SIAM Activity Group Uncertainty Quantification
Charter Renewal Application

This CHARTER RENEWAL APPLICATION applies to the SIAM Activity Group on Uncertainty Quantification. The SIAM Activity Group (or SIAG UQ) to which this renewal applies was originally formed under the aegis of SIAM in December 2010 by the SIAM Council and by the SIAM Board of Trustees with its initial operating period beginning December 11, 2010 and ending December 31, 2012. Its charter has been renewed by the Council and Board four times thereafter.

This SIAG has 804 members, including 381 student members and 423 non-student members as of December 31, 2019.

According to its Rules of Procedure, the objective(s) of the SIAG are:

- It is the purpose of the SIAM Activity Group on Uncertainty Quantification to foster activity and collaboration on all aspects of the effects of uncertainty and error on mathematical descriptions of real phenomena. It seeks to promote the development of theory and methods to describe quantitatively the origin, propagation, and interplay of different sources of error and uncertainty in analysis and predictions of the behavior of complex systems including biological, chemical, engineering, financial, geophysical, physical, and social/political systems. The SIAG serves to support interactions between mathematicians, statisticians, engineers, and scientists working in the interface of computation, analysis, statistics, and probability.

- Together with its partner UQ Interest Group in ASA, the SIAG organizes a biennial conference, sponsors minisymposia at conferences, publishes a newsletter biannually, and maintains anelectronic discussion group.

Within the framework of SIAM, the SIAG will conduct activities that implement its purposes. The SIAG on Uncertainty Quantification will organize activities in uncertainty quantification.

The SIAG is expected to:
1. Organize minisymposia at the SIAM Annual Meeting in years where there is no SIAG conference.

2. *At least once every seven years either organize a track of at least six Minisymposia at the SIAM Annual Meeting or have an activity group meeting held jointly with the annual meeting. The VP for Programs and the VP at Large will coordinate the scheduling with the SIAG chair.

3. Organize a biennial SIAM Conference on Uncertainty Quantification. The SIAG will consider dovetailing specialized workshops and conferences with the SIAM Annual meeting or other SIAG conferences. The chair of the conference organizing committee shall be either the program director or the chairperson of the SIAG or their designee. The organizing committee must be approved by the VP for Programs at least 16 months before the conference.

4. With the approval of the SIAM Program Committee, the SIAG may organize special sessions at SIAM meetings, and conduct special one- or two-day meetings immediately before or after a regular SIAM meeting.

SIAG meetings, workshops, and conferences may be organized only with the approval of the SIAM President and the SIAM Vice President for programs.

The SIAG has complemented SIAM's activities and supported its proposed functions.
The answers to the questions below indicate how this was accomplished and what the officers propose as the future directions for the SIAG.

List all current officers of the activity group (including advisory board, if relevant).

Chair: Omar Ghattas

Vice-Chair: Ralph Smith

Program Director: Catherine Powell

Secretary: Claudia Schillings

1. **How is the field covered by the activity group doing? Is it growing, is the focus shifting? What have been the significant advances over the last two years?**

   Uncertainty quantification (UQ) is a dynamic and vibrant field. Accounting for uncertainties in model-based inference, prediction, and optimization of complex systems has become essential, as computer models are increasingly used to support decision making for critical societal systems such as climate and natural hazards, energy systems, transportation systems, social and economic systems, and so on. This need is recognized broadly by all stakeholders, from academia to government to industry to society at large. The recent Covid-19 global pandemic is just the latest example: while the novel nature of the coronavirus has meant that modeling is crucial for guiding optimal interventions, the enormous societal consequences of these mitigations on both human health and welfare point to the critical need to fully account for uncertainties in as rigorous a manner as possible. However, rigorously accounting for uncertainties in models of complex systems remains a mathematical and computational challenge of the highest order, ensuring that UQ will remain a rich area of research for many years to come. This is reflected in the numerous US Federal agency research programs rolled out in recent years that are focused on research in UQ. These include programs at DOE (both within the Office of Science as well as the National Nuclear Security Administration), DARPA, NSF, AFOSR, ONR, and others. These programs were influenced in part by a DOE-commissioned National Academies report on uncertainty quantification that was published in 2012 (http://dx.doi.org/10.17226/13395), as well as a 2011 NSF-commissioned report on grand challenges in computational science (http://www.nsf.gov/od/oci/taskforces/TaskForceReport_GrandChallenges.pdf), both of which were led by, and had significant contributions from, SIAG/UQ members.

   One way to quantify the richness and vibrancy of UQ is the health of the biannual SIAM UQxx conference, which in 2020 unfortunately fell victim to the Covid-19 pandemic. It was originally scheduled for March 24—27 at the Garching campus of the Technical University of Munich, but was cancelled on March 7 as concerns about the spread of the disease began to trigger the cancellation of large events. The program would have featured 823 unique presentations, organized as 157 minisymposium sessions, 136 contributed talks, and 59 posters. There are six

SIAGs that are larger in size than SIAG/UQ (CSE, DS, DMA, OPT, APDE, and LS). To get a sense of how strong the UQ20 participation numbers are, let's compare with the equivalent figures for the most recent iterations of the signature conferences of these six SIAGs:

1. *2019 SIAM Conference on Computational Science and Engineering*: 401 MS sessions and 84 CP talks
2. *2019 SIAM Conference on Dynamical Systems*: 186 MS sessions and 150 CP talks
3. *2019 SIAM Conference on Data Mining*: 60 CP talks
4. *2017 SIAM Conference on Optimization:* 124 MS sessions and 84 CP talks
5. *2017 SIAM Conference on Analysis of Partial Differential Equations*: 67 MS sessions and 55 CP talks
6. *2018 SIAM Conference on the Life Sciences*: 61 MS sessions and 60 CP talks

The CSExx conference is far larger than any other specialty SIAM conference (and the SIAG/CSE's membership reflects that). But besides CSE19, UQ20 would have been somewhat smaller than the conference of the second largest SIAG, Dynamical Systems, and significantly larger than the next 4 largest SIAGs' conferences. Of course participation in a conference is just a proxy for the vibrancy and opportunities in a field, but these numbers do indicate that UQ is one of the most active areas of SIAM. This is quite remarkable, given the youth of the UQxx conference series: it has been held just four times, beginning in 2012. The growth in the number of registrations, from 506 for UQ12, to 813 preregistrations for UQ20 (a number that was sure to grow larger if onsite registrations had occurred), testifies to the growth in interest in UQ from among the applied math and computational science communities. Of course, it also reflects the excellent organizational job done by the conference co-chairs Elisabeth Ullman, Catherine Powell, and Amy Braveman and the rest of their organizing committee.

Finally, regarding the significant developments in the field itself and how it is evolving, it would be impossible to give justice to these topics in a paragraph. If one skims the abstracts of presentations at the UQ20 conference (https://siam-uq20.ma.tum.de/), one will get a good sense of the breadth and depth of the field and the directions in which it is evolving. A few common themes emerge: theoretical developments; extensions to high dimensional problems; fast algorithms; multilevel, multiscale, and multifidelity methods; dimension reduction; model reduction; tackling of more complex applications across many areas of science and technology; extensions from forward UQ to inverse problems and data assimilation (inferring uncertain parameters/states from uncertain data); extensions to optimal control and optimal design under uncertainty (optimization of the design or operation of a system when the model is uncertain); and UQ in machine learning. This last represents a nascent area, but one with great opportunities: interpretability and robustness have long plagued machine learning methods, particularly when applied to science and engineering problems, and UQ has much to offer in quantifying the confidence we might have in the resulting machine-learned models.

2. **How is the activity group doing? Is it remaining vibrant? Is the size of the SIAG stable or increasing? How is the SIAG keeping up with the changes in the field? How are the broader interests of SIAM reflected in the activities of the SIAG?**

The SIAG/UQ is thriving. The statistics above on how the UQxx conference has grown since its inception in 2012, and how its size compares with the size of the flagship conferences of the six SIAGs that are larger than SIAG/UQ, are testaments to this. Another measure of course is the number of members of the SIAG. Quoting figures from just the even years that UQxx conferences have been held (since memberships numbers typically experience a disproportionate increase in those years due to discounted registration fees for members), the SIAG membership has grown from 417 in 2012, to 529 to 2014, to 700 in 2016, to 831 in 2018, to 846 in 2020. Note, however, that the 2020 number wasn't able to benefit from the UQ20 conference, where discounts for SIAG members in onsite registrations would have motivated non-members to join. In any case, this makes SIAG/UQ the 7th largest of SIAM's 22 SIAGs, despite being one of the youngest. Of the current 846 members in SIAG/UQ, 355 are students, reflecting a healthy participation of the younger generation and boding well for the future of this field. Also, 34% of the SIAG are non-US based, reflecting geographical diversity. While just 15% of the non-student membership are female (with another 5% not indicating), 20% of the student members are female (with another 12% not indicating). While these numbers are low, they at least indicate an upward trend in membership in younger generations. Of note, the UQ20 organizing committee was 50% female, with three women as the co-chairs. This helps to signal to the broader UQ community the importance placed on inclusivity. Finally, 31% of members are non-academics (i.e. from lab, industry, or government) and 42% are not in math departments; both of these figures indicate healthy scientific and employer diversity among the members.

Regarding how the broader interests of SIAM are reflected in the SIAG, one way to measure this is the number of UQ-themed minisymposia at other SIAM conferences, a number that appears to be robust and reflective of the activity of SIAG members in other areas of SIAM. A notable example is the SIAM CSE conference: at its 2019 iteration, there were 40 minisymposia alone whose titles directly mentioned UQ themes (a number that does not include several dozen other minisymposia whose titles did not explicitly mention UQ themes, but whose talks addressed related topics, such as inverse problems, model reduction, dimension reduction, and machine learning). These 40 minisymposia alone represented 10% of the conference.

3. **Please list conferences/workshops the activity group has sponsored or cosponsored over the past three years, and give a brief (one sentence or phrase) indication of the success or problems with each.**

    a. SIAM UQ18: This conference was successfully held April 16-18 in Orange County, California, USA. The total number of registrations was down slightly (16%) from UQ16, which was held in Lausanne, Switzerland. This is likely attributable to the location in California, which is less convenient to the large contingent of Europeans who make up the SIAM UQ community.
    b. SIAM UQ20: As discussed above, this conference was scheduled for March 24-27 at the TU Munich and was destined for success, only to be cancelled due to Covid-19. There have been discussions between SIAM and TUM about postponement to 2021, but nothing conclusive has been decided as of the date of this report.

4. **Please indicate the number of minisymposia directly organized by the activity group at the last two SIAM annual meetings. When did the SIAG last organize a track at an annual meeting or meet jointly with the SIAM Annual Meeting?**

   The last SIAG/UQ-sponsored track at the SIAM Annual Meeting was at AN17, which included 10 minisymposium sessions. Thus, the SIAG is next scheduled to sponsor a track at AN24. The SIAG did not officially sponsor a UQ track at AN18, but at least 12 (of 169) minisymposia at the conference had titles devoted to UQ topics, and those included several that were directly organized by the SIAG leadership. There was no Annual Meeting in 2019, due to ICIAM 2019, but there were also numerous UQ sessions at this conference.

5. **Please indicate other activities sponsored by the activity group, to include newsletters, prizes and web sites. Have each of these been active and successful?**

   The first SIAG/UQ Early Career prize was awarded at UQ18 to Aretha Teckentrup. The second Early Career Prize prize, was awarded to Björn Sprungk (see https://sinews.siam.org/Details-Page/february-2020-prize-spotlight).

   The SIAG/UQ electronic mailing list remains the main form of communication between members.

6. **What activities are planned and proposed for the next period of the charter? Please describe scheduled and suggested future activities in detail.**

   The next major activity of the SIAG is SIAM UQ22.

7. **How can SIAM help the activity group achieve its goals?**

   The support that SIAM provides for the UQxx conference, the UQ journal (the SIAM/ASA Journal on Uncertainty Quantification – not overseen by the SIAG/UQ, but an effort that greatly benefits the SIAG membership), the SIAG/UQ Early Career Prize, the SIAG/UQ website, the various UQ-related books, and the mailing list are all invaluable for helping promote and sustain UQ among the worldwide applied math and computational science communities. The new community forum is expected to help further this goal.

8. **How can the activity group help SIAM in its general role of promoting uncertainty quantification?**

   The SIAG/UQ serves as the focal point for SIAM's activities in UQ. It has engendered a global community of over 800 senior and junior researchers and practitioners in uncertainty quantification, along with the leading conference in the field of UQ. These accomplishments have helped establish UQ as an absolutely essential concern for predictive science and model-based decision making, particularly important for systems that have significant impact on society. These accomplishments have also established SIAM as the leading professional society representing the field of UQ and have drawn worldwide attention to its activities.

This SIAG requests that the SIAM Council and Board of Trustees renew its charter for a two-year operating period beginning January 1, 2021.

Signed,

Omar Ghattas, SIAG/UQ Chair

June 10, 2020