

## **Application to Establish a Dual M.D.-M.S. Program in Medicine and Aerospace Engineering (Bioastronautics specialization)**

### *Participating Departments and Institutes:*

CU Anschutz, School of Medicine

CU Boulder, College of Engineering, Ann and H. J. Smead Department of Aerospace Engineering Sciences

### *Submitted by:*

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CU Boulder: Allison Anderson, Ph.D.

### 1. Bioastronautics and Space Medicine in Colorado

In 2019, NASA accepted the mandate to land the first woman and next man on the Moon within five years. These missions are a prelude to a human mission to Mars, the most complex technological feat our species has ever contemplated. Such missions will involve challenges that push humans to the extremes of their physiology, demanding spacecraft engineering and design beyond any current precedent in human spaceflight. To maintain human health and performance, the systems required for these missions will necessitate educating students with a multidisciplinary perspective. The University of Colorado, with a world-class Department of Aerospace Engineering Sciences on the Boulder campus and School of Medicine (SOM), is uniquely positioned to educate the experts that will lead this monumental undertaking.

In 2017, faculty from the CU Boulder Smead Department of Aerospace Engineering Sciences and CU Anschutz Medical Campus began a partnership to develop and offer a course merging space, wilderness, and emergency medicine with aerospace, biomedical, and systems engineering. Past CU President Benson referred to this course and our burgeoning initiatives as one of the “highlights of my time here, a sampling of the many things that captured my attention and speak to who we are and what we do.” This successful course was the catalyst for moving forward to establish a more formalized partnership and develop a dual M.D.-M.S. degree in Medicine and Aerospace Engineering, proposed herein. We see this effort as an extension of ongoing efforts to also further establish ties between our educational curriculums.

CU Boulder’s Aerospace Engineering emphasis in Bioastronautics is one of the leading academic programs for this discipline. Bioastronautics encompasses biological, behavioral and medical aspects governing humans and other living organisms in a spaceflight environment; and includes design of payloads, spacecraft habitats, and life support systems. In short, this focus area spans the study and support of life in space. Nineteen CU Boulder affiliates have flown in space as NASA astronauts, two of whom currently serve on our faculty, making CU one of the nation’s top five non-military schools for producing astronauts. The Bioastronautics group houses the FAA Center of Excellence for Commercial Space Transportation and is a participant in the NASA Space Technology Research Initiative to develop next generation smart spacecraft habitats.

CU Anschutz adds a wealth of experience in the clinical care of humans in remote and extreme environments through the Department of Emergency Medicine’s Wilderness and Environmental Medicine Section. Two principal faculty (Easter, Lemery) from the CU Anschutz Department of Emergency Medicine hold leadership roles within the NASA Human Research Program’s Exploration Medical Capability Element, which is charged with advancing medical system design and human health and performance for exploration missions to deep space. The same CU Anschutz

group also leads the medical support and logistics for the National Science Foundation's Polar Research Program, and formerly the NSF's United States Antarctic Program.

## 2. Program and Statement of Need

We propose an interdisciplinary dual M.D.-M.S. degree program, incorporating experts in medicine, engineering, spaceflight, education, analog simulation, and remote environment expedition support. The program aims to support clinical, educational, research, and design projects intended to serve research and development in the most extreme environments on and off Earth, leveraging our connectivity with NASA, both front range-based and national private space companies, and the recently re-established Colorado-based United States Space Command (Air Force).

The goal of this program is to educate the next generation of leaders in human spaceflight. We have identified a growing need within the larger human spaceflight community for physicians with engineering backgrounds to inform and lead NASA's exploration missions as well as the rapidly expanding commercial spaceflight industry (e.g., SpaceX, Virgin Galactic, Blue Origin, Sierra Nevada, etc.). Many of these industry leaders have a significant presence here in Colorado. Currently, there are no established educational programs in the United States with such a mission, and we believe that a CU-based dual program would serve as a world-class incubator for such talent, and draw educational and research opportunities toward CU.

Our program would be a dual M.D.-M.S. Aerospace Engineering degree-- its constructs relying heavily on established dual degree programs at CU (i.e., MD-MBA; MD-MPH, etc.). The sponsoring schools would be the CU Anschutz, School of Medicine, Department of Emergency Medicine and CU Boulder, College of Engineering and Applied Science, Smead Department of Aerospace Engineering Sciences. The dual degree program would require a coordinated curriculum for students to obtain both degrees in five years, and would be aimed at matriculated, degree-seeking students initially, and that future applicants would be new students who would be evaluated for admission to both programs at the same time. Students graduating from the program would be ideally positioned to, for example, enter careers as physician flight surgeons, medical officers for a human spaceflight company, or to develop medical technologies required for long duration exploration missions. Traditionally, individuals in fields like these are formally trained in one of the encompassed disciplines (i.e., either engineering or medicine) and then are introduced to the other through exposure on the job. By earning combined degrees in medicine and engineering, students will have a unique perspective and greater capabilities to contribute to this rapidly advancing field.

Stakeholders will be integral to effectively force multiply the impact and dissemination of our program, and we've already engaged with leaders in the field including: Major General John Barry, USAF (Ret), President and CEO of Wings Over the Rockies Air & Space Museum; Ms. Jenny Rankin, principal of the Denver-based Living Closer Foundation; the National Space Defense Center; the Sierra Nevada Aerospace Corporation; the Star Harbor Training Academy; and directors of the CU Anschutz Center for Combat Medicine and Battlefield Research-- who have co-led CU system engagement with the new U.S. Space Force.

Further, the Research and Innovation Office at CU Boulder established a mechanism to increase research collaborations between these two campuses. We believe the proposed program lays the foundation for future research collaborations and would advance CU President Kennedy's priority to "grow CU's significant research portfolio and economic impact," as well as manifesting a demonstrable, collaborative program synergizing the strengths and talents of two of CU's

campuses. Additional details on a long-term development plan beyond the proposed dual degree program are found in Section 13.

### 3. Statement on Curricula Duplication

There are no new courses proposed for this program. Although this program does not involve the creation of new courses, it formalizes a joint medicine and engineering integrated curriculum to establish an integrated program across these two fields. The authors of this proposal have established a course currently offered at CU Boulder, ASEN 5519: Medicine in Space and Surface Environments. This will be a required course for students in the dual degree program, but otherwise would be unchanged. All the other classes required are independently offered in the M.D. curriculum or independently offered in the M.S. curriculum.

### 4. Statement of Resources

No new resources are requested as part of the dual degree program.

### 5. Student Demand

It is anticipated that between 2-8 students per year will be admitted to the program, therefore we do not anticipate it causing an additional burden on course enrollment. These enrollment projections are estimated based on the current number of M.S. students who later plan to pursue medical school and M.D. students interested in space medicine, along with the desire to create a selective program. The degree program will be managed by CU Anschutz Department of Emergency Medicine and the CU Boulder Smead Aerospace Engineering Sciences Department through an extra departmental oversight committee, as described in Section 12: Program Administration. All faculty involvement falls within faculty teaching and service expectations.

### 6. Description of Curriculum

The requirement of this dual M.D.-M.S. program is the completion of all existing requirements for the M.D. program and the M.S. program respectively. For the M.S. program, students will complete 30 credit hours of graduate-level coursework (i.e., typically ten 3-credit courses) with grades of B or better in each course. Students will be enrolled in the Bioastronautics emphasis of the Aerospace Engineering Sciences degree program and will complete all required courses for this specialization. The equivalent of 9 credit hours from the M.D. program, as outlined below, will be requested to transfer to fulfill the elective credit requirements of the M.S. curriculum (It is customary in dual M.D.-M.S. programs to allow the transfer of a small number of credits in overlapping areas of the curriculum to facilitate the completion of both degrees within a five-year time period. For example, the School of Public Health accepts the transfer of up to 9 credits from the School of Medicine). Accordingly, students will complete an additional 21 credit hours of graduate-level coursework through CU Boulder. For the M.D. program, students must complete 70 total credits. No credits from the ASEN-M.S. degree will be applied.

### 7. Enrollment/Degree Conferral

Students must begin with the M.D. program and initiate the M.S. program in the 4<sup>th</sup> year. Upon enrolling in the dual M.D.-M.S. program, students must complete a degree planning form to outline their anticipated course selection. This form will be reviewed by the student and their faculty advisor. Figure 1 shows a graphical representation of the anticipated program timeline. The curriculum schedule for the 5-year program will be as follows:

- *Year 1:* M.D. curriculum, on campus at CU Anschutz. Students will follow the curriculum track as is traditional in the M.D. program. Up to 9 credits of the courses within the first 3 years will be eligible for transfer. For example, students are required to take 7 credits of Anatomy (IDPT 5001: The Human Body) in completion of the M.D. requirements, which could be transferred to CU Boulder as elective credits toward the M.S. degree.
- *Year 2:* On campus at CU Anschutz. Students will follow the curriculum track as is traditional in the M.D. program.
- *Year 3:* On campus at CU Anschutz completing clinical rotations. Students will follow the curriculum track as is traditional in the M.D. program.
- *Year 4:* On campus at CU Boulder, 3 courses per semester, totaling 18 credits (Note that this is a typical course load for many M.S. students in Aerospace). Students will take an official leave of absence from CU Anschutz (as per the precedent set by other M.D.-M.S. programs). The anticipated course schedule is as follows below. Note the schedule is structured to ensure all M.S. requirements in Bioastronautics listed in the Graduate Handbook are fulfilled. The M.S. Thesis Track and Graduate Projects options are outlined below. Students may also pursue any certificate option for which they are able to complete the course offerings:

Required on campus (both tracks):

ASEN 5158: Space Habitat Design

ASEN 5016: Space Life Sciences

ASEN 5519: Medicine in Space and Surface Environments (Offered by CU Boulder, but jointly taught by CU Boulder and CU Anschutz faculty)

Track 1: Graduate Projects Track

ASEN 5018/6028: Graduate Projects. Two-semester sequence course. Required on campus. Students typically select a graduate project associated with Bioastronautics, but this is not required.

Track 2: M.S. Thesis Track

M.S. Thesis credits, 6 credits total. Research must be at the intersection of engineering, medicine, and human spaceflight. The thesis topic will be determined by the student and the thesis advisor. Required on campus.

Required courses, one of which will be completed on campus in Year 4, the other of which will be completed remotely in Year 5 (a list of courses that satisfy these requirements are listed in the Aerospace Graduate Student Handbook):

1 Math course: completed from the approved list of courses

1 Out of Focus Area: completed from the approved list of courses

- *Year 5:* On campus at CU Anschutz completing clinical rotations. In addition to the curriculum track for the traditional M.D. program, students will take one remaining M.S. course, a total of 3 credits. If the student chooses the M.S. Thesis option, the student may also defend and submit their thesis in Year 5. Students may use the intercampus enrollment process for this one remaining course.

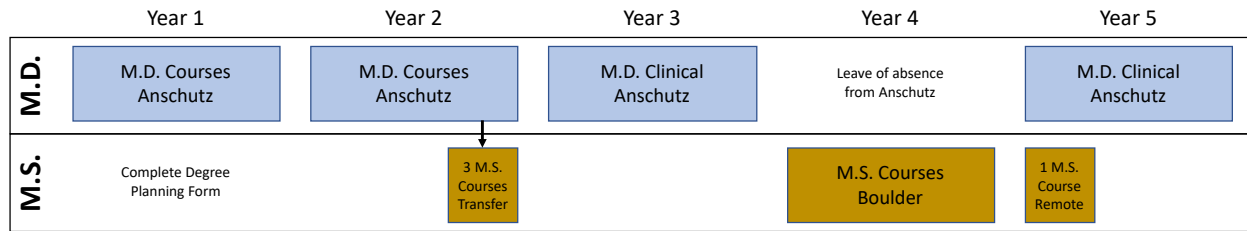


Figure 1: Graphical representation of anticipated program timeline.

Students following this plan will meet Master’s Degree Minimum Registration Requirements; Students must register full-time at CU Boulder for at least two semesters, part-time for at least four semesters, or full-time for at least one semester and part-time for at least two semesters. Students who follow the curricular plan above will follow the procedures at each campus to be conferred the M.S. and M.D. degrees at the end of Year 5. Students with extenuating circumstances may request award of the degrees on a different timeline.

Students enrolled in the ASEN M.S. program at CU Boulder are subject to CU Boulder Graduate School rules and policies related to the M.S. degree. Students enrolled in the M.D. program at CU Anschutz are subject to the SOM’s rules and policy related to the M.D. degree.

Each school shall notify the other if a student enrolled in the dual degree program is (i) expelled or suspended for academic or nonacademic reasons, (ii) subject to disciplinary action, (iii) placed on probation, (iv) otherwise not continued in good standing in that program, or (v) who voluntarily withdraws from either or both programs. In matters involving academic ethics, each school shall have jurisdiction to determine under its own procedures whether misconduct has occurred, and the consequences thereof, with respect to credit to be given towards the degree offered by that program and the standing of the student in that program.

## 8. Tuition and Fees

While registered on the Boulder campus doing M.S. work, students will pay CU Boulder tuition and fees, be counted in enrollment as a CU Boulder student and have appropriate rights and responsibilities accordingly. While registered on the CU Anschutz Campus doing SOM degree work, students will pay CU Anschutz tuition and fees, be counted in enrollment as a CU Anschutz student and have appropriate rights and responsibilities accordingly. Students who are dual enrolled via the intercampus enrollment process in the final semester will be subject to the existing tuition and fee agreements.

## 9. List of Potential Faculty

This list represents an initial set of faculty who may participate in the program. Faculty may be added or removed from this list as determined by the program’s oversight committee.

### *CU Boulder*

Allison Anderson, Ph.D. - AES  
 Torin Clark, Ph.D. - AES  
 Dave Klaus, Ph.D. - AES

### *CU Anschutz*

Jay Lemery, M.D. - Emergency Medicine

Benjamin Easter, M.D., MBA - Emergency Medicine  
Vik Berbata, M.D. - Emergency Medicine

#### 10. Admission Requirements

Completion of a dual M.D.-M.S. program is rigorous, and the admissions standards should reflect this degree of difficulty. Given that students would matriculate to the program seeking the dual degree, some students may have deficiencies as compared to the list of prerequisites listed in the admissions requirements of each program separately. The objective is to avoid making the admissions process overly onerous for the students, a precedent which has been set by other M.D.-M.S. programs. Accordingly, we propose the following admissions criteria for the dual program.

Applicants must fully meet all the requirements for and successfully apply to the M.D. program. Because of requirements for medical licensure and regulatory oversight, there is no flexibility to exempt students from the requirements of admission to the School of Medicine. Of note, admission to the School of Medicine is highly selective, with over 7,000 applicants for approximately 180 positions.

Similarly, applicants must meet requirements for application to the M.S. program at the Ann and H.J. Smead Department of Aerospace Engineering Sciences (this MOU applies to the traditional M.S. program Bioastronautics track only). While students who meet the traditional admissions criteria are favored, we propose the following modifications so as not to be overly exclusionary or restricted (based on Admission Requirements as of June 2020):

- Courses in linear algebra and differential equations would not be required. However, students in the dual program will be adult learners with respect to their own skills in mathematics, and may need to complete additional courses or self-study to prepare for some M.S. courses. There are approved math courses within the M.S. curriculum which do not have either of these courses as a prerequisite.
- In place of the requirement for two semesters of upper division undergraduate courses in engineering or physics, students must have taken two semesters of upper division undergraduate courses in a STEM field and 2 semesters of Calculus-based physics.
- The Medical College Admission Test (MCAT) shall be accepted in place of the Graduate Record Examination (GRE).
- Students may use recommendation letters already written for application to the School of Medicine provided that they attest to the student's ability to perform in a rigorous academic program.

To apply for the dual program, students will submit separate applications to each school according to the above requirements. On the respective applications, they will indicate their desire to matriculate in the dual program, and complete an additional personal statement describing their interest. Each school will make its own admission decisions independently, but the admission to the dual M.D.-M.S. program will be done concurrently. The oversight committee of the dual M.D.-M.S. program will make the final selection of students who will be enrolled in the program.

Of note, in the dual degree program's first 1-2 years, applications may also be accepted from students already enrolled in the School of Medicine provided that they otherwise meet all the above requirements.

#### 11. Financial Support/Financial Aid

As matriculated students in the School of Medicine, students will be eligible for financial aid and scholarship opportunities through the SOM.

## 12. Program Administration

The program will be administered by an executive committee of three faculty members, which will initially consist of:

Dr. Lemery, who will assume the initial role of Program Coordinator, and be charged with overall administration and coordination between the two campuses. The Section of Wilderness and Environmental Medicine, Department of Emergency Medicine, School of Medicine will provide support through a part-time administrative assistant (approximately 0.2 fte) to the program. Dr. Lemery currently serves as the Chief of this Section.

Dr. Anderson, who will serve as the CU Boulder AES liaison, and be charged with integrating the program into the wider goals of the AES graduate program. The AES liaison will serve as the primary faculty member to work with AES to ensure that all engineering degree requirements are met by the students. This individual will also evaluate prospective students for admission to the M.S. program.

Dr. Easter, who will serve as the CU Anschutz liaison, and be charged with integrating the program into the wider goals of the CU Anschutz M.D. program. The CU Anschutz liaison will serve as the primary faculty member to work with the SOM to ensure that all M.D. degree requirements are met by the students. This individual will also evaluate the prospective students for admissions to the M.D. program.

Within the first year, we will convene a board of advisors (4-6 individuals) of government and industry stakeholders and CU affiliate faculty (e.g., CU COMBAT Center).

Beyond the M.D./M.S. program outlined in this proposal, an additional goal of this effort is to formalize the relationship between these two groups, with the intent of increasing the partnership. In future years, we anticipate growing the partnership to include research and expanding the curriculum to CU system faculty, graduate and undergraduate students. We believe a robust relationship with CU Development will be integral for the long-term success of this program, and we will have a shared articulated strategy for philanthropy within the first 12 months.

## 13. Metrics of Success

The timeline below proposes the steps by which a successful program will be established and will serve as our initial strategic milestones:

- Year 1
  - Successful recruitment of approximately two students (with between 4-8 additional students per year thereafter)
  - Educational programs targeted to the CU community, occurring regularly on both Boulder and Anschutz campuses, supported by core and affiliate faculty, to demonstrate impact and dissemination of the program on the CU community.
- Year 2
  - Increase applicants to program through recruitment via established industry and academia channels
  - Continuation and growth of CU community educational programs
  - Evidence of dissemination and impact of this program:
    - Initial philanthropic support procured
    - Industry research partnerships acquired

- Years 3-5
  - Continuation and growth of CU community educational programs
  - Consider increasing M.D./M.S. student cohorts to more than two per year
  - Successful placement of graduates into industry, academia, and civil service positions to grow the field
- Long term
  - National reputation as ‘best-in-class’ education program for excellence in medicine and bioastronautics
  - Successful integration of graduates into human spaceflight industry, government, and academia

#### 14. Sunset Clause/Termination

Without additional action by both parties, the agreement will be terminated 7 years from the date of final approval. Either party may terminate the agreement with written notice at any point. In either case, students already admitted to the program shall be allowed to complete their degrees. If both programs request continuation of the agreement, they shall review and amend as necessary, and make a request to each campus’s graduate dean and provost to extend for another period of 7 years.

#### 15. Program Review

This dual degree program will be included as part of the review of the Department of Aerospace Engineering graduate program for the purposes both of CU Boulder program review and of reporting on degree programs by CU Boulder to the University of Colorado System.