A FRESH LOOK AT
Engineering 2020:
Vision for Excellence

DECEMBER 2013
www.colorado.edu/engineering/2020

College of Engineering & Applied Science
UNIVERSITY OF COLORADO BOULDER
From the Dean

Dear Students, Faculty, Staff, Supporters, and Friends:

I am pleased to invite you to review this refreshed strategic plan, Engineering 2020: Vision for Excellence. More importantly, I ask that you join us in its implementation. Despite challenges, we have made tremendous progress in the past five years, and we are proposing even more ambitious goals and greater innovation over the rest of this decade. So, hold on to your hats, open your checkbooks, and come along!

Robert H. Davis, Dean
College of Engineering and Applied Science
University of Colorado Boulder
December 2013

PS: And those sticky notes? They represent 10 early-stage ideas that could provide disruptive change in how we educate students. A portion of our budget will be used to pursue such ideas.

1. Name the College
... partner with key supporters to endow our college, departments, and programs, and move us to the forefront of modern engineering education and innovation

2. Integrated BS/PhD Programs
... attract the brightest and best students, and involve them in research early in their time at CU-Boulder to fast-track them for integrated degrees
I. Preface and Summary

In late 2008, the College of Engineering and Applied Science at the University of Colorado Boulder published a strategic plan, *Engineering 2020: Vision for Excellence*. Our strategic planning process sought answers to the following questions:

*Where are we now? Where would we like to be in the future? How will we get there? And how will we measure our progress?*

Now, at its five-year anniversary, we analyze progress on this plan and present updated goals and strategies. In brief, we have come through the recession in strong shape, have already met or exceeded most of our prior goals for 2020, and have launched several innovative programs. In particular, from 2007 to 2013, our undergraduate enrollments increased 25%, our graduate enrollments increased 35%, and our research grant awards increased 80%. We have also made good progress in diversity, with 56% more women and 87% more underrepresented minorities among our undergraduates in fall 2013 compared to fall 2007, while quality measures also increased. Our revised plan includes two ambitious, new goals:

1. **Doubling of engineering enrollments**, from just over 4000 students in the baseline year (Fall 2007) to over 8000 students by Fall 2020, while also increasing student quality and diversity. The motivation for growth includes a resurgence in student interest in engineering education and careers, projected increases in Colorado high-school graduates, heightened interest for international students, and projected needs of engineering employers. Moreover, enrollment growth will bring new resources to foster innovation, excellence and transformation, and it will enhance the impact and reputation of our college and campus.

2. **Ranking in the top 20 of U.S. engineering programs**, at both the graduate and undergraduate levels. We have been ranked in the top 40 for many years and seek to move to the next level and be widely recognized as a world leader for excellence and innovation in engineering research and education.

II. What Has Changed in the Past Five Years?

Of course, much has changed in the past five years since *Engineering 2020* was written, both in our own progress and in the world around us. Key external changes during this period and how they have affected our college are summarized below.

**RECESSION**
The stock market lost about half of its value within a few months of the launch of our strategic plan in fall 2008. The ensuing recession led to state budget cuts, reduced endowment values, and postponement of faculty hires and building projects at academic institutions across the country. Remarkably, our college has come through the recession with greater strength and an increased budget, due to increased student enrollments and faculty/staff efforts, and is proceeding with robust plans for growth.

**INCREASED APPLICATIONS & ENROLLMENTS**
Over the past six years, applications to our college have more than doubled for both graduate and undergraduate study, representing a strong resurgence in interest in engineering education, after 25 years of flat or declining U.S. engineering enrollments (*Engineering Workforce Commission*). As a result, we have grown our enrollments while improving selectivity and diversity. Table 1 shows that our peers have also grown,

<table>
<thead>
<tr>
<th></th>
<th>FT Faculty</th>
<th>BS Students</th>
<th>MS/ME Students</th>
<th>PhD Students</th>
<th>Res Exp</th>
<th>Stud/Fac</th>
<th>PhD/Fac</th>
<th>Res/Fac</th>
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<td><strong>2007 CU</strong></td>
<td>156</td>
<td>2914</td>
<td>713</td>
<td>493</td>
<td>51M</td>
<td>26.4</td>
<td>3.2</td>
<td>327K</td>
</tr>
<tr>
<td><strong>2012 CU</strong></td>
<td>163</td>
<td>3382</td>
<td>904</td>
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<td>78M</td>
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<td>4.3</td>
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<td>872</td>
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<td>23.3</td>
<td>3.6</td>
<td>386K</td>
</tr>
<tr>
<td><strong>2012 Peers</strong></td>
<td>243</td>
<td>5340</td>
<td>866</td>
<td>910</td>
<td>106M</td>
<td>29.3</td>
<td>3.7</td>
<td>452K</td>
</tr>
</tbody>
</table>

though proportionately more at the bachelor’s and master’s levels and less at the PhD level. During 2007-2012, our undergraduate enrollments increased 16%, while those of our peers increased 23%, on average; faculty counts for both CU and our peers increased less than 5%. The peer colleges are larger than our college by about 50%, on average, in faculty and undergraduate numbers.

RANKINGS
The National Research Council published in 2010 its first rankings of engineering graduate programs in 15 years, solely based on quantitative metrics. Our college showed great improvement, with four of six departments (Aerospace, Chemical, Civil, Mechanical) ranked in the top 15 programs (public and private) in the country, based on the midpoint of the regression-based quality score (http://graduate-schools.phds.org/rankings). However, our improved metrics have had less impact on the U.S. News & World Report rankings, for which our overall graduate program improved from 39th to 34th (based on a combination of metrics and reputation) in the past five years, while our undergraduate program improved from 33rd to 32nd (solely based on reputation). We remain the top-ranked engineering program in the Mountain Time Zone.

TECHNOLOGY
The rapid advance of the internet, social media and other technologies have affected how students communicate and learn, and hence how we teach. In just the past year, MOOCs (massive open online courses) have received considerable attention for low-cost delivery of educational content to the masses. The University of Colorado has joined Coursera and delivered four MOOCs (two from our college) in Fall 2013. However, our primary focus for the use of technology is on blended and online learning to improve the education of our own students. An example is the development of screencasts, the online solving of problem sets with instructor guidance.

III. What Has Not Changed?
On the other hand, our vision and core values have not changed. Our vision is to be a recognized world leader for excellence and innovation in engineering research and education and is based on the following core values of our college:

Global Society: Our innovative research programs seek to create and disseminate knowledge to improve global society in areas such as health and well-being, energy and environmental sustainability, and infrastructure for both developed and developing communities. Similarly, our innovative educational programs seek to prepare graduates with not only technical knowledge and excellence but also skills for societal leadership and global citizenship.

Active Learning: We design the student experience based on engineering educational research findings that demonstrate enhanced learning through active engagement of students, both within the classroom and through personalized and team-based opportunities such as design projects, discovery learning, service learning, internships and leadership programs.

Inclusive Excellence: To improve the educational experience and better serve global society, we are committed to building a culture of inclusive excellence of diverse faculty, staff and students with high ethical and performance standards.

IV. Where Are We Now?

PEOPLE
Table 2 provides comparisons between selected goals or metrics established in 2008 and our accomplishments as of Fall 2013. Student enrollments have increased much faster than projected, and they already exceed the prior targets for Fall 2020. Quality measures of entering students have also increased beyond our 2020 goals. We have made gains in student retention and graduation rates, though we are well below the target of 70% of entering freshmen graduating from our college within six years (but above the national average of about 55%). Due to the recession and associated state budget cuts, faculty increases have lagged behind student increases, resulting in larger classes and heavier faculty workloads. Fortunately, as described in Section V, campus leadership has agreed to a plan to add the necessary faculty lines, using tuition revenues associated with recent and projected enrollment increases.
Our college has also made important strides in diversity. Figure 1 shows that the representation of women in our undergraduate class has increased substantially in the past five years, reaching 23% and exceeding the national average of 19% in Fall 2012. Substantial gains in underrepresented minorities also have been made in the past three years. Our leading edge indicators are even stronger, with 28% women and 14% underrepresented minorities among new freshmen entering in Fall 2013, up from 20% and 7%, respectively, five years earlier. Our tenure-line faculty includes 18% women, exceeding the average of 14% for all U.S. engineering colleges in Fall 2012. Only 6.1% of our tenure-line faculty members are underrepresented minorities, compared to a national average of 6.0% (not including Puerto Rico), so improvement is needed for a diverse faculty to be part of our strategy to attract diverse students.

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>2007 Baseline</th>
<th>2010 Target</th>
<th>2020 Target</th>
<th>2013 Results</th>
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<tr>
<td>Number of BS Students</td>
<td>2914</td>
<td>3100</td>
<td>3350</td>
<td>3657</td>
</tr>
<tr>
<td>Average Composite ACT</td>
<td>28.0</td>
<td>28.2</td>
<td>28.5</td>
<td>29.6</td>
</tr>
<tr>
<td>Third-semester Retention</td>
<td>83%</td>
<td>83%</td>
<td>86%</td>
<td>85%</td>
</tr>
<tr>
<td>Six-year Graduation Rate</td>
<td>54%</td>
<td>55%</td>
<td>70%</td>
<td>61%</td>
</tr>
<tr>
<td>Number of Master’s Students</td>
<td>713</td>
<td>730</td>
<td>785</td>
<td>919</td>
</tr>
<tr>
<td>Number of PhD Students</td>
<td>493</td>
<td>540</td>
<td>665</td>
<td>704</td>
</tr>
<tr>
<td>Number of Tenure-line Faculty</td>
<td>156</td>
<td>175</td>
<td>203</td>
<td>170</td>
</tr>
</tbody>
</table>

**Table 2** Progress on student and faculty metrics in the CU-Boulder College of Engineering and Applied Science. The 2007 baseline and 2010 and 2020 targets are from the *Engineering 2020* strategic plan published in 2008. Data are based on the fall semester census. Faculty counts do not include tenure-line engineering faculty budgeted outside our college, such as in administration and research institutes, or humanities faculty rostered in our college.

### PLACES

In *Engineering 2020*, we determined a need for an additional 138,000 assignable square feet (asf) of office, instructional and research space by the year 2020, a 42% increase from 326,000 asf at that time (not including centrally-scheduled classroom and computer labs). New building projects were slowed by the recession, but we now have good progress and plans to report:

1. **Biotechnology Building:** The Jennie Smoly Caruthers Biotechnology Building (JSCBB) on the East Campus was built without state funding and opened in 2012. Most of the Department of Chemical and Biological Engineering (ChBE) moved into this building, occupying approximately 36,000 asf (not including shared classroom and common space). State funding has been approved to finish shelled

![Figure 1](image-url)  #3. Achieve Parity

... build a culture of inclusive excellence that attracts students who mirror Colorado’s diverse population

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University of Colorado College of Engineering and Applied Science

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teaching space in 2014, and a fifth wing is part of a campus request for state funding in fiscal-year 2015-16; these projects would add 14,000 asf for ChBE.

2. Aerospace Building: Plans for an Aerospace Building have been recast for the East Campus as a larger building (approximately 84,000 asf) that would hold all of the Department of Aerospace Engineering Sciences, instead of a smaller addition to the Engineering Center on the Main Campus. The campus and college have committed support for this building, and state funding has been requested for construction as early as 2015-16. Substantial fundraising success will also be required to bring this building to fruition.

3. Fleming: In an opportunity not anticipated when Engineering 2020 was written in 2008, the College of Engineering and Applied Science has been allocated about 34,000 asf in the old Fleming Law Building — including the former library space starting in 2013 and basement-level offices and several project rooms starting in 2010. We are currently working with an architect to create an Engineering Design Center or “Idea Forge” in the library area, with open, flexible “makerspaces” for design courses and student groups. The seven classrooms in Fleming have been refurbished, and receive high use for engineering courses.

4. Sustainable Energy and Environment Complex (SEEC): SEEC, formerly referred to as the Geosciences Building, is to include a new laboratory building on East Campus and the adjacent office building that originally was occupied by U.S. West. It will house several campus and federal groups studying environmental sustainability and renewable energy, including the Renewable and Sustainable Energy Institute (RASEI). We estimate that 8,000 asf in SEEC will be office and lab space for RASEI fellows with tenure homes in the College of Engineering and Applied Science. In addition, Environmental Engineering and Water Resources have been invited to move to about 30,000 asf of lab and office space in SEEC. Completion is expected in 2015.

The four projects listed above will total 206,000 asf of new space for our college, exceeding the goal in Engineering 2020, which included two additional projects: expansion of the Integrated Teaching and Learning Laboratory (ITLL) and a new engineering complex. At least a portion of the ITLL expansion is included as a satellite facility in the proposed Aerospace Building (as the aerospace undergraduate program is a primary user of the ITLL), and increased undergraduate project space will also be provided in the Fleming Building. A new engineering complex as a single building does not appear feasible (as funding is not sufficient to complete such a large project all at once), so growth space will be developed as a series of smaller buildings – starting with Biotechnology, Aerospace and SEEC. Moreover, substantial renovations of the current Engineering Center are also proposed.

PROGRAMS

We have made excellent progress on most of the programmatic initiatives described in Engineering 2020 — Vision for Excellence, as well as several new directions. The list below summarizes progress on key initiatives since 2008.

1. BOLD/GoldShirt: Our Broadening Opportunity through Leadership and Diversity (BOLD) Center was
founded in 2009. BOLD has a mission of recruiting, supporting and graduating diverse engineering students. It started the GoldShirt Program in 2009, to provide a new pathway for talented and motivated students to obtain the necessary preparation to succeed in engineering study. Substantial gains in diversity have occurred since BOLD and GoldShirt began.

2. Engineering Honors Program: The Engineering Honors Program (EHP) has grown from 65 to 238 students in the past five years. The Andrews Hall Residential College opened in 2009 and houses both EHP students and BOLD/GoldShirt students, as well as the EHP Faculty Director and his family. It promotes a diverse student body, active learning and high retention.

3. Engineering Leadership Program: The Engineering Leadership Program was started in 2011 and quickly grew to 50 students in 2012-13, with 45 more applicants for 2013-14. It is partnered with the Presidents Leadership Class and includes courses, leadership seminars, leadership experiences and mentoring, leading to a certificate in engineering leadership.

4. Global Engineering: We have expanded our global engineering efforts to include (i) an international engineering certificate with opportunities in six languages/cultures, (ii) a Global Engineering Residential Academic Program (RAP) starting in 2013 along with a global engineering certificate, (iii) a $5 million endowment secured in 2009 for the Mortenson Center in Engineering for Developing Communities, (iv) the inaugural chapter of Engineers Without Borders-USA started in 2001, and (v) a quadrupling of international undergraduates in our college from 67 in 2007 to 265 in 2013.

5. New Degree Programs: We have launched several new degrees in the past three years:
   - MS in Information and Communication Technology for Development in 2010
   - PhD in Telecommunications in 2012
   - MS/PhD in Architectural Engineering in 2012
   - BA in Computer Science in 2013
   - BS in General Engineering Plus in 2013
   - MS/PhD in Materials Science and Engineering in 2013

Additional new programs at both undergraduate and graduate levels are being planned and are described later. These new programs are part of our strategic efforts to grow enrollments, increase diversity and strengthen our global reputation.

6. Research Programs: In the past five years, our college and campus have made substantial progress with four overarching research and educational initiatives aimed at solving critical problems of global society:
   - The Materials Science and Engineering Program was started in 2010 with the appointment of a director (Distinguished Professor Chris Bowman of Chemical and Biological Engineering) and is making great strides with faculty hiring, selection of faculty fellows and affiliates across the campus, a seed-grants program and approval of MS and PhD degrees.
   - The BioFrontiers Institute was formally approved in 2011. It is directed by Nobel laureate Tom Cech and includes Distinguished Professor Kristi Anseth of Chemical and Biological Engineering (ChBE) as one of its associate directors. BioFrontiers and ChBE, along with Biochemistry, are housed in the state-of-the-art Jennie Smoly Caruthers Biotechnology Building, which opened in 2012. The Institute and building promote interdisciplinary research and education to improve human health and welfare.
   - AeroSpace Ventures (formerly AeroSpace Systems Science and Engineering) was delayed because of the economic downturn but now has new life through the leadership of our Department of Aerospace Engineering Sciences and its chair, Professor Penny Axelrad. The campus has committed faculty lines and funds toward a new building for this initiative, which will bring engineers and scientists together for a systems approach to aerospace research and education.
   - Energy Systems and Environmental Sustainability research has been catalyzed by (i) the formation of the Renewable and Sustainable Energy Institute (RASEI) in 2010, of which half of the initial academic fellows and the Associate Director (Professor Ryan Gill of Chemical and Biological Engineering) are from our college, (ii) the reassignment in 2012 of the former chemical engineering wing of the Engineering Center to be used for energy and environmental sustainability education and research, and (iii) the announcement in 2013 by the campus of plans to form a new school for sustainability and environment, with which we anticipate having synergistic efforts in research and education.

Although progress has met or exceeded our objectives for the six program areas listed above, there are other plans that we have chosen not to pursue or that have been delayed due to resource limitations. In particular, we have set aside plans to form a center for engineering education research and assessment, as funding and the necessary faculty for a
successful center have not been secured. Also, a campus-wide initiative in computational science and engineering has focused on development of computing infrastructure. In our revised plan, we propose to add a programmatic thrust in “Big Data” analytics applied to further strengthen our research expertise in the four areas cited above (aerospace, biotechnology, energy and environment, and materials science and engineering).

RESOURCES

Engineering 2020 laid out a plan for increased institutional support, grant support and private giving to facilitate the plans for growth and new programs. Table 3 shows that good progress has been made. While there were cuts in state support due to the recession, the institutional support for our college has increased due to enrollment and tuition growth. We have doubled the total amount of engineering scholarship awards over the past six years, using a combination of college and gift funds. The number of endowed chairs and professorships and the college endowment have also increased, with one new chair ($2,000,000 minimum) and five new professorships ($500,000 minimum). Moreover, our faculty has been very successful with grant funding, even in a time of nearly flat or declining federal research funds. Figure 2 provides a longer-term view of research grant funding in our college. After a 12-year period of little change, our annual grant support has nearly doubled over the past six years. The endowment value has not increased as fast as projected, because the economic downturn decreased both the investment value and new gifts.

V. Where Are We Going? How Will We Get There?

In this section, we lay out revised goals for the College of Engineering and Applied Science at the University of Colorado Boulder and outline action plans to achieve these goals. Our vision is to be a renowned world leader for excellence and innovation in engineering research and education, ranked in the top 20 among U.S. engineering programs. We will accomplish this vision through active, discovery-based...
learning and a focus on inclusive excellence and engineering for global society. Our revised goals are even more ambitious than those set five years ago in *Engineering 2020: Vision for Excellence*. Table 4 lays out new goals for size, diversity and quality measures. Our aim is to double enrollments from just over 4000 students in 2007 and about 5000 students in 2012 to over 8000 students by 2020, while also increasing student quality and diversity. The case for growth is based on four primary factors:

1. **Student interest:** Applications to our college have doubled in the past six years, at both the graduate and undergraduate levels. The Western Interstate Commission on Higher Education has predicted a 28% increase in Colorado high-school graduates (compared to 9% for the U.S. as a whole) from 2005 to 2022. And, CU-Boulder has initiated recruiting efforts for international undergraduates, with a goal of 10% international students (15% in engineering) by the end of this decade. Our college is also partnering with several Colorado school districts to develop pre-engineering and STEM (science, technology, engineering and mathematics) programs to help interest and prepare more students for these fields.

2. **Employer demand:** The U.S. Bureau of Labor Statistics has predicted up to 62% job growth during this decade for various engineering disciplines. The National Association of Colleges and Employers also reports strong demand for engineering graduates, with the highest starting salaries going to students who majored in engineering or computer science. Anecdotally, most major corporate recruiters at our college anticipate substantially increased hiring due to a combination of company growth and an upcoming bolus of retirees.

3. **Enhanced reputation:** A larger engineering enrollment will help enhance the reputation of our college, as having more alumni increases public perception and various size metrics are positive factors in rankings. Moreover, it will enhance the reputation of our campus as a whole, as engineering students are of high quality, serve society and bolster the economy.

4. **Transformative innovation:** Enrollment growth will bring new resources, which will foster and support innovation and excellence. The associated investments will be transformative, as we develop state-of-the-art facilities and leading-edge programs, helping us to attract the very best faculty and students.

For comparison, Table 4 also provides 2012 peer averages for the public engineering schools with graduate rankings of 21-40 (overall) by U.S. News & World Report, as well as 2012 aspirational averages for the public schools ranked in the top 20.

The aspirational schools, on average, have larger research and

| Table 4 | Current status and new targets for student enrollments, diversity and quality measures, along with increases in faculty numbers. CU faculty counts do not include our humanities faculty or engineering faculty budgeted outside our college. Data are for the fall semester. The peer group and data sources are the same as for Table 2, except the retention and graduation rates are from a preliminary nationwide study, as peer data are not yet available. The aspirational group is composed of the public engineering colleges with graduate programs ranked in the top 20 overall by U.S. News & World Report and includes UC Berkeley, UCLA, UCSB, UCSD, Georgia Tech, Illinois, Maryland, Michigan, Purdue, Texas, Texas A&M, and Wisconsin.

<table>
<thead>
<tr>
<th>2007 Baseline</th>
<th>2012 Results</th>
<th>2016 Target</th>
<th>2020 Target</th>
<th>2012 Peers</th>
<th>2012 Aspirational</th>
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<td>5400</td>
<td>5340</td>
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<td>% Women</td>
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<td>23%</td>
<td>28%</td>
<td>33%</td>
<td>20%</td>
</tr>
<tr>
<td>% URM s</td>
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<td>13%</td>
<td>16%</td>
<td>11%</td>
</tr>
<tr>
<td>% International</td>
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<td>6.0%</td>
<td>10%</td>
<td>15%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Average Composite ACT</td>
<td>28.0</td>
<td>29.1</td>
<td>30.0</td>
<td>30.5</td>
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</tr>
<tr>
<td>Third-Semester Retention</td>
<td>83%</td>
<td>86%</td>
<td>88%</td>
<td>90%</td>
<td>80%</td>
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<tr>
<td>Six-year Graduation Rate</td>
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<td>60%</td>
<td>65%</td>
<td>70%</td>
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<tr>
<td>Master's Students</td>
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<td>PhD Students</td>
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<td>% International</td>
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<tr>
<td># Tenure-Line Faculty</td>
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<td>163</td>
<td>205</td>
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<tr>
<td>% Women</td>
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<td>18%</td>
<td>22%</td>
<td>25%</td>
<td>14%</td>
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<tr>
<td>% URM s</td>
<td>5%</td>
<td>6%</td>
<td>7%</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td># FT Instructional Faculty</td>
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<td>33</td>
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</table>
graduate programs than does our current peer group. Thus, we seek to differentially grow our graduate program and align with the aspirational group. Buildup of the PhD program may extend past 2020 due to the lag in filling a multi-year program.

In the following subsections, we outline broad objectives and plans to meet our growth goals and, more importantly, to advance our vision and core values outlined in Section I.

**HOW WILL WE BUILD INCLUSIVE EXCELLENCE AND DIVERSITY?**

Our overarching objective for people is to attract outstanding and diverse students, faculty and staff and to empower them to succeed. Strategies to meet this objective include:

1. **Branding and Recruitment**: Develop an aligned view of key differentiators for our college and a branding strategy to communicate these differentiators to prospective students, parents, alumni, donors, corporations, faculty and other stakeholders in order to elevate recognition of the excellence of our college and to attract outstanding students, faculty and staff. Establish a comprehensive U.S. and international recruiting strategy for both graduate and undergraduate students, with resources and staff to implement it, to increase student quality and diversity.

2. **Performance and Retention**: For students, implement Global Engineering as our third Residential Academic Program (RAP) in the 2013-14 academic year, expand the first-year projects course offerings, add more math work groups, enhance drop-in tutoring (Student Success Center) for key freshman and sophomore courses, and provide early intervention/consultations with students considering transfer out of our college. For faculty and staff, upgrade orientation programs, expand award recognition programs, support career-enhancement opportunities and jointly develop improvement plans for those with need.

3. **Diversity**: Increase student diversity through strategic recruiting, increased scholarships, new degree programs that attract students from underrepresented groups, support of the BOLD Center and its recruitment and outreach efforts, and expansion of the GoldShirt Program. Increase faculty diversity through targeted advertisements and networking, using a portion of new faculty lines for spousal hires and special opportunities, and by creating a welcoming environment with a variety of support programs and infrastructure.

**HOW WILL ENGINEERING FOR GLOBAL SOCIETY BE ADVANCED?**

Our overarching objective for globalization is to create and nurture innovative research and educational programs to improve global society and prepare our graduates for global citizenship and leadership. Strategies include:

1. **Research Innovation and Excellence**: Develop programs and centers of excellence in key research areas that meet societal needs and for which our college, campus and partners have particular strengths. These areas and differentiators include:
   - **Aerospace** (CU-Boulder excellence and established Colorado industry, with societal applications in communications, environmental monitoring, security and transportation)
   - **Biotechnology** (CU-Boulder and CU system excellence and growing Colorado industry with applications in health care and wellness)
   - **Computational Science and Engineering** (opportunities in “Big Data” that cut across multiple disciplines of CU-Boulder strength and have broad industry need, including aerospace, biotechnology, energy, environment and materials)
   - **Energy and Environmental Sustainability** (CU-Boulder excellence, opportunities with RASEI and NREL, Colorado energy economy and environmental focus)
   - **Engineering for Developing Communities** (CU-Boulder founder of Engineers Without Borders and Mortenson Center in Engineering for Developing Communities, strong global interest of students and corporate partners)
   - **Materials Science and Engineering** (CU-Boulder excellence, foundational area for many disciplines and industries)
2. Educational Innovation and Excellence: Develop new programs that will attract outstanding and diverse students and prepare them to contribute engineering expertise to improve society. New degrees and minors planned include:

- **Big Data** (create professional MS program in analysis and applications of large data sets)
- **Environmental Engineering** (enhance current BS degree and add MS and PhD degrees; national enrollment data show high representation of women in this discipline)
- **General Engineering** (implement BS in General Engineering Plus degree approved to start in 2013-14, with “plus” concentrations preparing engineers to serve society in careers such as teaching, business and health; enrollments with high diversity are expected)
- **Materials Science and Engineering** (implement MS and PhD degrees approved to start in 2013-14, with strong interdisciplinary participation)
- **Technology, Arts and Media – TAM** (expand the popular TAM minor, with over 60% women enrolled, to create a new BS degree in Technology, Arts and Media; leverage it and other academic programs of the Alliance for Technology, Learning and Society (ATLAS) to equip students with technological skills to serve society)
- **Bioengineering and Energy Minors** (create college-wide minors in key areas of student interest and industry need, such as bioengineering and energy, and consider future expansion of these minors to new majors)

3. Global Competency and Business Acumen: Ensure that graduates are globally competent. Establish partnerships with international institutes so that study-abroad engineering students can stay on track with their degree programs. Support implementation of the new Global Engineering Certificate and RAP. Integrate the global nature of engineering in the core curriculum. Hire a full-time staff member to coordinate these efforts. Also ensure that graduates have strong business acumen. Work with the Leeds School of Business to develop engineering-business collaborative programs such as the new business minor plus, and/or further expand the role of the Engineering Management Program at the undergraduate level and market this effort to more fully communicate its offerings. Provide engineering project economics knowledge for all students.

**HOW WILL WE PROMOTE ACTIVE LEARNING?**

It has been known for over 2500 years that students learn by doing (I hear ... I forget, I see ... I remember, I do ... I understand – Confucius, c 500 BC). In addition to laboratory courses and a healthy dose of homework in traditional courses, our innovations to promote active learning include:

1. **The Idea Forge**: Create an Idea Forge in the Fleming building as a new facility for students to design and build...
hands-on, team-based projects, whether associated with a course, a student society or competition, or the imagination of individual students. Include open, flexible “makerspaces”, supported by electronics, rapid prototyping and machine shops for student use.

2. Discovery, Professional and Service Learning: Expand opportunities for discovery learning by involving more undergraduates, as well as graduate students, in faculty research laboratories. Work with key corporate partners to expand co-ops, internships and other professional-learning opportunities. Grow the earn-learn program and the Engineers Without Borders student chapter to provide more students with service-learning experiences.

3. Blended Learning: Develop and use on-line resources to supplement classroom learning. Use “flipped” classrooms to provide active-learning experiences during class meetings. Make selected courses available on-line, especially for students who are away from campus during summer or on a study-abroad or internship experience.

HOW WILL FACILITIES NEEDS BE MET?
In addition to needing more space to accommodate growth, we need better space with different configurations than we have had in the past. For example, with increased undergraduate enrollments coupled with our emphasis on active learning, there is a need for larger, flexible classrooms and student-project areas. Similarly, modern laboratory designs and facilities are needed for state-of-the-art research in areas such as aerospace, biotechnology, energy and environmental sustainability, and materials science and engineering. New building projects for meeting these needs include:

1. Biotechnology Building: Finish the shelled classrooms and teaching labs of the Jennie Smoly Caruthers Biotechnology Building on East Campus, and construct a fifth wing for this building. The classrooms will help meet growth needs, while the teaching labs will promote hands-on learning. The fifth wing will have an active-learning theme, including an active-learning classroom at its core, surrounded by laboratories that facilitate interdisciplinary research and discovery learning by graduate and undergraduate students. State funding has been committed to complete the shelled classrooms and teaching labs in late 2014, and the campus has committed funds to design the fifth wing and requested state funding for its construction in 2016.

2. Aerospace Building: Construct a modern Aerospace Building on East Campus, of sufficient size to house the Department of Aerospace Engineering Sciences and provide for interdisciplinary collaborations and active, projects-based learning. Our goal is to complete construction by 2017 with a combination of campus, college, state and private funds.

3. Fleming Building: Convert the former law library in the Fleming Building into the Idea Forge, and integrate it with adjacent office and study space, with infrastructure upgrades and a visually impactful design and “wow” factors to create an engineering functionality and identity that facilitate active learning and elevate the perception of our college. The goal is to open the Idea Forge in late 2014, with renovations covered from a combination of college funds and private gifts. In addition, support the proposed move of Applied Mathematics to the Fleming office tower, which would further strengthen the Fleming building as an academic community for engineering students and also free up about 7000 asf in the Engineering Center.

4. Sustainable Energy and Environment Complex: Move environmental engineering and selected RASEI fellows to SEEC. Propose a 50,000 asf expansion of SEEC to house the rest of the Department of Civil, Environmental and Architectural Engineering by the end of this decade.

Table 5 provides a summary of how these buildings will meet space needs due to proposed growth. Also included is current space for the ATLAS Institute, which joined our college in 2013. A key feature of the space plan to accommodate doubling of engineering enrollments is the relocation of three departments (Aerospace, Chemical, Civil) to new facilities on East Campus during this decade.

The classroom space in Table 5 does not include campus-scheduled classrooms used by our college. Planning to add campus-scheduled classrooms lags behind the rapid growth in engineering enrollments, and so we propose two additional strategies to make effective use of existing
classrooms. We also plan to undertake major renovations of the Engineering Center and to establish new research facilities in existing space.

5. Educational Facilities: Expand daily class schedules and the Integrated Teaching and Learning Lab (ITLL) hours to include more early morning and evening courses, open department-controlled classrooms for college-wide scheduling, develop cloud-computing and laptop solutions to free computer labs for other needs, pilot on-line courses and use on-line materials to supplement classroom experience, and consider expanding the ITLL.

6. Summer Session: Establish summer session as a legitimate “semester” of engineering study, develop a financial model that incentivizes faculty and departments to participate in summer session, include more core and other high-demand engineering courses and lab/design courses in summer session, and broaden summer financial aid to encourage student participation.

7. Engineering Center Renovations: Work with campus leadership to develop and fund a plan to make strategic renovations of the current Engineering Center over the next ten years. This building complex is nearly 50 years old and has many outdated features (such a small classrooms and labs) that are not well-suited for active learning and modern engineering education and research.

8. Research Facilities: Develop and fund a competitive process for supporting centralized research facilities with specialized equipment. A potential source of funds is to make a slight reduction in tenure-line faculty hiring and use the savings from salaries and start-up packages.

WHAT NEW FINANCIAL RESOURCES ARE REQUIRED?

Table 6 provides revised financial resource goals for our college, in addition to funding the capital projects described above. The general-fund support, which is primarily derived from tuition, will require a much steeper increase than proposed five years ago (see Table 3), because of the accelerated growth of enrollments in our college. Campus leadership approved in 2012 a plan submitted by the Dean to build a continuing increase of $12 million (plus inflation) into the annual budget of the College of Engineering and Applied Science over a nine-year period, based on 50% growth from 2007 to 2020. With a revised growth goal of 100%, an additional $13 million in continuing annual funding will be needed. These funds will be used to increase faculty, staff, teaching assistants, student aid and operating budgets.

As seen in Table 6, we propose to grow our scholarship awards even faster than outlined in Engineering 2020, to attract and support a larger number of talented and diverse students. Starting with the 2013-14 academic year, the campus is adding merit-based scholarships for the top 25% of admitted freshmen, further increasing our ability to attract outstanding students. We also propose to grow our endowment support for students, faculty and other needs. To achieve these goals, we plan to expand our Engineering Development team, equip it with marketing tools that detail the differentiators of our college and provide major naming opportunities for buildings, departments and the college. Finally, we have increased our target for research grant

<table>
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<th>2012-13 Actual</th>
<th>2016-17 Target</th>
<th>2020-2021 Target</th>
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<tr>
<td>CU Engineering General Fund</td>
<td>$43 M</td>
<td>$56 M</td>
<td>$75 M</td>
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<tr>
<td>Engineering Scholarships</td>
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<td>Endowed Chairs and Professors</td>
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<td>College Endowment</td>
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<td>$135 M</td>
<td>$180 M</td>
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<tr>
<td>New Research Awards</td>
<td>$72 M</td>
<td>$90 M</td>
<td>$135 M</td>
</tr>
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Table 6 Current status and new goals for financial resources to support enrollment growth and new programs in the College of Engineering and Applied Science. Amounts are in current dollars, with 2.0% inflation assumed for future amounts.
awards, though near-term continued growth in this area will be a challenge due to reductions in federal spending. To meet the higher target, we will provide additional support to faculty for proposal preparation by increasing our investment in the Office of the Associate Dean for Research.

VI. What Challenges Might We Face?

Of course, meeting the ambitious goals of this refreshed strategic plan and obtaining the resources to support the proposed growth will face challenges from various fronts, including but not limited to:

DECLINING STATE AND FEDERAL SUPPORT
State support has already declined to only about 3% of our annual college budget, and we have made adjustments through expenditure reductions and increased tuition and enrollments. However, if state support for capital projects is not available in the near future, then there will be considerable challenge for new building construction to support growth. In particular, we will need to rely more on private support from individuals and corporations, which will require strong differentiators, marketing and development efforts. On the other hand, if there are reductions in federal research funding, then we will face challenges in meeting goals for research awards and in growing graduate enrollments, as federal dollars account for over 70% of our research award total and are the primary vehicle to support graduate students. Additional investment in proposal and research infrastructure and in corporate partnerships will be needed for continued growth in research awards.

COMPETITION FOR TOP STUDENTS
As state support for higher education has declined across the country, we expect more schools to compete for the best out-of-state students. We also expect more top Colorado students to consider out-of-state options. Moreover, while our undergraduate engineering enrollments have grown by 25% since 2007, nationally they have grown by 26%. Thus, it will be a significant challenge to simultaneously grow in student numbers, quality and diversity, and we will need better scholarship support and marketing of our differentiators for CU to be an engineering school of choice for top students. We are also seeing increased competition for top graduate students in engineering, and so the availability of fellowships, assistantships and modern facilities is key to successful recruiting efforts.

COMPETITION FOR TOP FACULTY
Similarly, as engineering schools grow across the country (and world), there will be increasing competition for top faculty members. We expect this competition to occur at both the level of Assistant Professor, as schools add fresh talent to educate increasing numbers of engineering students, and at higher ranks, as schools seek to attract successful faculty members from other institutions and expand their research portfolios. To compete as a top-tier engineering program, we will need competitive salaries and startup packages, modern facilities, outstanding students, and endowed chairs and professorships.

ONLINE EDUCATION
The rise of MOOCs and other online education vehicles has been seen by some people as a “threat” to institutions of higher education, in the sense that the consumer (i.e., students) can receive an online education at lower expense than in a traditional setting. While we agree that a fully online education is appropriate for some individuals (e.g., members of the public interested in life-long learning or non-traditional students or working professionals seeking advanced degrees or certificates, such as we already offer through the Center for Advanced Engineering and Technology Education), our primary focus will be the use of online technologies to improve the education of our own students. One example is blended learning, where students watch online lectures or short screencasts on their own time, and then scheduled class time is used more for interactive learning, discussion and problem solving – elements of the much-studied “flipped” classroom. Another example is students taking an occasional course through online distance learning, such as during the summer or to provide flexibility to undertake internships or study abroad without falling behind in a course sequence.

LACK OF INVESTMENT
Doubling enrollments will require substantial campus investment in both buildings and personnel. With reductions in state funding, pressures to keep tuition affordable and enrollment declines in some other fields, there is potential that the necessary investments in our college will not be made. This scenario would result in a more modest growth for our college and would curtail transformational change.

VII. Concluding Remarks
Our new goals of doubling enrollments by the end of this decade and being ranked among the top 20 U.S. engineering programs are ambitious. As we set our sights on these goals, our efforts will be underpinned by our core values of inclusive excellence, active learning and engineering for global society. With strong leadership and will, we are confident that success can and will be achieved, and we look forward to this success and broad recognition for excellence and innovation in engineering research and education.
From the Chancellor

Dear CU Family and Friends:

It is an honor to endorse the refreshed strategic plan of the College of Engineering and Applied Science at CU-Boulder. The college has made important innovations in engineering research and education over the past five years, surpassing nearly all of its goals. It is the top engineering program in the Greater Rocky Mountain Region, and one of the best in the nation. During my 13 years as Provost and now Chancellor, it has been a pleasure to watch the College of Engineering and Applied Science grow and create new, leading-edge programs. The refreshed Engineering 2020 plan reflects even greater innovation and ambition, and is well in tune with the campus Flagship 2030 plan. I very much look forward to its success.

Philip P. DiStefano, Chancellor
University of Colorado Boulder

PS: Those sticky notes? Love them! And note #6 translated: Go Global ... create dual degrees, internships, projects and study-abroad programs for engineering students with international vision.

8. 200 Assistantships
... raise support to permanently fund 200 new graduate assistantships to attract and empower the world’s best grad students to pursue their dreams

9. “Sumester”
... elevate summer session for students to catch up, get ahead, or explore nontraditional courses — including online options that reach around the world

9x759"Sumester"
... elevate summer session for students to catch up, get ahead, or explore nontraditional courses — including online options that reach around the world
10. Be innovative.
   Be surprising.
   Be bold.

Be Boulder.