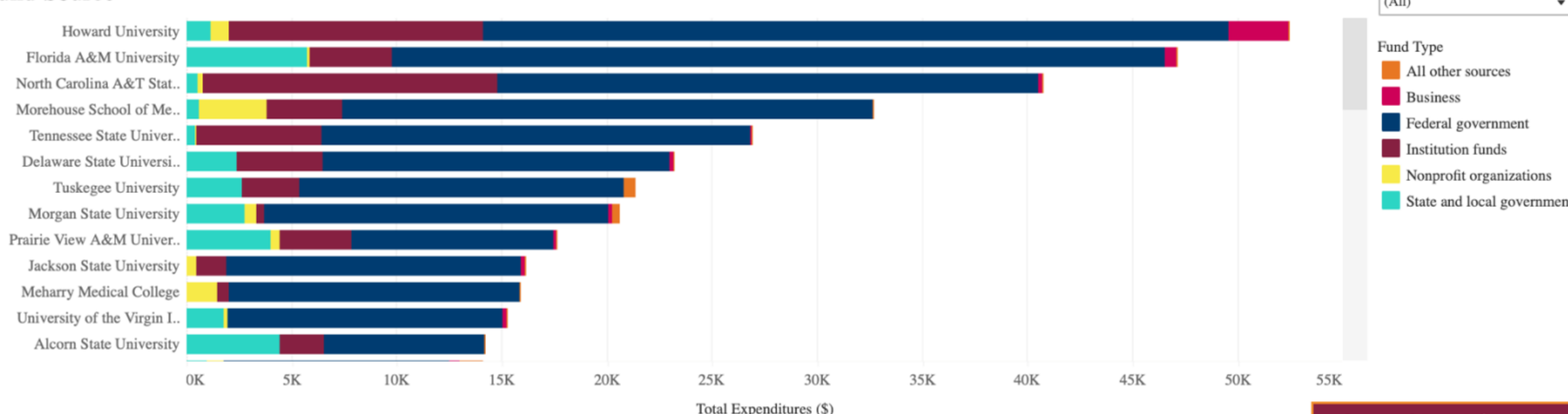
Institutional Research Expenditures

Data Source: NSF HERD, Fiscal Year 2021

Funding Field



Fund Source



Contact & Data Information

Institution: Texas Southern University

Research Field: (All)

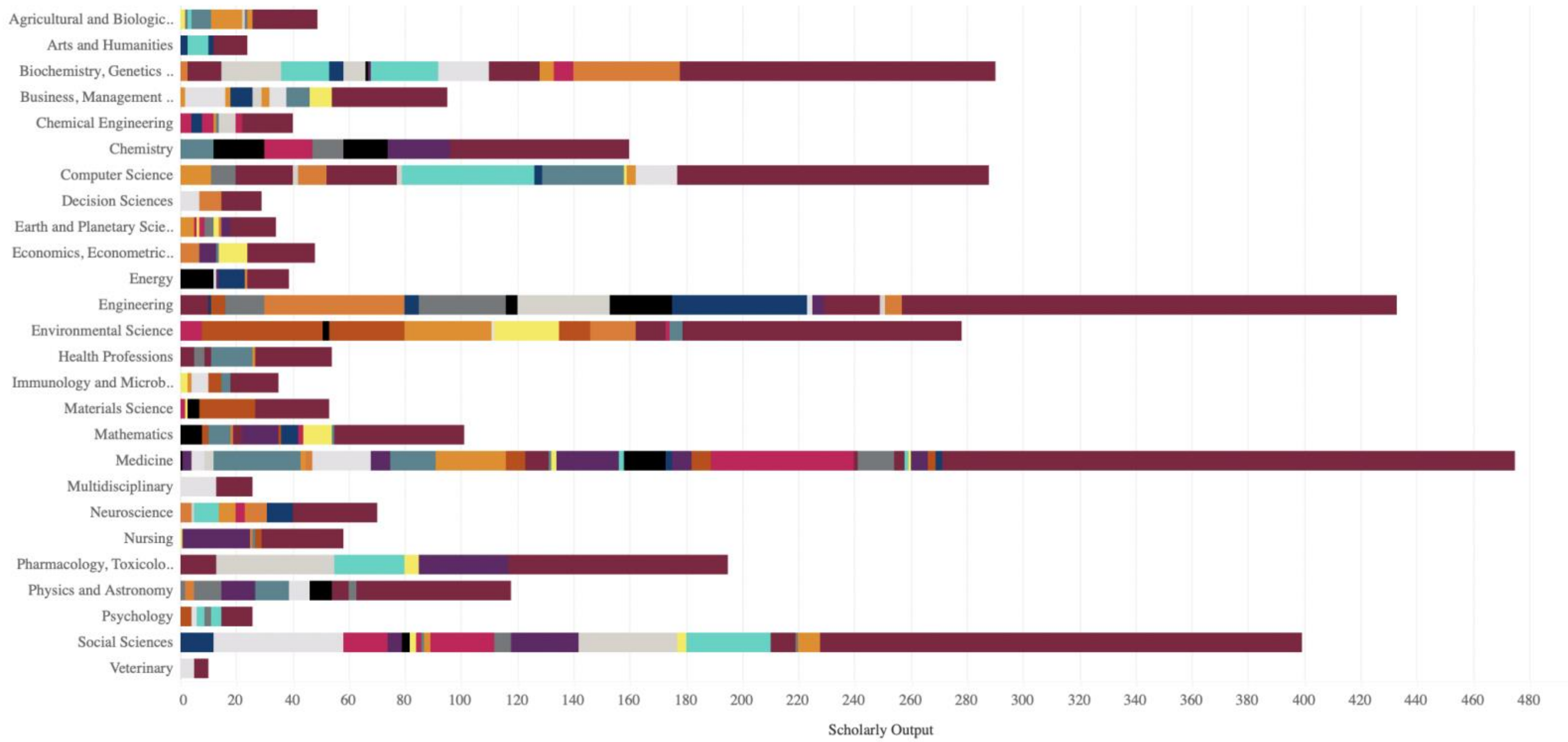
Subcategory: (All)

Note: Dash (-) in subcategory is uncategorized

Institutional Research Fields

Data Source: SciVal, 2017-2022+

Research fields and subcategories across select HBCUs (by number of publications)



Contact & Data Information

HBCU INSTITUTION OVERVIEW | RESEARCH EXPENDITURES | RESEARCH FIELDS | RESEARCH STRENGTHS | PATENTS | CONTACT & DATA

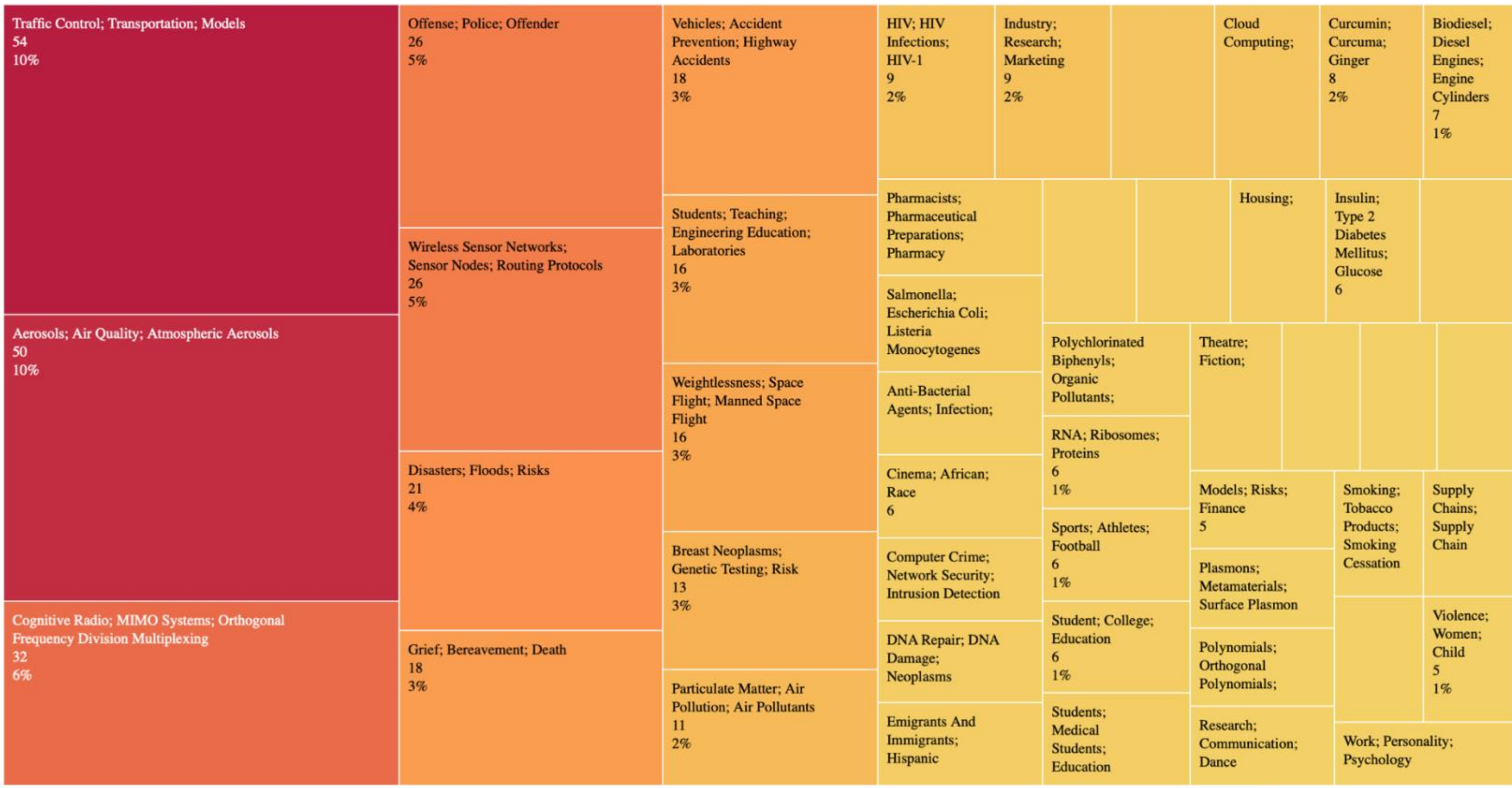
Topic Cluster: (All)

Institution: Texas Southern University

Institutional Research Strenghts

Data Source: SciVal, 2017-2022+

Research strengths at HBCUs with at least 5 publications since 2017



Contact & Data Information

Patents Filled with HBCUs as an Assignee

Data Source: Dimensions, 2017-2022

Patents

Domain	Publication number	Patent title	Fields of Research (ANZ..	Inventor names	CPC (primary)	Filed year	
US	US-9850195-B2	Aspirin derivatives and uses thereof	32 Biomedical and Clini..	SANG SHENGMIN	C07C69/86	2017	https://..
	US-9950987-B2	Aspirin derivatives and uses thereof	32 Biomedical and Clini..	SANG SHENGMIN	C07C69/78	2017	https://..
	US-9973275-B2	System and method for lighting and buil..	33 Built Environment an..	Nyarko Kofi; Emiyah Chr..	H04J14/086	2017	https://..
	US-10053496-B2	Compositions and methods for exosome..	31 Biological Sciences; ..	BOND VINCENT CRAIG; ..	C12P21/02	2017	https://..
	US-10059894-B2	Gasifier	35 Commerce, Manage..	Wang jin tong	C10J2200/152	2017	https://..
	US-10077356-B2	Preparation and uses of bio-adhesives	31 Biological Sciences; ..	FINI ELHAM H	E01C7/35	2017	https://..
	US-10172838-B1	Self-emulsifying formulation of CARP-1 f..	32 Biomedical and Clini..	SACHDEVA MANDIP; PA..	A61K47/16	2017	https://..
	US-10201539-B2	Composition for reducing nervous syste..	32 Biomedical and Clini..	XIONG ZHIGANG; SIMO..	A61K9/00	2017	https://..
	US-10206974-B2	Antimicrobial compositions and method ..	31 Biological Sciences; ..	BOND VINCENT CRAIG; ..	Y02A50/30	2017	https://..
	US-10220025-B1	Self-emulsifying formulation of CARP-1 f..	32 Biomedical and Clini..	SACHDEVA MANDIP; PA..	A61K47/16	2017	https://..
	US-10222113-B1	Solar adiabatic cooling apparatus	37 Earth Sciences; 51 P..	MAGEE CHARLES	F24F2221/38	2017	https://..
	US-10308942-B2	Methods and compositions for treating ..	32 Biomedical and Clini..	CONFORTI LAURA; YUN ..	A61K9/1272	2017	https://..
	US-10316403-B2	Method for open-air pulsed laser deposi..	40 Engineering; 40 Engi..	DARWISH ABDALLA; SA..	C23C14/3485	2017	https://..
	US-10333620-B2	System and method for lighting and buil..	46 Information and Com..	Nyarko Kofi; Emiyah Chr..	H04W4/029	2018	https://..
	US-10336796-B2	Treatment of ischemia	Null	SIMON ROGER P; XIONG..	A61P43/00	2017	https://..
	US-10342766-B2	6-shogaol derivatives and activities ther..	34 Chemical Sciences; 3..	SANG SHENGMIN; ZHU ..	A61P27/02	2018	https://..
	US-10358784-B1	Soil matrix water table control apparatus	41 Environmental Scien..	Cherrier Jennifer; BOLQ..	C02F2103/001	2017	https://..
	US-10363230-B2	6-shogaol derivatives and activities ther..	34 Chemical Sciences; 3..	SANG SHENGMIN; ZHU ..	A61P25/02	2018	https://..
	US-10370625-B2	Cleaning composition, method of makin..	40 Engineering; 43 Hist..	HAWKINS WALTER; REY..	A01N25/06	2017	https://..
	US-10406156-B2	Composition for reducing nervous syste..	32 Biomedical and Clini..	XIONG ZHIGANG; SIMO..	A61K9/0085	2017	https://..
	US-10414804-B2	Method of inducing an immune respons..	31 Biological Sciences; ..	BOND VINCENT CRAIG; ..	C12N2740/16322	2018	https://..
	US-10440960-B2	Pest control composition	30 Agricultural, Veterina..	CHAO SHIRLEY	A01N65/40	2018	https://..
	US-10457901-B2	Cleaning composition, method of makin..	40 Engineering; 43 Hist..	HAWKINS WALTER; REY..	C11D17/0039	2018	https://..
	US-10525050-B2	Alkylated tetrahydroisoquinolines for bi..	32 Biomedical and Clini..	ABLORDEPPEY SETH Y	A61K31/4725	2018	https://..
	US-10544193-B2	Compositions and methods for treating ..	32 Biomedical and Clini..	BOND VINCENT CRAIG; ..	A61K47/60	2018	https://..
	US-10546207-B2	Normalized defect characterization of p..	40 Engineering; 40 Engi..	SUNDARESAN MANNUR ..	G06T2207/10048	2017	https://..
	US-10556872-B2	Fatty acid synthase inhibitors and meth..	31 Biological Sciences; ..	KAUSHIK VIVEK; IYER A..	C07D239/553	2018	https://..
	US-10583417-B2	Filtration system and methods of using ..	31 Biological Sciences; ..	RANGARI VIJAYA; TIIMO..	B01D2239/1241	2017	https://..
	US-10603316-B2	Composition and methods for preventin..	32 Biomedical and Clini..	XIONG ZHIGANG; SIMO..	A61K31/155	2018	https://..
	US-10604729-B2	Liquid loading composition, method of ..	34 Chemical Sciences; 3..	HAWKINS WALTER; REY..	C11D17/0013	2018	https://..
	US-10610566-B1	Inducing CNS neurite outgrowth with Mo..	31 Biological Sciences; ..	GEORGES BEATRICE; M..	A23L33/40	2018	https://..

Original assignee (primary)

(All)

Status

- [ ] (All)
- [ ] Null
- [ ] Abandoned
- [x] Active
- [ ] Expired - Fee Related
- [x] Granted
- [x] Pending
- [x] Published Application
- [ ] Withdrawn

Domain

- [ ] (All)
- [ ] AU
- [ ] BR
- [ ] CA
- [ ] CN
- [ ] EP
- [ ] ES
- [ ] HK
- [ ] IN
- [ ] JP
- [ ] MX
- [ ] NZ
- [x] US
- [ ] WO
- [ ] ZA

CPC (primary)

(All)

Fields of Research (ANZSR…

(All)

Contact & Data Information

Contact & Data Information

For more information or further analyses related to this data contact:

Sarah Over, PhD
Engineering Collections & Research Analyst
mailto:sover05@vt.edu

For other projects, reach out to:
mailto:researchintel@vt.edu

Data Source Information:

Institutional Collaborations, Authors & Research Fields:
Source: SciVal - all HBCUs, including for each institution:
- Top 500 authors (max) per institution
- Top 100 collaborating institutions

Last updated: 2023/3/28
Coverage: 2017-2022+

Research Strengths/Topic Clusters:
Source: SciVal
Last updated: 2022/12/7
Coverage: 2017-2022+

Research Expenditures:
Source: NSF HERD (https://ncses.nsf.gov/pubs/nsf23304)
Last updated: 2022/12/15
Coverage: FY 2021 dataset

Patents:
Source: Dimensions (https://app.dimensions.ai/)
Last updated: 2023/02/19
Coverage: 2017-2022
Note: HBCU institutions may not be the primary assignee, check dimensions link for full details

(Use back arrow at bottom right to return to previous dashboard)