4.0

Space Needs Analysis and Benchmarking

4.1 Space Inventory

The facilities inventory was provided by the university. This is a room-by-room listing of all assignable square feet (ASF) located in university-owned buildings. During the preliminary stages of the analysis, the consultant reviewed anomalies and worked with the college to correctly classify some spaces in the facilities inventory.

All space in this analysis is shown in assignable square footage, which is defined as the usable space contained within classrooms, laboratories, offices, etc. It does not include circulation and building service space, nor does it include the thickness of walls or structural components like building columns, which would be part of the building gross square footage (GSF). Specific GSF information for buildings can be found in sections 2.2 and 5.1.3.1 through 5.1.3.8 of this report. The following table shows the buildings that were included in the base year 2013 existing space category.

Building	ASF
Water Science & Engineering	26,540
Wendt Commons	52,778
Mechanical Engineering Building	153,783
Engineering Hall	265,802
Engineering Centers Building	112,402
1410 Engineering Drive	34,390
Materials Science & Engineering Building	25,547
Engineering Research Building	84,479

Figure 4A: **ASF per Building**

In the analysis of space needs at the plan horizon, the Water Science & Engineering Building was removed from the College of Engineering space inventory as the programs of the college presently located in the building are assumed to move to the main college campus location. The Extension Building located east of the college site is the location of the Engineering Professional Development (EPD) program. The building is slated for removal from the university inventory. The EPD would like to be located closer to the college site, therefore the Extension Building ASF was not included in either the base year or the plan horizon. The Wisconsin Energy Institute Building was not included in the study as the research space located in that facility is used primarily by other than college staff.

The College of Engineering has 751,398 ASF of space that was included in this study. The space was distributed into 12 individual space categories for purposes of this analysis. These space categories were assembled somewhat based on the space use codes included in the Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 edition, published by the National Center for Education Statistics[11].

Office and research space use about 68% of the total space allotted to the CoE. Teaching and open laboratories as well as classrooms are the next three highest use of college space. The remaining seven space categories account for about 10% of the total CoE ASF.

FICM	Space	ASF
110, 115	Classroom Space	51,773
210, 215	Laboratory Space	63,204
220, 225	Open Laboratory Space	52,123
250, 255	Research Space	276,575
310, 315	Office Space	232,870
410, 420, 430, 440, 455	Library Space	38,766
N/A	Collaborative Learning/Study	4,382
530, 535	Central Media Services	3,130
610, 615, 620	Assembly & Exhibit	3,620
650, 655, 665, 680, 685	Merchandising/Lounge/Meeting	3,071
710, 720, 725, 730	Central Computer/Shop/Storage	8,258
N/A	Other Academic Department Space	13,626
	Total ASF	751,398*

**4,323 ASF outside agency/non-useable space is not included in total A*SF.

Figure 4B: **Existing 2013 Space Distribution**

[11]U.S. Department of Education, National Center for Education Statistics. (2006). *Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 Edition* (NCES 2006-160). U.S. Department of Education. Washington, DC: National Center for Education Studies.

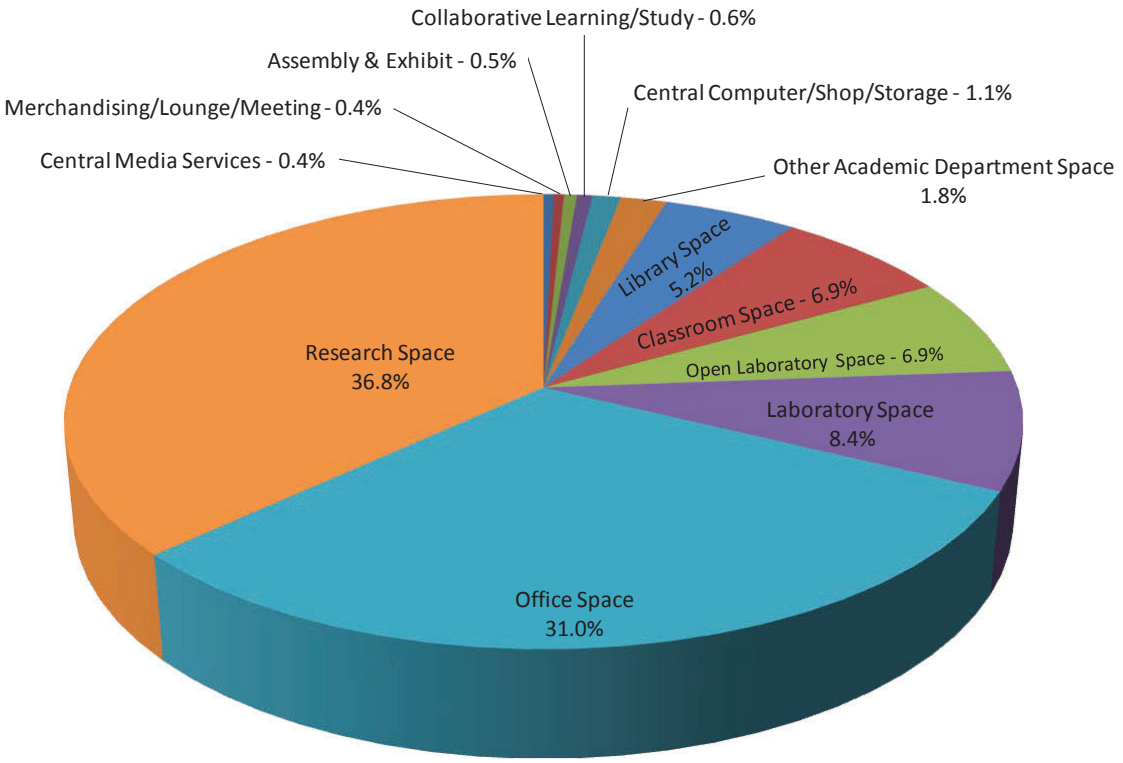

Figure 4C: **Existing Space**

4.2 Utilization

An analysis of existing space utilization was not part of the consultant team's scope for this project. However, a feasibility study was conducted by the University Office of Sustainability to determine whether use of instructional space (classrooms and labs) can be improved through the use of optimization techniques for instructional space scheduling. The full report is included in the Appendix for reference.

Recommendations included in the report included the following:

- Pilot the optimization of the Spring 2015 schedule of classes for CoE in coordination with the Office of the Registrar. This may lead to strategies to optimize scheduling for all UW-Madison classes campus-wide.
- Elevate scheduling responsibilities from department to the college level to obtain greater utilization of instructional space.

- Develop a change management plan to encourage faculty and staff to accept the findings and conclusions of this and previous studies and adopt the flexibility and process changes necessary to allow improvements for campus through optimization.

To project space needs by space type, Paulien & Associates applied normative guidelines appropriate for the College of Engineering. Where applicable, the University of Wisconsin System guidelines were applied. Modifications to the UW System expectations were made for classrooms, teaching laboratories, and office space classifications. These modifications are articulated in detail in the Paulien Report included in the Appendix and were reviewed in detail/ approved by UWSA during the process. Benchmarking, comparative analysis, and other common guideline sources were used where none existed from the University of Wisconsin System.

4.3 Outcome of Space Metric Analysis

4.3.1 Classrooms and Service Space

Classrooms are defined as any room generally used for scheduled instruction requiring no special equipment and referred to as a general purpose classroom, seminar room, or lecture hall. Classroom service space directly supports one or more classrooms as an extension of the classroom activities, providing media space, preparation areas, or storage. The classroom station size is considered as including the classroom service area space. However, additional service space can be justified on a program or classroom basis.

The metric for determining classroom space is based on the University of Wisconsin System guidelines. The guidelines are an average of 35 hours per week for scheduled instruction. The University of Wisconsin System uses a sliding scale of student station occupancy based on the section size, but at the master plan level, 67% was determined to be an appropriate metric. The application of the guideline uses the target utilization of 35 hours per week, multiplies it by the target student station occupancy of 67%, and divides the result into the 25 square feet per student station. This calculation produces a guideline of 1.07 ASF per weekly student contact hour (WSCH) for lecture courses.

Assignable square feet per weekly student contact hour (ASF/WSCH) is calculated as follows:

Lecture Guideline per Weekly Student Contact Hour (WSCH):

$$\frac{25 \text{ ASF/Station}}{35 \text{ Weekly Room Hours } \mathbf{X}\ 67\% \text{ Student Station Occupancy}} = 1.07 \text{ ASF/WSCH}$$

As further explanation, the total number of weekly contact hours for a lecture course section is obtained by multiplying the enrollment of the course section by the number of meeting hours in one week. For example, a history course with 45 students enrolled which meets three times a week for one hour produces 135 WSCH. Multiplying the 135 WSCH by the classroom guideline of 1.07 ASF generates 144.5 ASF of classroom space.

EXAMPLE OF CLASSROOM GUIDELINE APPLICATION

Step 1 • Calculate Weekly Student Contact Hours for Lecture Section
Enrollment (45) X Weekly Room Hours (3) = Weekly Student Contact Hours (135)

Step 2 • Calculate Classroom Guideline

$$\frac{\text{25 ASF/Station}}{\text{35 Weekly Room Hours X 67\% Student Station Occupancy}} = \text{1.07 ASF/WSCH}$$

Step 3 • Calculate Guideline Square Footage
Weekly Student Contact Hours (135) X ASF/WSCH (1.07) = Guideline Square Footage (144.5)

It should be noted that there is no true comparison of existing classroom space to guideline space on a program-by-program basis. This is due to the fact that the guidelines are applied by course and the departmental classroom needs can then be calculated; however, most classrooms are viewed as a campus wide resource and are centrally scheduled. In practice, most departments do not control the classrooms they use, but have first choice of hours when they can schedule the room.

4.3.2 Classrooms

During the campus conversations with the academic departments of the CoE, most department chairs suggested that many of the lecture courses would be better served if delivered in an active learning classroom environment. Over the summer of 2014, the college converted some space in Engineering Hall to active learning environments. The calculation of the ASF per station in this renovated space is approximately 35 ASF/station.

The course file supplied to Paulien & Associates included course components of DIS (discussion), LEC (lecture), and SEM (seminar). The discussion and seminar courses are primarily lower enrollment program specific lectures, whereas many of the lecture courses are in the enrollment levels of 92-100 students that will soon be more prevalent. It is many of these types of courses that would be more desirable to be taught in active learning environments. It was, therefore, recommended that for course components of LEC, the assignable square foot per station differ from the University of Wisconsin System standard of 25 ASF to 30 ASF/station. Increasing the ASF/station to 30 would be the average between 25 and 35 ASF, and would generate slightly more total ASF

of classroom space for College of Engineering courses to compensate for the desire for these active learning environments.

Application of the existing UW System guideline of 35 WRH at a SSO of 67% and a modified square foot per student station of 25 ASF (DIS and SEM course components) and 30 ASF (LEC course components) illustrates a surplus of around 14,200 ASF at the current student enrollment. As the student population increases to the plan horizon, the surplus of classroom space decreases to just over 500 ASF.

Classroom Space Factors

Course Component	ASF per Station	Weekly Room Hour	Student Station Occupancy
DIS	25	35	67%
LEC	30	35	67%
SEM	25	35	67%

ASF = Assignable Square Feet

It must be noted that the classroom guideline application includes only CoE courses. Most of the existing pool of classrooms in the CoE buildings are general use classrooms and are used by other colleges for instructional delivery. It was noted in meetings that about 116 sections were not included in the University's utilization analysis. These course sections were primarily taught by Liberal Arts departments. Therefore, the total classroom space in CoE buildings needs to reflect the use of these spaces by other than CoE courses. This is a University wide discussion that would need to occur during more detailed planning studies. The team discussed re-calculating the numbers to include non-CoE courses, which would show higher actual utilization of existing classrooms. However, because campus-wide utilization was not part of this study, the team could not accurately project utilization. In addition, the team acknowledged that there are CoE students taking classes in non CoE facilities. For these reasons, the team agreed that this study would present the data based on CoE courses only.

The UW System is contemplating increasing the classroom utilization metric for WRH from 35 hours per week to 40 hours per week. Paulien & Associates calculated the difference in the classroom space needs analysis outcomes if the higher utilization metric were used.

Classroom Guideline Comparisons

Space Category	2013 Existing ASF	2013 Guideline ASF	2013 Surplus/ (Deficit)	2021 Existing ASF	2021 Guideline ASF	2021 Surplus/ (Deficit)
Existing UW System guideline of 35 hours Classroom & Service	51,773	37,546	**14,227**	51,355	50,839	**516**
Proposed UW System guideline of 40 hours Classroom & Service	51,773	32,852	**18,921**	51,355	44,486	**6,869**
	Difference:		**4,694**	**Difference:**		**6,353**

ASF = assignable square feet

The use of the higher metric for classroom space use would decrease the total amount of classroom space needed by almost 4,700 ASF at the existing 2013. At the projected 2021 plan horizon, the surplus of classroom space would increase by almost 6,350 ASF. The current classroom utilization expectation of 35 WRH was used in the campus wide space needs analysis contained in this study.

4.3.3 Teaching Laboratories and Service Space

Teaching laboratories are defined as rooms used primarily by regularly scheduled classes that require special purpose equipment to serve the needs of particular disciplines for group instruction, participation, observation, experimentation, or practice. Station sizes in teaching laboratories vary by discipline. Space requirements are calculated with a formula that is similar to those used to determine classroom space requirements, except that the ASF per student station varies by discipline.

The scheduled weekly room hour average for teaching laboratories is generally found to be less than scheduled use of classrooms due to the need for preparation time of specialized equipment prior to class. Conversely, the student station occupancy is normally higher as the number enrolled in a laboratory exercise is more closely monitored, safety being a key issue as well as the limitations of faculty observation.

Paulien & Associates has provided space planning services to many colleges of engineering at research intensive universities throughout the United States. The weekly hours of use of teaching laboratories in colleges of engineering are found to be less than one would typically find in colleges of science and other colleges that offer core curriculum in laboratory settings. In colleges of engineering there are no multiple high enrollment lower division sections to offset lower enrollment in the upper division sections, as can be found in programs that offer core curriculum. As an example, Biology is often a core course in a laboratory setting for almost all disciplines. Therefore, Biology is able to offer lower division courses in multiple sections within a single laboratory environment to satisfy the need for students requiring this core course. This offsets the lower weekly room hour utilization in many of their upper division science laboratories, thereby attaining the average weekly room hour of use for its Biology department teaching laboratories.

The most commonly used guidelines we find for colleges of engineering are between 18 to 24 weekly room hours for lower division courses and between 12 to 16 weekly room hours for upper division course sections. The Instructional Space Optimization Feasibility Study draft prepared by the University shows that the College of Engineering teaching laboratories are presently used approximately 20 weekly room hours for scheduled instruction. It is, therefore, Paulien & Associates' recommendation that the 20 weekly room hours be used in lieu of the 24 weekly room hours as suggested by the University of Wisconsin System to generate the square footage of teaching laboratory need for the study. This was agreed to by UWSA.

Teaching Laboratory Guideline

Course Component	ASF per Station	Weekly Room Hour	Student Station Occupancy	ASF per Weekly Student Contact Hour
LAB	Varies	20	80%	Varies

ASF = Assignable Square Feet

As the University of Wisconsin System does not have a guideline for student station occupancy, a metric of 80% student station occupancy is suggested and was used based on the consultant's experience with similar institutions. The teaching laboratory space per student station guideline is based on approximately 50 different subject areas. Based on the consultant's experience at both the master plan and at the program plan level, guidelines were selected for use in this analysis that are reflective of a research extensive university.

Instructional Laboratory Space Factors

Discipline	ASF per Station*	Weekly Room Hour	Student Station Occupancy
Engineering	80	20	80%
Agricultural Engineering	125	20	80%
Chemical Engineering	120	20	80%
Civil/Construction/Transport	120	20	80%
Electrical/Electronics/Communications	100	20	80%
Mechanical Engineering	140	20	80%
Industrial & Management Engineering	70	20	80%
Metallurgical Engineering	120	20	80%
Engineering Mechanics	150	20	80%
Geology	60	20	80%

ASF = Assignable Square Feet

** ASF per station includes a factor for support/service space*

The ASF per station factor shown in the table above includes support space to the laboratory environment. The ASF per station is suggested by the guideline recommendations of the Western Interstate Commission on Higher Education, as well as the Council of Educational Facility Planners International. Some guidelines are offset by detailed studies Paulien & Associates has prepared for other institutions that include engineering programs. When reviewing the information supplied by the instructional space optimization feasibility study committee, it was noted that if all teaching laboratory spaces that do not show utilization were removed from the equation, the CoE presently has approximately 185 ASF per station of laboratory and laboratory support space in CoE buildings.

The College of Engineering currently has 63,204 ASF of space categorized as teaching laboratories. Application of the modified guideline results in a need for 62,431 ASF at the current on-campus student enrollment, or what Paulien & Associates would consider relative balance at the master plan level of analysis. At the plan horizon, the

guideline increases to almost 83,500 ASF, and the space surplus at the base year reverts to a space deficit of almost 20,300 ASF.

The UW System is contemplating increasing the teaching laboratory utilization metric for WRH from 24 hours per week to 32 hours per week. Since this analysis uses a modified WRH expectation of 20 WRH, a modified proposed guideline of 28 WRH was used for this comparison. Paulien & Associates calculated the difference in the teaching laboratory space needs analysis outcomes if the higher utilization metric were used. This was agreed to by UWSA.

Teaching Laboratory Guideline Comparisons

Space Category	2013 Existing ASF	2013 Guideline ASF	2013 Surplus/ (Deficit)	2021 Existing ASF	2021 Guideline ASF	2021 Surplus/ (Deficit)
Modified Existing UW System guideline of 20 hours						
Teaching Laboratory & Service	63,204	62,431	**773**	63,204	83,478	**(20,274)**
Modified Proposed UW System guideline of 28 hours						
Teaching Laboratory & Service	63,204	44,593	**18,611**	63,204	59,628	**3,576**
	Difference:		**17,838**	**Difference:**		**23,850**

ASF = assignable square feet

The use of the higher metric for teaching laboratory space use would decrease the total amount of teaching laboratory space needed by almost 17,800 ASF in the base year existing 2013. At the plan horizon projected 2021, the deficit of about 20,300 ASF would revert to a surplus of about 3,600 ASF. This reflects a total difference of 23,850 ASF in the ASF outcome. The teaching laboratory utilization expectation of 20 WRH was used in the space needs analysis contained in this study.

4.3.4 Office & Office Service Space / Academic & Administrative

Office space delineation is a manner of cataloging data and may be influenced by whether departmental space assignments are correctly reflected in the facilities inventory. Office ASF in existing buildings is often reflective of a period of time or design standard that was considered appropriate at the time of construction but may not now meet the guidelines for contemporary office arrangements. The need for office space at the master plan level should be considered in totality with the complete picture being illustrated by the outcomes of the office space needs.

The guideline application for office space needs is based upon employee types and the additional application of space amounts for office service and conference space needs. Office space includes private offices and workstations. Office service space includes work rooms (i.e., printer areas, copy machines, office supplies) and office storage (i.e., file rooms). The space allocated for conference rooms is not to suggest that all conference rooms be departmentally controlled. Typically, some conference room space is located near department offices, and other space is available generally in the building as a campus-wide resource.

The CoE provided staffing information with individual job title, department, headcount, full-time equivalent, and full-time or part-time status. The consultant then organized each into major categories as shown in the table below. Using the staffing file provided by the university, each employee requiring space is allocated an office or workstation amount as well as support (i.e., work rooms, file rooms, etc.) and conference space.

A calculation was performed that estimates the existing ASF per office, making some assumptions as to what offices are single occupancy in nature. The average across the CoE buildings is approximately 160 ASF. The CoE also reviewed staff that may have more than one office, such as a primary faculty office and an office within a research cluster. This resulted in the identification of only five such instances, which is minor in relation to the entire outcome. The College also tried to determine if staff from other Colleges or entities had offices in CoE buildings, but that task proved to be overwhelming and was terminated.

The consultant recommended that a modification to the UW System office guidelines be made to better reflect the current state of offices and the addition of staff over time. The approved recommendation included the use of a modified guideline to better reflect existing conditions for the base year Existing 2013 scenario. The 2013 Peer Faculty and projected 2021 scenarios would then apply the UW System guidelines to all new staff. The Office Guidelines table shown at right, identifies the modified and the UW System guidelines applied in the manner articulated above.

There is currently almost 233,000 ASF of office and office service space in CoE buildings. At the current staffing levels using the modified guidelines there is a guideline generated need for almost 205,300 ASF, which results in a surplus of around 27,500 ASF. In the 2013 Peer Faculty scenario the overall space surplus reduces to about 14,500 ASF, and at the 2021 plan horizon the office space surplus reverts to a deficit of over 66,600 ASF. Physical planning for the master plan will use the total ASF of office need as the metric. When more detailed studies are performed such as pre-design or renovation studies, the consultants or college will need to apply the UW System guidelines where possible to attempt to balance the office needs versus what presently exists.

Employee Type	2013 Modified Guidleine ASF	2013 Peer Faculty UW System Guideline ASF	2021 UW System Guideline ASF
Dean	300	185	185
Assoc Dean	200	120	120
Asst Dean	200	120	120
Director	180	120	120
Assoc Director	160	120	120
Faculty	160	120	120
Professor Emeritus	60	60	60
Visiting Professor	160	120	120
Research Faculty	160	120	120
Visiting Researcher	160	120	120
Faculty Adjunct	60	60	60
Postdoctoral	40	40	40
Professional	160	120	120
Research Professional	40	40	40
Technical	110	110	110
Research Technical	40	40	40
Secretarial & Clerical	80	80	80
Teaching Assoc/Asst	40	40	40
Graduate Assistant	40	40	40
Student Worker	40	30	30

4.3.5 Research Laboratories & Research Laboratory Service Space

Research laboratories are rooms used for unscheduled laboratory experimentation or training in research methods and observation. The research may be conducted by either faculty or students for both funded and non-funded research. This room type does not have utilization expectations.

The computation of research space is a complex issue, especially for a comprehensive college that is research intensive. There are different approaches that could be used at the master planning level: a space factor per $100,000 in research expenditures, or a space factor per research team, or a space factor per tenured or tenure track (T/TT) faculty.

Analysis of research expenditures was conducted with past and projected yearly research expenditure dollars supplied by the CoE. There was, however, no method by which the college could parse the dollars by building as some college research is performed in other than CoE buildings. The outcome of this methodology was considered to over generate research laboratory space. Therefore, the consultants chose a space factor per full-time tenure or tenure track (T/TT) faculty as the methodology for purposes of this analysis. The number of T/TT faculty was adjusted where possible for those faculties that are known to perform research in other than CoE buildings and are anticipated to continue to do so by the plan horizon.

During a meeting and presentation of draft findings with Dean Robertson, it was requested that the consultants look at a 2013 base year analysis that includes an increase in college faculty to a student to faculty ratio of 20 to 1 that represents the existing condition at many of the college's peer programs. The CoE is presently at an approximate student to faculty ratio of 24 to 1. This resulted in the analysis of office and service and research space at a third level. The consultants requested that the college assist in the definition of the quantities of faculty and how many would be anticipated to be tenure or tenure track so that a third research laboratory analysis could be performed in support of the physical planning effort. The following table is the result of this effort.

	Existing 2013			2013 Peer Faculty			Projected 2021		
Department	Faculty Adjunct	Faculty	T/TT Faculty	Faculty Adjunct	Faculty	T/TT Faculty	Faculty Adjunct	Faculty	T/TT Faculty
Admin/Other									
Biomedical Engineering *	2	16	15	2	27	25	5	42	35
Chemical & Biological Engineering	1	20	18	1	23	23	3	38	30
Civil and Environmental Engineering	19	23	25	19	27	25	22	40	35
Electrical and Computer Engineering	4	42	38	4	42	38	8	50	45
Engineering Physics	2	17	20	2	20	20	5	35	30
Engineering Professional Development	16	38	6	16	40	6	20	50	10
Industrial and Systems Engineering	2	17	17	2	17	17	5	30	25
Materials Science and Engineering	3	14	13	3	15	15	7	30	25
Mechanical Engineering	1	36	29	1	55	47	5	75	60
Grainger Institute for Engineering	0	0	0	0	0	0	0	0	0
	50	**223**	**181**	**50**	**266**	**216**	**80**	**390**	**295**

Note: All numbers in headcount
Faculty Adjunct less than .60 FTE
T/TT = Tenure/Tenure Track
Two "Associate Professor" included in "Faculty" but have < .60 FTE

The total T/TT faculty at the base year Existing 2013 was 181 with 50 faculty adjuncts. To compare to the college's peer group at the current enrollment, the T/TT faculty would need to number approximately 216. At the plan horizon undergraduate enrollment projection of 6,000 headcount students, it is anticipated that the College will require 295 T/TT faculty positions.

The 181, 216, and 295 T/TT faculty positions were used to determine the guideline space needs for research laboratory space in the needs analysis. The positions were allocated to each CoE department. An adjustment was made to the department of Biomedical Engineering as, during the meeting with this department, it was noted that about 40% of the faculty perform research in CoE buildings. The remaining faculty perform their research at the Medical School or other buildings not part of the CoE inventory. The T/TT faculty in the Engineering Professional Development was excluded from this guideline application, as they were assumed not to perform research on campus. The T/TT faculty for this analysis was adjusted accordingly.

The consultant researched previous studies completed by the firm for colleges of engineering as well as the existing ASF per T/TT faculty in the CoE. A guideline was developed for each department based on modules of square feet for the principle investigator and a team of post docs, graduate students, and other staff that work in the research laboratories. The modules vary from 520 ASF for mostly computational types of research to heavy research in programs with large equipment needs or a 1,760 ASF module. This resulted in an ASF per T/TT faculty per department that was applied to generate the recommended total ASF need. The table that follows illustrates the outcomes of the analysis for the three scenarios.

	Existing 2013					
Department	Existing ASF	Current Space per T/TT Faculty	Guideline ASF per T/TT Faculty	Current T/TT Faculty in Guideline	Guideline ASF	Surplus/ (Deficit)
Admin/Other	59,769				65,746	(5,977)
Biomedical Engineering *	12,194	1,524	1,440	8	11,520	674
Chemical & Biological Engineering	34,488	1,916	1,760	18	31,680	2,808
Civil and Environmental Engineering	28,343	1,134	1,440	25	36,000	(7,657)
Electrical and Computer Engineering	39,411	1,037	960	38	36,480	2,931
Engineering Physics	27,923	1,396	1,760	20	35,200	(7,277)
Industrial and Systems Engineering	10,895	641	520	17	8,840	2,055
Materials Science and Engineering	24,102	1,854	1,760	13	22,880	1,222
Mechanical Engineering	39,416	1,359	1,440	29	41,760	(2,344)
Grainger Institute for Engineering **						
	276,541			**168**	**290,106**	**(13,565)**

	2013 Peer Faculty			Projected 2021			
Department	Ideal T/TT Faculty in Guideline	Guideline ASF	Surplus/ (Deficit)	Target Year Existing ASF	Projected T/TT Faculty	Guideline ASF	Surplus/ (Deficit)
Admin/Other		65,746	(5,977)	53,567		65,746	(12,178.9)
Biomedical Engineering *	11	15,840	(3,646)	12,194	14	20,160	(7,966)
Chemical & Biological Engineering	23	40,480	(5,992)	34,488	30	52,800	(18,312)
Civil and Environmental Engineering	25	36,000	(7,657)	15,774	35	50,400	(34,626)
Electrical and Computer Engineering	38	36,480	2,931	39,411	45	43,200	(3,789)
Engineering Physics	20	35,200	(7,277)	27,923	30	52,800	(24,877)
Industrial and Systems Engineering	17	8,840	2,055	10,895	25	13,000	(2,105)
Materials Science and Engineering	15	26,400	(2,298)	24,102	25	44,000	(19,898)
Mechanical Engineering	47	67,680	(28,264)	39,416	60	86,400	(46,984)
Grainger Institute for Engineering **							
	196	**332,666**	**(56,125)**	**257,770**	**264**	**428,506**	**(170,736)**

* Assume 40% T/TT Faculty research in CoE buildings
** T/TT Faculty in Departments
T/TT = Tenure/Tenure Track

The base year Existing 2013 outcomes reflect a minor deficit of research laboratory space, which is consistent with the empirical information received by the consultant during on campus work sessions. Assuming the CoE can increase faculty to balance with the student to faculty ratios of their peers, the 2013 Peer Faculty scenario reflects a larger space deficit of slightly over 56,000 ASF for research laboratory space. The plan horizon Projected 2021 space needs shows a deficit of over 170,000 ASF in this space category.

4.3.6 Open Laboratories & Open Laboratory Service Space

The space classified as Open Laboratories includes rooms that are open for student use and that are not used on a regularly scheduled basis. These rooms may provide equipment to serve the needs of particular disciplines for group instruction in informally or irregularly scheduled classes. Alternatively, these rooms are used for individual student experimentation, observation, or practice in a particular field of study. The size of these laboratories is based on equipment size, the station size, and student count desired, and should be determined on an individual basis. Types of rooms included in this category include, but are not limited to, open computer laboratories, language laboratories, independent art studios, music practice rooms, and tutorial and testing facilities.

Space categorized as Open Laboratory space in the facilities inventory include the shop space in the B level and the first floor studio space in the Engineering Centers Building; the CAE space in 1400 Engineering Drive and the Wendt Library; several spaces in the basement level of Engineering Hall; and several spaces in the basement level of the Engineering Research Building. Also included are several wet and dry laboratories assigned to Engineering Physics and located in the Mechanical Engineering Building.

There is currently 8.6 ASF per student headcount of Open Laboratory space in the CoE buildings. A guideline of eight ASF per student headcount was applied at the 2013 base year and a guideline of seven ASF per student headcount at the plan horizon. During conversations with the CoE constituents it was noted that space was desired in the future for student groups for hands-on experimentation. Not all space for active student learning requires specialized equipment and is included in other space categories in this analysis. Therefore, at the plan horizon additional space will be needed in this classification.

4.3.7 Other Space Types

4.3.7.1 Library Space

The Wendt Library is a component of the University of Wisconsin-Madison library system with the staff being CoE employees. The facility includes volumes, manuscripts, patents, and government documents, but also includes an active learning classroom, the Wisconsin Collaborative for Enhanced Learning, and associated space on the upper level. The campus is in flux as to the ultimate future programming of the library, as the University Libraries are presently undergoing a study of all library space on campus. The CoE has representation on the study committee and will assist in the development of that plan. The consultants performed an analysis of the current and future space needs for the Library assuming the array of spaces typically programmed in a contemporary library setting. These include reader stations, technical services, office space, and collections. The collections for the study were assumed to equal the existing collection at both the base and plan horizon. Reader stations were assumed to increase with the enrollment increase of the college. The following table illustrates the outcome of the analysis.

Library Collections

	Current Items	Conversion Factor	2013 Volumes	Volume Growth	2020 Volumes
Books/Serials (Volumes	63,067	1.00	63,067	0.00%	63,067
Manuscripts & Archive	62,866	1.00	62,866	0.00%	62,866
Gov't Documents (Vol	201,904	19.00	10,627	0.00%	10,627
Unbound Serials (Displ	0	0.50	0	0.00%	0
Microforms	1,594,789	80.00	19,935	0.00%	19,935
Audio/Visual Materials	3,477	5.00	695	0.00%	695
E-Books	0	1.00	0	0.00%	0
Total Volume Equivalents			**157,190**		**157,190**

Library Guideline Application and Analysis

Collection Space	*No. of Volume Equivalents* 0 - 80,000	80,001 - 200,000	200,001 - 600,000	600,001 - 2,000,000	2,000,001 and above	2013 Guideline ASF	2020 Guideline ASF
ASF per Volume	*0.08*	*0.02*	*0.02*	*0.02*	*0.02*		
2013 Collection Space	6,400	1,544	0	0	0		
2020 Collection Space	6,400	1,544	0	0	0		
					Total Collection Space	7,944	7,944

Study Space	Percent of Headcount	2013 Headcount	2013 Stations	2020 Headcount	2020 Stations
Undergraduate Students	8%	4,322	346	6,000	480
Graduate Students	8%	1,706	136	2,250	180
Faculty (FTE)	2%	319	6	319	6
	Total Study Stations		**489**		**666**
Regular Study Stations	*50% @ 25 ASF/Station*		6,100		8,325
Multimedia Study Stations	*50% @ 35 ASF/Station*		8,540		11,655

	2013 Guideline ASF	2020 Guideline ASF
Total Study Space	14,640	19,980
TOTAL COLLECTION & STUDY SPACE	**22,584**	**27,924**
Service Space *(18.0% of Total Collection and Study Space)*	4,065	5,026
Lounge Space *(3 ASF per Study Station)*	1,466	1,999
TOTAL LIBRARY GUIDELINE SPACE	**28,115**	**34,949**
Existing Space	*38,766*	*38,766*
SURPLUS / (DEFICIT)	**10,651**	**3,817**

Overall, the Wendt Library currently has around 38,800 ASF of library space. The space needs analysis for the Library showed a need for just over 28,000 ASF at the current student enrollment and the assumption stated previously. At the plan horizon, the guideline application shows a projected total need of slightly less than 35,000

ASF of Library space. Both scenarios assume the use of compact shelving on the lower level of the building. The outcomes show a surplus of space even with increased reader stations due to enrollment growth. The possibility would, therefore, exist to add additional active learning space to the building. The outcome of the University wide study will influence the outcomes of this analysis.

4.3.7.2 Collaborative Learning/Study

There has been a strong movement toward more learner-centered instruction where students are required to be more active during class time and are often expected to engage in collaborative group projects as part of their overall class experience. This recognition of active learning has been more recently recognized as Constructivist theory, one that recognizes that knowledge is created through experience, rather than passively delivered from teacher to student. Coupled with research on higher student retention rates from participatory, active peer-to-peer learning, formal and informal collaborative learning spaces are being created in response to these discoveries that support student-directed initiatives and allow students to define their best pace, setting and learning modalities while fostering discovery, innovation, and scholarship.

Significantly greater content retention rates happen with peer-to-peer and mentoring educational settings. Informal areas and collaborative spaces are conducive to supporting these trends; they provide comfortable seating that fosters peer-to-peer informal conversation while giving students access to technologies that allow for social and global discussion, and sharing of research and content within group settings. The university has begun to implement these types of learner-centered instructional delivery options across campus. The consultant encourages the university to continue this progressive movement in all academic and support facilities on campus.

To aid in the creation of this space typology, the consultant has created a space category and developed a guideline space need for collaborative study spaces for the CoE. The CoE inventory was reviewed and selected room records were collected to form the basis for this space category. The following table shows those rooms aggregated to this category.

Selected Collaborative Learning Spaces

Space Use Code	Room ID	ASF
680	ECB 1076	225
680	ECB 1086	143
650	ECB 2139	403
410	ENGR HALL 1621	441
410	ENGR HALL 1629	1,105
410	ENGR HALL 1639	432
650	ENGR HALL 2250	467
650	ENGR HALL 2548	260
410	MATRLS SCI 231	208
650	MECH ENGR 1180	465
650	MECH ENGR 1188	465

ASF = assignable square feet

*No stations were identified for these rooms in inventory information provided by UW-Madison. Since they are not classrooms, teaching labs, or offices, we do not usually see station counts in inventories for the space use codes in the 400s and 600s.

The consultant used two ASF per student headcount as a guideline factor in determining an adequate amount of collaborative and study space for the college. This results in a need of about 12,000 ASF of this space in the base year 2013 and 16,500 ASF at the plan horizon. As buildings are constructed or renovated, this space type will need to be factored into the program to make sure that it is included in the project.

4.3.7.3 Central Media Services

Engineering Media Services provides equipment, video production, graphic design and other services to the College. The consultants did not meet individually with this department but understand that the services provided are an important tool for student success. The space allocated to this category includes 530 Space Use Code from the Higher Education Facilities Inventory and Classification Manual (FICM) described as Media Production. The guideline assumed that the current space is adequate for this service in the base year 2013. At the plan horizon, the guideline generates a need for about 1,150 additional ASF to support these efforts.

4.3.7.4 Assembly & Exhibit

Assembly & Exhibit Space is defined as any room with an academic focus designed and equipped for the assembly of large numbers of people. This includes theaters, auditoriums, concert halls, and arenas. Exhibit spaces are used for exhibition of materials, works of art, or artifacts intended for general use by students and the public. Examples

of Assembly & Exhibit space at the College of Engineering rooms in Engineering Hall include ENGR HALL 1640, 1610, 1610A, 1610B, and in the Materials Science and Engineering Building room MATRLS SCI 250. These are space codes in the 610's from a Space Use Code perspective in the FICM. As with Collaborative study space types, the college needs to showcase "Engineering" in a more aggressive manner through providing galleries and other space in new and renovated facilities.

4.3.7.5 Merchandising/Lounge/Meeting

This space category includes the food service merchandising space in the first level of Engineering Hall, as well as merchandising and lounge space in the Wendt Library and the Mechanical Engineering building. As with the previous two categories this space type is anticipated to be replicated in any new construction or major renovations. This will supply some of the space needs for social interaction among students, faculty and staff.

4.3.7.6 Central Computer/Shop/Storage

The space included in this category is located in all the buildings on the CoE site. It includes central computer spaces for the Computer Aided Engineering department, as well as Chemical and Biological Engineering. It also represents much of the shop space in the B level of the Engineering Centers Building. To assist in the promotion of hands on instruction and to help support technology and departmental needs, this space will continue to be needed in CoE facilities. The guidelines applied generate about 12,300 ASF at the plan horizon that reflects a deficit when compared to the 8,250 ASF that presently exists.

4.3.7.7 Other Academic Department Space

The space classified as Other Department Space includes all other space assigned to a department that has not been included in the other space classifications. There is currently about 2.3 ASF per student headcount of Other Academic Department Space at the CoE. This space typology includes departmental library space and the Wisconsin Collaborative for Enhanced Learning (WISCEL) offices in the Wendt Library.

At the plan horizon the consultant applied 2.0 ASF per student headcount for the other academic department space. This is a slight reduction at the base year in total ASF as some of the spaces classified as this space type exist only because the space is available for use, and some of this space could be consolidated into other space categories if necessary. At the plan horizon the surplus reverts to a deficit of about 3,200 ASF.

4.4 Trends and Projections

Projections for space needs were developed based on the understanding that Engineering research and educations has undergone significant changes over the past several years and will continue to evolve in upcoming years. Changes in learning and research environments outlined below were taken into account along with UW System standards and national metrics to derive projected space needs.

Changes in Engineering "Learning"

- Engineering professional development requires hands-on learning with design programs that integrate student experiences and activities very early on in their collegiate careers. Team based projects are becoming increasingly important in engineering and require space to fulfill their needs such as the growth in "maker space."
- The act of making and the desire to put engineering "on display".
- Learning environments are team-based and foster communication skills in addition to discipline-specific knowledge.

Changes in Research/Research Environment:

- Research funding and scale is changing – targeting large-scale centers composed of interdisciplinary teams from across engineering disciplines organized around common initiatives.
- Infrastructure needs to be readily available, flexible, and adaptable to support more shared (core) facilities vs. discipline-specific laboratories.
- Increased use of shared facilities, such as characterization tools, synthesis, and processing labs to optimize existing resources and foster collaboration.
- Engineers are also increasingly working across disciplinary boundaries and creating, in some cases, new fields of engineering. For example, environmental engineering experiments may involve civil, agricultural, mechanical, electrical, and chemical engineers. The belief that cross-pollination can lead to innovation creates a need for more "people space" that facilitate interaction and collaboration.

Initially two outcomes of the space needs analysis were performed; one at the base year existing 2013 condition and one at the projected 2021 plan horizon. Following a meeting with the Dean, an additional analysis was performed at the base year condition with the added assumption of the CoE increasing tenure or tenure track (T/TT) faculty to an approximate 20 to one (1) student to faculty ratio to closely match the CoE's peer programs existing ratio. This third analysis affected the findings for office and research laboratory space categories.

The following table is a summary of the analysis.

Space Needs Analysis

	Existing 2013 *Student Headcount = 6,028*			2013 Peer Faculty *Student Headcount = 6,028*			Projected 2021 *Student Headcount = 8,250*		
Space Category	**Existing ASF**	**Guideline ASF**	**Surplus/ (Deficit)**	**Projected Existing ASF**	**Guideline ASF**	**Surplus/ (Deficit)**	**Projected Existing ASF**	**Guideline ASF**	**Surplus/ (Deficit)**
College Space									
Classroom & Service	51,773	37,546	**14,227**	51,773	37,546	**14,227**	51,355	50,839	**516**
Teaching Laboratories & Service	63,204	62,431	**773**	63,204	62,431	**773**	63,204	83,478	**(20,274)**
Open Laboratories & Service	52,123	48,225	**3,898**	52,123	48,225	**3,898**	52,123	56,212	**(4,089)**
Research Laboratories & Service	276,575	290,106	**(13,531)**	276,575	332,666	**(56,091)**	257,802	428,506	**(170,704)**
Offices & Service	232,870	205,316	**27,554**	232,870	218,385	**14,485**	227,593	294,245	**(66,652)**
Library	38,766	28,115	**10,651**	38,766	28,115	**10,651**	38,766	34,949	**3,817**
Collaborative Learning/Study	4,382	12,056	**(7,674)**	4,382	12,056	**(7,674)**	4,382	16,499	**(12,117)**
Central Media Services	3,130	3,130	**0**	3,130	3,130	**0**	3,130	4,288	**(1,158)**
Assembly & Exhibit	3,620	6,028	**(2,408)**	3,620	6,028	**(2,408)**	3,620	8,250	**(4,630)**
Merchandising/Lounge/Meeting	3,071	6,029	**(2,958)**	3,071	6,029	**(2,958)**	3,071	8,250	**(5,179)**
Central Computer/Shop/Storage	8,258	9,043	**(785)**	8,258	9,043	**(785)**	8,258	12,375	**(4,117)**
Other Academic Department Space	13,626	12,056	**1,570**	13,626	12,056	**1,570**	13,226	16,500	**(3,274)**
College Space Subtotal	*751,398*	*720,081*	***31,317***	*751,398*	*775,710*	***(24,312)***	*726,530*	*1,014,391*	***(287,861)***
COLLEGE TOTAL	**751,398**	**720,081**	***31,317***	**751,398**	**775,710**	***(24,312)***	**726,530**	**1,014,391**	***(287,861)***
Other	*2,806*				*2,806*		*2,806*		

The results illustrates a space surplus at the Existing 2013 base year and space deficits at both the 2013 Peer Faculty and Projected 2021 levels of analysis.

The Existing 2013 base year results show surpluses of space in the classroom, office and Library categories. The classroom guideline analysis includes only CoE courses in the results. It has been noted by the university that in fall 2013 other colleges used classroom space in the CoE buildings, as many classrooms are a university-wide resource. Many existing offices in CoE buildings are much larger than the UW System expectations for these spaces. A modified guideline was used to better reflect existing conditions thus reducing the overall Office & Service surplus to about 27,500 assignable square feet (ASF). The Research Laboratories & Service space category shows a slight deficit of 13,500 ASF, which is consistent with the empirical information obtained in conversations the consultant held with department chairs. The Library analysis shows that by addressing the assumptions articulated later in this document, space should be available for addressing needs of the college such as active learning and other academic initiatives. This analysis does not address the quality of spaces in the CoE buildings; however, the project team is investigating and documenting space quality as a major component of this master planning effort.

The 2013 Peer Faculty analysis as stated previously reflected an assumption of increased T/TT faculty positions at the current condition. This analysis affected the Office & Service and the Research Laboratories & Service space categories. The outcomes decreased the office space deficit as the additional staffing results in greater need for office

and service space in the college. The T/TT faculty positions also increase the need for research space as all faculties in this classification require research laboratory space, whether for individual research endeavors or participation in centers or institutes.

The Projected 2021 plan horizon analysis assumes an increase in undergraduate student headcount to 6,000 with accompanying increases in T/TT faculty, graduate assistants, and other support staff in the college. The guideline applications by space category addresses these assumptions and results in the gap between existing space and the guideline space amounts increasing in all space categories.

The total space deficit is about 289,000 ASF at the Projected 2021 target. The project team will use the outcomes of this analysis, as well as other studies being performed in tandem with this analysis, to develop scenarios for near and long term capital projects for the college.