Responses to 2016 EPEAB recommendations

The sections below contain the relevant sections from the 2016 EPEAB report (in *italic*), followed by the responses and/or updates from the local Engineering Physics Program Committee.

University-wide budget cuts represent a significant threat

Issue: *The EP program, like the Physics Department and other Departments in general, will be impacted by the budget cut at NMSU. The Department of Physics operates on a very lean overhead. As such, budget cuts will directly translate to Department or Program impacts. Past budget cuts have impacted both Teaching Assistant and Research Assistant hires – that then ultimately caps the number of students in Department programs. However, from 2005 to 2015, undergraduate student enrollment—both within the EP program and Physics Department wide-increased by between 300 and 400 percent. However, future undergraduate enrollment will likely be capped due to budget cuts or reductions.*

Recommendations: *While it is hoped that the administration will recognize the out-sized value of the EP Program in terms of its ultimate impact on economic activity in New Mexico, and limit this reduction, there are avenues available to increase research revenues in support of faculty and students through two principal paths:*
1) Increase success at competing for government research grants.
2) Form strategic partnerships with New Mexico government and industrial research institutions.

With respect to funding, it is the sense of the Committee that professors in Physics, as in other Engineering Departments are putting significant effort into grant writing with demonstrated successes. How the "success rate" of grant proposals could be increased should be a strategic discussion among the Department Faculty. On partnerships within the government sector, the two largest National Laboratories in the US are in New Mexico. While there presently exists valuable collaboration between Los Alamos and Sandia National Laboratories (SNL) research staff and NMSU faculty, for example, between the SNL Center for Integrated Nanotechnologies and the Chemical and Materials Engineering Department, the Committee recommends continued development of additional strategic alliances. Both Los Alamos and Sandia face staff demographics where approximately 25% of the work force will have to be replaced over the next 5 years (e.g. 2000 employees at Los Alamos). Hiring across all Laboratory functionalities (technical staff, support staff, etc.) will require significant recruiting. NMSU should position itself as an important skilled labor source for this purpose. Here, the Committee believes that the skills afforded EP graduates will be of high value to fill National Laboratory positions.

Another avenue for an NMSU Strategic Alliance with Los Alamos is through the contract re-competition process slated to begin in 2017. Here, negotiating with the National Nuclear Security Administration (NNSA) by way of the New Mexico Congressional Delegation could ensure that the new contract values Laboratory support of New Mexico Institutions of Higher Education through research and teaching partnerships.

Response 1:

Several prestigious federal laboratories are located in New Mexico, including Los Alamos National Lab, Sandia National Labs, AFRL, NASA, and White Sands Missile Range (Army Research Lab). At both the institutional and the individual researcher level, NMSU is engaged in significant efforts to leverage the strengths of these labs for education and research. The former Vice President for Research (VPR), Vimal Chaitanya, tried (unsuccessfully) to increase NMSU's collaboration with Sandia through a consortium of universities for managing the Sandia and/or Los Alamos National Labs. On the other hand, an educational partnership agreement with AFRL was recently renewed. The former VPR and department head (DH) Zollner are board members of the New Mexico Consortium, a non-profit NGO to increase interactions between Los Alamos and the three state research universities. The former VPR and a group of DHs visited White Sands (ARL) two years ago to explore research areas of common interests. Groups of NMSU students visited NASA on a few occasions. So far, these institutional attempts have not resulted in significant benefits to EP, because the interests of the labs often fall elsewhere (range management and ecology, astronomy, civil engineering, etc).

At the departmental level, Vasiliev spent a semester on sabbatical at Sandia National Labs, and Zollner hopes to spend his sabbatical at AFRL. Zollner and Fohtung have active projects at CINT (Center for Integrated Nanotechnologies). In addition, Ni and Hearn used to have a collaborative research project with LANL and AFRL. Most importantly, the Department of Physics hired five faculty members (Nakotte, Urquidi, Fohtung, Wang, Cooper) to collaborate with Los Alamos scientists on projects of interests to LANL.

In the recent years, NMSU's successes to leverage the strengths of the national labs have declined. Student internships at those labs are very selective, highly competitive and typically mission-driven. The labs tend to hire from institutions that have a stronger research infrastructure. Since NMSU is a land-grant minority-serving institution, our students and faculty have a difficult time competing with prestigious out-of-state universities. In fact, the return-on-investment for departmental expenditures to build connections with federal labs in the state could definitely be improved.

On the other hand, our graduates are generally very competitive for permanent employment positions at national labs, contractors (like Raytheon), and private sector employers. The reduced commitment of the labs in the state is a significant problem, as it results in a smaller number of graduate and undergraduate internships for our program. Current budget woes of funding agencies add to this problem.

Increasing the success of NMSU faculty to obtain external research grants is not within the department's direct control. Given the state support for NMSU and thus NMSU's support for research, our faculty is often not competitive with more affluent institutions. Despite the low grant-proposal success rates, most physics faculty regularly submits proposals to federal agencies. Moreover, many grant opportunities are limited by an internal competition within NMSU, where the physics department only occasionally succeeds. As a minority serving institution (MSI), NMSU has benefitted from some DOD funding earmarked for HBCU/MSI

institutions. Unfortunately, similar programs are less common within DOE and NSF, and HBCU/MSIs often have a much lower success rate than majority institutions, which are able to write stronger proposals with stronger institutional support.

Increasing burden of program coordination:

Issue: *Past EPEAB Committee reports have highlighted the increasing need for funding administrative support to the growing EP Program. EP is a complex program. While this comes with high overhead demands, as previously demonstrated, it also produces greater positive impacts, both economically and technologically. EP is integrated across two colleges and multiple disciplines, and is accredited. Maintaining accreditation (which is highly recommended) represents an additional burden which is currently borne by faculty. Additional Program-related activities include recruiting, advising, curriculum development and coordination, academic program review, orientation of students, participation in meetings and events in the College of Engineering, and extracurricular activities. The EP Program has had no separate funding for program coordination since 2010; additionally, there is no faculty release time budgeted for EP Program work.*

Recommendation: *The EPEAB again recommends that the University administration recognize the return on investment and find additional resources to restore EP Program coordination funding.*

Response 2:

Over the last two years, both colleges (Arts & Sciences and Engineering) lost significant resources (especially staff positions) due to the budget cuts. For example, the Physics Department lost its fiscal assistant position and each college lost at least one records clerk. Additional staff positions may be lost in colleges and departments with cuts to be imposed by Team 6, an NMSU entity that is tasked to explore budget-reduction options. No faculty member from Physics has been appointed to Team 6.

The loss of permanent departmental and college staff positions has required the department to use discretionary funds to pay for temporary staff. This reduces the availability of operational funds for educational programs, such as student travel, instructional lab supplies and equipment, and faculty development. In part, this loss of funds was compensated by a new engineering technology fee which pays for our instructional labs. For the remaining staff position and for the department head, the workload has increased significantly, since the colleges (especially engineering) have pushed some tasks from the college to the department.

Even maintaining the *status quo* and preventing further losses seems like a long shot at the moment. It is not likely that we will be able to obtain two staff positions for the department given present budgets, one to recover our lost fiscal assistant position and another to gain an engineering physics program manager.

Possible mandated reduction in credit hours for degree completion

Issue: A proposal is under consideration that would mandate a reduction in the minimum number of credit hours required for graduation for all programs at NMSU (and other NM Universities). The current EP requirement is 128 credits, which is proposed to be reduced to 120. This one-size-fits-all proposition is purportedly directed toward making any degree achievable in four years.

NMSU's requirement of 128 credits for award of an EP degree is already below the median of peer institutions offering the BSEP degree. Additionally, the unusually heavy Core Curriculum (CC) and Viewing the Wider World (VWW) requirements at NMSU (43 credits) are higher than at peer institutions (30-37 credits). This further dilutes the number of critical Engineering and Science credits needed for success.

Statistics maintained by the program show that the average number of credits earned by a BSEP graduate is 168, with only one student graduating with fewer than 130. While a portion of the additional work is generally attributable to rectifying insufficient math preparation, several other reasons should not be overlooked: Because of the rigor of the EP program, students often elect to acquire additional minors, particularly in math, which only requires two additional courses. Other students opt for double majors. While the statistics explain in what courses additional credits were earned, the EPEAB spoke directly with 21 current and former EP students for their perspective on 'why'. The answer given to the board was uniform and strong: These students either felt their performance in upcoming classes would benefit with the additional coursework, or more often, that they had special technical interests for which they wanted additional knowledge to prepare themselves for career choices. The baseline program was seen as too sparse to support their personal goals. No student interviewed expressed that reducing the number of required credits would benefit them, or result in them graduating sooner. Therefore, any university-wide reduction in required credits is unlikely to have a substantive effect on the EP Program's four-year graduation rate.

Recommendation: *The EPEAB strongly recommends against deleting any core engineering or science requirements from the curricula for the degrees in Engineering Physics. However, because of the ever-changing content of courses in both colleges, due diligence should be given to the few opportunities where some course content may overlap. While the EPEAB did not have the necessary insight for a full review of every course, a few areas to look are offered: There may be some potential overlap in Math 392 and Phys 395 which might be combined, and depending on the prerequisite needs of AE 424, some content of AE 362 might be reduced or eliminated. If a reduction in CC or VWW requirements is realized, this may provide a means to alleviate some pressure on the curriculum, and provide students with an opportunity to pursue internships during their course of study.*

The EPEAB concurs with the EP Committee's 2014 response: "…that while the reduction of the total number of credits for the Engineering Physics Program is desirable, this reduction should not come at the expense of core engineering, physics, and math courses. The best solution would

be to reduce the number of General Education and Viewing the Wider World (VWW) credits required for all majors."

Response 3:

There is continued persistent pressure from NMSU's Board of Regents and the university's upper administration to develop a 120-credit-hour curriculum for all degree programs, and most programs (including some engineering programs) have changed their curriculum accordingly. On the other hand, the EP Program Committee and with most other engineering programs strongly feel that a reduction to 120 credits greatly jeopardizes the quality in achieving the expected expertise of program graduates, given the current constraints due to ABET and GenEd/VWW. Changes to GenEd/VWW were expected to be in place by now, but no final decisions have been made yet. A complicating factor is that the changes in GenEd/VWW are a state-wide effort, which needs to be agreed upon by all NM institutions. The university-wide task force hasn't fully settled on how to achieve the revised goals and outcomes of GenEd/VWW requirements, but the task force seems to embrace discussions on an 'effective reduction' through a re-design of GenEd/VWW components, such that it can be offered through program-specific offerings.

Aside from GenEd/VWW, all engineering programs (including EP) re-visited their program requirements, and this often resulted in substantial changes and modifications to better streamline each program, without affecting the program quality. Obviously, changes made by our engineering counterparts (AE/ME, ChME and EE) for their majors led to changes in the curriculum of our EP concentrations, in addition to other modifications/equivalencies that were agreed upon. It should be noted that such changes didn't result in any reduction of credit hours for the EP program. The changes are reflected in the updated flow charts that will be available prior to the EPEAB meeting, and they will be discussed in greater detail at the meeting.

Another more recent effort is the proposal to combine all engineering capstones into one college-wide capstone, therefore allowing students for different engineering disciplines to participate in the same capstone, regardless of their actual major. The college-wide engineering-capstone task force is co-chaired by Heinz Nakotte and Gabe Garcia (ME).

Internships and the effect on timely graduation

Issue: Despite the outsized impact of the EP Program, small programs can be affected by small operational issues. Here, in talking principally with students, class availability and phasing are issues that should be on the radar of the administration. Specifically, the availability of core courses and associated pre-requisites directly affects the time required to complete the EP degree. In several EP focus areas, there is virtually no way to accommodate a semester slip of a "critical path course", without delaying the degree by one year. For example, the ability of students to perform "field internships" was deemed by the committee of high-value to EP student education. We understand the constraints in faculty availability for teaching core courses. Nevertheless, perhaps a more proactive alternatives process, where students could petition for

using other available courses of suitable subject matter to fulfill core course requirements could help with this issue. Here is an example where the reduction in program coordination between departments during curriculum change negotiations creates difficulty.

Recommendation: The physics department is working hard to help students navigate the required EP course schedules, but a more systemic and collaborative solution involving the College of Engineering Faculty is recommended. Improved coordination during curriculum changes is a key element of this.

Response 4:

The Department of Physics does receive occasional internship announcements from a variety of entities. Those are forwarded by e-mail to all undergraduate students (EP and physics), advertized on the Undergraduate Bulletin Board, and a folder with internship application materials is kept in the departmental office. Another avenue of securing internships is the Annual Career Fair at NMSU, and we have always encourages students to attend it.

To date, however, the EP program has had no formal mechanism to keep track of summer and other internships that our EP students may have participated in or unsuccessfully applied to. In preparation for the 2017 EPEAB meeting, we sent out several survey requests to our undergraduate students to see who of those have had an internship. The response was marginal at best, and therefore our current assessment in that field is limited to mostly 'anecdotal' information. Two of our stronger EP students have complained that they applied for internships each summer, but with no success. This is a somewhat disturbing result, and it may be taken as an indicator that internships are often awarded based on personal contacts with the granting entity rather than upon competitive evaluation of an applicant's credentials. At present, the Department of Physics has only limited contacts and connections for a successful internship program.

On the other hand, we are aware of previous or upcoming internships for several of our undergraduate students, such as Jaime Moya (Sandia National Laboratories - Explosive Dynamic and Reactive Science Group; summer of 2017) , Taylor Uselman (BRAIN program, University of Colorado – Denver and NMSU, summers of 2016 and 2017), Michael Kaemingk (CERN, summer 2017), Rachel Ridgeway and Lauren Penera (both, NM Alliance for Minority Pariticipation). Moreover, several of our students have worked on research projects with NMSU's Astronomy Department throughout a semester and/or summer.

In future, we will rely on the advisors to ask students about internships during the advising sessions, which are scheduled at the end of each semester.

Improving opportunities for undergraduate research:

Issue: Successful undergraduate research experience is strongly correlated with professional performance. Past EPEAB reports have highlighted a need to provide on campus undergraduate research opportunities for EP students. Support for undergraduate opportunities in the Physics Department has varied with the funding environment and faculty tenure. Currently, opportunities for on-campus physics research are at low ebb. While this is not likely a permanent condition, this situation highlights the need and recommendation to continuously pursue external opportunities for students as an option.

Response 5:

We inquired with all faculty involved in the EP program about (EP or physics majors) undergraduate involvement in their respective research projects. Six physics faculty members (out of 14) and one engineering faculty responded and reported that they involved undergraduates in research in the last two years. Other faculty either didn't involve undergraduates in their research or ignored the request.

Based on the responses, the total number of our undergraduate students involved in research currently or recently is 20; almost all these students are juniors and seniors, so compared to the total number of juniors and seniors in our combined EP and physics programs (14 juniors and 43 seniors), this is 35% of the relevant population. In other words, there are ample opportunities for undergraduate students in our program to get involved in on-site research activities, and our students make use of it.

Following below are the actual (unedited) reports about the extremely diverse set of projects our undergraduate students are engaged in.

Lauren Waszek: I am currently working with Zoe Burns, who is using seismic data to explore the super rotation of the inner core. The novel part of this work with regards to previous studies is that she is using data with much shallower ray paths through the inner core, meaning we have greater constraint over the geodynamical processes which formed the region, and fewer differences between the ray path of interest and the reference ray. Next semester she will work on a separate project, testing a Python code that models growth, rotation, and translational modes of the inner core, and comparing the output parameters (age, growth rate of material) to real seismic data. The projects are still in early stages, but I suppose something noteworthy is that Zoe was very informed about the types of projects she was interested in pursuing, and self-motivated to perform independent research.

Robert Cooper: I have had 2 UG students work for me: Michael Kaemingk and Corey Boehm.
-- Michael Kaemingk (EP - EE student), graduates spring '18.
Michael has worked with me since spring '16. He has focused on slow control electronics development with ZedBoards and Arduinos. He went to Indiana U. in summer '16 to help assemble a 35-kg LAr detector for COHERENT. It is operational at ORNL. He has presented his work at APS DNP and APS 4CS-TS. He is also an AMP scholar for this school year. Finally, he will go to CERN to participate in an REU program.
-- Corey Boehm (Physics student), graduates spring '18 .
Corey started working with me at the start of this semester (spring '17). So far he has setup my Linux system and is working on CAEN electronics and digitizers. As the semester progresses, he will work on my neutron detectors to develop a neutron imager downstairs. He is currently applying to 6-8 REU programs at the moment to (hopefully) work on something astronomy related.

Stefan Zollner: Between summer 2015 and spring 2017, I had the following seven undergraduate students:
-- Dominik Martens: Dominik and Troy are working on a setup this spring (2017) to allow steam oxidation of silicon with wet oxygen using our rapid thermal annealer. Previously, we have only oxidized silicon and germanium using dry oxygen. They have ordered parts and I hope that the setup will be completed and tested by the end of the spring 2017 semester.
-- Troy Powell: See Dominik
-- Jacqueline Cooke: Jackie has worked on the optical properties of complex metal oxides, especially the temperature dependence of the band gap of LSAT. She attended the AVS International Symposium in Nashville, TN, last November and gave a talk about her research. She also gave talks at the APS Four Corners Section Meeting in Las Cruces in November 2016 and at the New Mexico AVS chapter meeting in Albuquerque in May 2016. She was also a coauthor on two journal articles (with Nathan Nunley and Nalin Fernando) on the optical constants of LSAT and the temperature dependence of the interband critical points of germanium.
-- Alexandra Hartman: Alexandra Hartman studied the crystal structure of complex metal oxides (based on Ni and Co) over the summer 2016, but unfortunately the films produced by our collaborators were not very good. She also helped some UTEP students perform XRD and ellipsometry measurements on similar samples produced at UTEP. Recently, I asked her to step in as SPS President and lead our departmental K-12 outreach and recruiting efforts, which has not given her much time for research. She also maintains our ellipsometry and SPS web sites.
-- Jaime Moya: Jaime has investigated the optical and structural parameters of thin layers of ZnO and SrTiO3 using ellipsometry and x-ray reflectance. He has become an expert in x-ray reflectance. He has also produced thermal oxides on Ge. He regularly visits Sandia National Lab to perform infrared ellipsometry measurements for our group on various materials. His research has been supported with a fellowship from NM-AMP. In March 2017, he attended the 2017 Emerging Research National Conference in STEM in Washington, DC, and gave a talk . He also had a poster at the AVS International Symposium in November 2016 in Nashville, TN. He gave talks at several other conferences and was a co-author of ten talks and posters given by other students. Jaime and I attended the National Mentoring Community conference in Miami, FL, hosted by the American Physical Society. He was a coauthor of a journal article (with Nathan Nunley as the first author).
-- Khadijih Mitchell: Khadijih Mitchell performed ellipsometry measurements on complex metal oxides, especially CeO2 and Co3O4. She attended the International Conference on the Physics and Chemistry on Semiconductor Interfaces (PCSI) in 2014. She was a coauthor of a journal article on Co3O4. She was also a coauthor of eight talks and posters at conferences. She later lost interest in condensed matter physics and became SPS President, where she led our K-12 outreach and recruiting efforts. She also created our ellipsometry web site http://ellipsometry.nmsu.edu.
-- Yatzary Sanchez: Yatzary was a physics freshman. I invited her to join our research group and perform ellipsometry measurements. Because of poor grades and personal issues (mother's divorce), she did not do much research. She recently left our program to move to Houston with her mother.

Matthias Burkardt: I worked with Waverly Gorman. She made some movie animation illustrating how initial/final state interactions affect spin observables. She did some 1+1 dimensional toy model calculations studying how quark distributions in a BB-molecule differ from those in two widely separated B-mesons. What she found is that the difference looks remarkably like the EMC effect. The results were presented at the 4CS meeting (I gave short talk since she took physics GRE on that day), at Spin 2016 (Waverly presented poster), HUGS 2016, women in physics conference (poster), and one more occasion which I forgot (poster). The results are published in the proceedings for Spin 2016 and a longer paper is in the works.

Edwin Fohtung: I have worked with the following undergraduate students within the last two years: Douglas Brown, Oscar Jaramillo Perez, Alejandro Salas, and Rachel Ridgeway.

-- Douglas Brown: Worked on phase retrieval algorithm for the reconstruction of lattice and atomic displacements in highly strained nanoparticle. Douglas was awarded a financial aid of $500 USD for his poster and also additional travel support to the International Workshop on Phase Retrieval and Coherent Scattering in Chicago. Douglas also worked as in intern in the theory and software group at Oakridge National laboratory.

-- *Oscar Jaramillo Perez and Alejandro Salas:* Both of these folks worked on the probing of Magneto-electric transport properties in perovskite nanostructures. They both built a 3D- capacitor cell that can be used to probe electric field induced magnetization and magnetic field induced electric polarization in hexaferrites nanoparticles showing room temperate quantum-spin liquid Like behavior.

-- *Rachel Ridgeway:* Received an Undergraduate Research Scholar (URS) support to work of Fourier Ptychography. In this project, Rachel is expected to perform 3D imaging of bio-materials using an approach that defeats the diffraction limit by achieving finer than half of a wavelength resolution.

Stephen Pate: Alistair McLean worked with me for three summers at Fermilab. During that time he worked on three different topics. The first was the construction of a cosmic ray detector that was placed in the experimental hall that would later contain the MicroBooNE liquid-argon time projection chamber. The NMSU team measured the flux of cosmic rays in the hall and verified that the commonly accepted cosmic ray simulator gave the right flux. The second project involved the detailed testing of the optical properties of wavelength-shifting plates in a bath of liquid argon. The third project, the most significant of the three, was the development of a 3D virtual reality app illustrating neutrino interactions inside the MicroBooNE liquid-argon time projection chamber. This app has been used by many visitors to Fermilab and in particular was viewed by DOE Secretary Ernest Moniz.

Steve Stochaj: EP students, Mike Lopez, Cameron Radosevich, Nate Nunley and Juan Treto worked with me in the NanoSat Lab.