



UMass

Dartmouth

COLLEGE OF ENGINEERING

Office of the Dean

July 13, 2018

Dr. Tesfay Meressi
Associate Provost for Graduate Studies
University of Massachusetts Dartmouth
285 Old Westport Road
Dartmouth, MA – 02747

Dear Dr. Meressi,

In response to your letter dated November 6, 2018 requesting a five-year review of the Center for Scientific Computing and Visualization Research, a committee comprising of Drs. Mehdi Raessi, Hillary Farber, Yifei Li, Alex Fowler and I, met during late Fall and Spring semesters.

The review has been completed and the report is attached for your record.

The directors of CSCVR, Drs. Sigal Gottlieb and Gaurav Khanna, will receive a copy of the report. The Center's Directors and Governing Board shall have twenty days to respond to the five-year review and to the written comments and recommendations of the Provost by submitting a written response to the Chancellor. After this twenty-day period the Chancellor shall make a final recommendation concerning the Institute or Center. Based upon the five-year review, and additional materials submitted to him by the Director, Governing Board, and Provost, the Chancellor may: (1) recommend to the President the continuance of the Institute or Center for another five years; (2) recommend modification and restructuring of the Institute or Center; or (3) terminate the Institute or Center without further review or appeal.

If you have any questions, please do not hesitate to contact me.

Sincerely,

A handwritten signature in black ink, appearing to read 'Ramprasad Balasubramanian'.

Ramprasad Balasubramanian
Interim Dean, College of Engineering



Center for Scientific Computing and Visualization Research
Five-year Review

Center Missions:

The mission of the Center for Scientific Computing and Visualization research (henceforth referred to as the Center or CSCVR) is to promote and conduct high-level interdisciplinary and multidisciplinary research in scientific computing, and to mentor students of scientific computing – high-school students, undergraduates, and graduate students - in a supportive, broad, and deep interdisciplinary research environment. The Center also aims to support, facilitate, and promote the activities of the scientific computing group, which is comprised of over a dozen researchers from Electrical and Computer Engineering (ECE), Mechanical (MNE) and Civil Engineering (CEN), Mathematics (MTH), Physics (PHY), Biology (BIO) and SMAST, who develop and use computational algorithms to simulate complex physical problems and visualize these solutions to gain greater insights into them. The Center works closely with CITS to support faculty research and keeps UMass Dartmouth at the forefront of high performance computing and visualization research in the state of Massachusetts. Through seminars and workshops, the Center fosters collaborative research within the group and between the members of the scientific computing group and researchers at other Universities, National Labs, and Industry, and enhances the reputation of the UMass Dartmouth.

Introduction:

The Center for Scientific Computing and Visualization Research was created with the goal of organizing a collaborative, interdisciplinary group of scholars to establish an internationally recognized center of research in scientific computing at UMass Dartmouth. The center faculty is comprised of scientists with complementary backgrounds and interests who develop and apply computational algorithms to simulate and visualize complex physical problems.

Since its inception, the CSCVR faculty has produced substantial number of publications in high-impact journals. They have received prestigious awards and competitive grants for their research centered around scientific computing. The Center has hosted a name of important research conferences. The Center provides high quality discovery-based learning experiences to undergraduate and graduate students across at least three colleges – Engineering, Arts & Sciences and SMAST. In 2016 the CSCVR faculty helped establish the *Computational Science and Engineering (CSE)* option in the newly created Engineering and Applied Sciences Ph.D. program at UMass Dartmouth. At the time of this report, there are 16 Ph.D. students in the CSE track and advised by center faculty.

Surveys for the center faculty and students have been carried out by this review committee. The survey results suggest that the center is successful in achieving the core activities and objectives:

- Promoting high-level interdisciplinary and multi-disciplinary research in scientific computing
- Mentoring students in scientific computing
- Promoting activities of the scientific computing group
- Facilitating activities of the scientific computing group
- Keeping UMass Dartmouth at the forefront of high performance computing and visualization research

- Fostering collaborative research within the group and between the members of the scientific computing group and researchers at other Universities, National Labs, and Industry
- Enhancing the reputation of UMass Dartmouth

Based on this evidence, the review committee strongly feels that the Center has been successfully fulfilling its mission over its first five years of its existence.

Accomplishments in Research and Scholarship:

The review committee identified the following noteworthy research and scholarship accomplishments from the center faculty:

- In Summer 2016 Lance Fiondella (ECE) was at the Office of Naval Research, Summer Faculty Fellowship Program Visiting Researcher, Reliability and Maintainability (R&M) Division, Naval Air Systems Command (NAVAIR).
- Mehdi Raessi (MNE) and EAS-CSE student Ashish Pathak had two papers published in Journal of Computational Physics on their three-dimensional volume-of-fluid (VOF) method.
- In Summer 2016 Gaurav Khanna (PHY) was awarded a new National Science Foundation (NSF) grant to continue his computation research on black holes and gravitational waves.
- In January 2016 Gaurav Khanna (Physics), together with colleagues Lior Burko at Georgia Gwinnett College and Anil Zenginoglu at the University of Maryland, published a Rapid Communication in Physical Review that includes the first computer simulation of the interior of a rotating black hole, uncovering the possibility of using them as a portal for hyperspace travel. This work received media attention with full length coverage in Forbes Magazine, Universe Today and The Standard Times.
- In January 2017, Mehdi Raessi (MNE) was awarded a Department of Energy (DOE) grant for research on Evaporation Sub-Model Development for Volume of Fluid (eVOF) Method Applicable to Spray-Wall Interaction. The cost-share portion of this DOE grant was awarded by the Massachusetts Clean Energy Center through a separate grant.
- In October 2015 Lance Fiondella (ECE) was awarded an NSF grant for research on Robust Algorithms for an Open Source Software Reliability Tool.
- In October 2015, Amit Tandon (MNE) completed an Office of Naval Research (ONR)-sponsored expedition to the Indian Ocean that brought together 50 scientists from the U.S. and India to study the conditions that create monsoons in the Bay of Bengal, which affect weather patterns around the globe and the agrarian economy of more than one billion people in Indian Ocean nations.
- In July 2015, Mehdi Raessi (MNE) was awarded (as a co-PI) an ONR grant for research on the role of scale in the development and evolution of stratified shear turbulence, entrainment and mixing.
- In July 2015, Sigal Gottlieb (MTH) was awarded an Air Force Office of Sponsored Research (AFOSR) grant for her research on strong stability preserving time-stepping methods.
- In July 2015, Lance Fiondella (ECE) was awarded a grant from the National Center for Risk and Economic Analysis of Terrorism Events (CREATE) at University of Southern California for his research on Dynamic Transportation Network Vulnerability Assessment Algorithms.

- In June 2015, Geoff Cowles (SMASST) was awarded a National Ocean and Atmospheric Association (NOAA) (check) Saltonstall-Kennedy (S-K) Grant for his use of archival tagging data to develop geolocation methodologies for North Atlantic ground fish.
- In April 2015, Vanni Bucci (BIO) received an award from the National Institute of Health (NIH) to apply Big Data to design smarter and targeted treatments for infectious intestinal diseases.
- In April 2015, Vanni Bucci (BIO) received an award from the NSF for developing a new computational framework for the prediction of microbiome dynamics.
- In April 2015, Lance Fiondella (ECE) was awarded an Army Research Laboratory (ARL) grant on Rotorcraft Trade space Exploration incorporating Reliability Engineering.
- In March 2015, Lance Fiondella (ECE) was awarded a grant from Systems Engineering Research Center (SERC), a University-Affiliated Research Center of the US Department of Defense, Stevens Institute of Technology, for research on software reliability modeling.
- In March 2015, Sigal Gottlieb (MTH) was featured in BostInno in an article titled “Sigal Gottlieb’s Passion for Math Advances Scientific Computing at UMass Dartmouth (<http://tinyurl.com/z5jonoz>)”
- In February 2015, Robert Fisher (Physics) together with several colleagues including EAS-CSE graduate student Rahul Kashyap, published a paper on Spiral Instability: Can Drive Thermonuclear Explosions in Binary White Dwarf Mergers in *Astrophysical Journal Letters*.
- In January 2015, Akil Narayan (MTH) was awarded an AFOSR Young Investigator Research Program (YIP) grant for a project titled “Optimal and unstructured high-order non-intrusive approximations for uncertain parameterized simulations”. Dr. Narayan has since left the University for a position at University of Utah.

Outreach and collaborations activities:

A year after its formation the Center organized a day-long conference within the UMass system focused on High Performance Computing. Two years later, the Center expanded the scope of participants to include faculty from all major research universities in the Boston area who are members of the Massachusetts Green High-Performance Center (MGHPC), along with industry stakeholders and academics. The Center sponsors events throughout the year, bringing notable speakers to campus to present their work. A notable visitor was renowned physicist Dr. Kip Thorne who visited campus for an event on the Hollywood blockbuster film, *Interstellar*. Dr. Thorne is the originator and one of the executive producers of the 2014 movie, which is based on black holes, spatial wormholes, and other concepts at the forefront of theoretical gravitational physics. The event provided a platform for Center’s faculty to showcase some of their work. Events such as the one with Dr. Thorne appeal to a wide audience within and outside the UMass community. Moreover, these types of events foster engagement among students and faculty. The Center’s active calendar of events serves to make UMass Dartmouth a focal point of activity and research in the field of computational science in Massachusetts. It also provides a rich opportunity for collaboration among departments through the interdisciplinary nature of these events.

CSCVR Faculty Survey Outcome

The review committee performed the following survey to the Center faculty to get their views on whether the Center has fulfilled its mission over the previous five years. The survey contains seven questions:

- 1) Promoting high-level interdisciplinary and multi-disciplinary research in scientific computing
- 2) Mentoring students in scientific computing
- 3) Advertising activities of the scientific computing group
- 4) Facilitating activities of the scientific computing group
- 5) Keeping UMass Dartmouth at the forefront of high performance computing and visualization
- 6) Fostering collaborative research within the group and between the members of the scientific computing group and researchers at other Universities, National Labs, and Industry
- 7) Enhancing the reputation of UMass Dartmouth

The rating scale that was used is as follows: 1-Outstanding, 2-Very Good, 3-Good, 4-Fair, 5-Poor.

The review committee received the following outcome:

Question 1. Overall Rating 1.33 (Outstanding)

Comments:

Comment 1: Overall the center does well in providing an organizational framework within which faculty and students from different disciplines can learn from and work together with one another. There is room for improvement, however: a healthy interdisciplinary mix requires both mathematical frameworks and algorithms, as well as domain specialists working on applications to real-world science and engineering problems. The mix within the CSCVR, both in terms of faculty and activities, tends to be on the algorithm side of that balance. For example, by my count, seven of the eight seminars scheduled for spring 2018 are from faculty whose primary affiliation is a mathematics or applied mathematics department.

Long-term strategies to continue to hire faculty in complementary disciplines to further leverage the strong mathematics group on campus would certainly be welcomed, but even short-term strategies to broaden the composition of the seminar series and activities into a range of topics at the nexus of science and engineering applications and algorithmic development would help.

Comment 2: Our faculty and center have developed a strong reputation for high-level research.

Question 2. Overall Rating 1.16 (Outstanding)

Comments:

Comment 1: We have had success in mentoring graduate students and placing them in good internships and postdocs.

Comment 2: The creation of the core EAS curriculum provides a vehicle for faculty from different disciplines to engage with and instruct students from across the Center's disciplines. These teaching experiences provide the basis for future formal (e.g. thesis committee) and informal mentoring. For this reason, rotation of the teaching of the core courses throughout the Center disciplines would be advantageous.

Comment 3: This is a difficult question to answer because I am not sure this is an activity of the center, rather it is an activity of the affiliates of the center. Students who are pursuing topics in scientific computing and are advised by the center faculty have done well, both undergraduates who have participated in peer-reviewed research and gone on to top graduate programs and graduate students who regularly publish in competitive journals and have won awards for their efforts. I consider this success an indirect effect of the center.

Comment 4: The first cohort of Math-based EAS-CSE students all benefited from being affiliated with the center. They have all secured top-notch postdoctoral positions on a tough job market.

Question 3. Overall Rating 1.43 (Outstanding)

Comment 1: The multiple CSCVR mail lists are well organized and utilized. The center is also quite effective in getting exposures to entities outside of the center through the website and UMassD news etc.

Comment 2: While some efforts have been made, I think they can be greatly expanded. I would like to see a regular, quarterly newsletter featuring recent research + a spotlight. I would be willing to expend time on this. These might seem outdated but I receive a newsletter from the Texas Advanced Computing Center which arrives as an embedded document in my email and is very nicely done. They also have a web version and I will put the link below. CSCVR folks produce a lot of graphics-friendly content and have had some major achievements and I would like to see greater distribution of these in an archived manner. I would also want the newsletter to include new faculty, either new hires or new center affiliates and mention their research.

<https://www.tacc.utexas.edu/newsletter/2017/april>

Comment 3: Primary activities are distributed through e-mail to all Center faculty and students. This works well.

Comment 4: It has not always been easy to get the university to publish our stories but we've been announcing them internally.

Question 4. Overall Rating: 1.428 (Outstanding)

Comment 1: The center is very effective in this regard thanks largely to the hands-on approach of the directorate.

Comment 2: Regular seminars and special events have brought many faculty members together. Sharing information about grants and texts for proposals have helped facilitate success.

Comment 3: The CSCVR does well in planning activities with its limited resources. When we first began, we started without any significant resources provided by the campus, apart from the CSCVR space itself. As our resources grow, it will be important to focus new activities on interesting areas at the juncture of the disciplines represented by the Center.

Question 5. Overall Rating: 1.286 (Outstanding)

Comment 1: The existence of a core of strong faculty, along with tremendously efficient shared computational facilities, helps further the research agenda of the CSCVR group.

Comment 2: There is no question that CSCVR folks (such as Gaurav) have made substantial contributions to the University's prominence on this topic. I am somewhat concerned that if one is referring to the true cutting-edge we are leaning fairly heavily on a few individuals. Perhaps this is not unusual but it does bring some concern of stability as we have seen several promising researchers drawn away by enticing opportunities elsewhere.

Comment 3: Without a doubt! We are the go-to campus within the UMass system when it comes to HPC. Nationally, we are getting more and more attention through, for example, the advisory board of the center.

Question 6. Overall Rating 1.286 (Outstanding)

Comment 1: Again, excellent job

Comment 2: I think Sigal has done a good job connecting faculty members within CSCVR and this has resulted in some fruitful collaborations. I can't really speak much about connections made outside the University as most of these have been on an individual researcher basis.

Comment 3: The Center does well in sponsoring visiting scientists to give seminars, and our first batch of graduating students will serve as ambassadors to the program to the wider world. In the future, as resources grow, it would be wonderful to host visiting scientists for longer visits — from a week to a semester, including sabbaticals, facilitating actual research activities on the campus.

Question 7. Overall Rating: 1.14 (Outstanding)

Comment 1: Unequivocally true! I think the center made UMassD much more appealing to computational science researchers. Internally, it plays a unique role in helping retain excellent faculty some of whom have been actively recruited by other schools.

Comment 2: The Center consists of some of the most highly-talented and productive faculty and students on the campus, and I am proud to be affiliated with it. The Center does a tremendous amount to enhance the reputation of UMass Dartmouth for its minimal resources!

CSCVR Students Survey Outcome

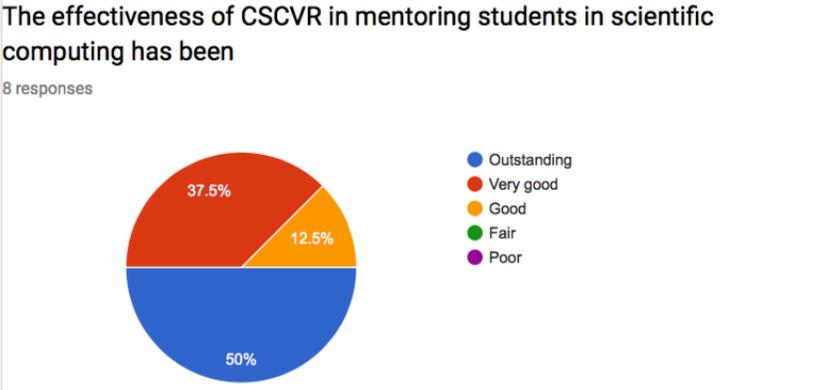
To determine the Center’s success in fulfilling its mission over the past five years the following survey consisting of seven questions was sent out to 22 CSCVR students and alumni:

- 1) The effectiveness of CSCVR in mentoring students in scientific computing
- 2) The performance of CSCVR in promoting high-level interdisciplinary and multi-disciplinary research in scientific computing
- 3) The performance of CSCVR in supporting and facilitating the activities of the scientific computing group
- 4) The effectiveness of CSCVR in advertising the activities of the scientific computing group
- 5) The performance of CSCVR in keeping UMass Dartmouth at the forefront of high performance computing and visualization
- 6) The performance of CSCVR in fostering collaborative research within the group and between the members of the scientific computing group and researchers at other Universities, National Labs, and Industry
- 7) The effectiveness of CSCVR in enhancing the reputation of UMass Dartmouth.

The total number of responses received was 8, which are presented below. The responses were very positive. In almost all questions, at least 50% of the responders rated the performance (or effectiveness) of the CSCVR as Outstanding. In addition, two students/alumni provided the following comments

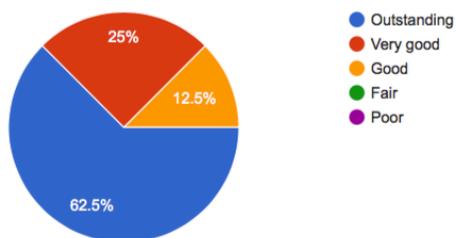
- *It's been working pretty well.*
- *As an alumnus, I look forward to hearing the latest news of the CSCVR. Please keep up the good work!*

Below is the summary of the responses from those surveyed.



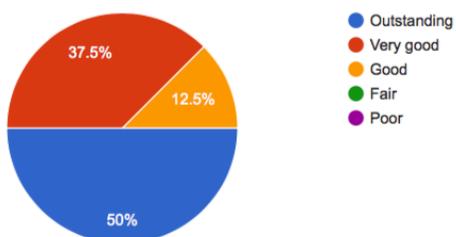
The performance of CSCVR in promoting high-level interdisciplinary and multi-disciplinary research in scientific computing has been

8 responses



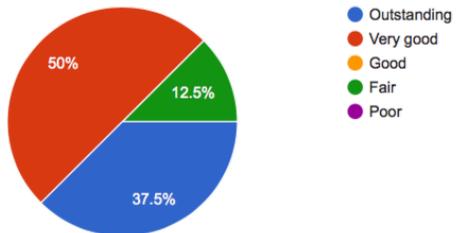
The performance of CSCVR in supporting and facilitating the activities of the scientific computing group has been

8 responses



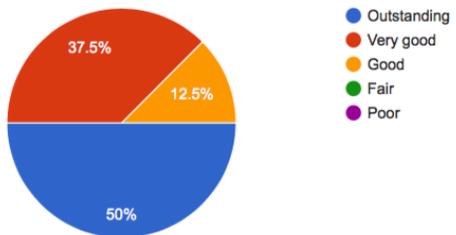
The effectiveness of CSCVR in advertising the activities of the scientific computing group has been

8 responses



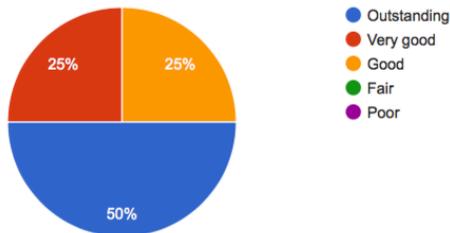
The performance of CSCVR in keeping UMass Dartmouth at the forefront of high performance computing and visualization has been

8 responses



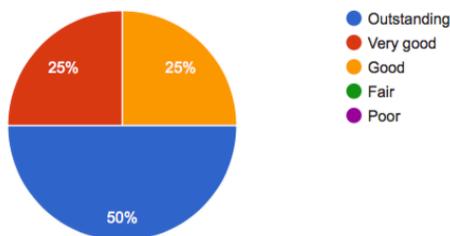
The performance of CSCVR in fostering collaborative research within the group and between the members of the scientific computing group and researchers at other Universities, National Labs, and Industry has been

8 responses



The effectiveness of CSCVR in enhancing the reputation of UMass Dartmouth

8 responses



CSCVR Budget and Finance:

While the Center has not received a dedicated annual budget allocation, the College of Engineering supports its activities in the following manner. The Center director is provided an annual stipend of \$15,000 in addition to two course releases. One to two EAS students have been annually funded in the form of research assistants, over the years to support Center’s activities. The Center also enjoys a unique indirect-cost distribution model. Each time a Center faculty member submits an external grant proposal that uses the Center’s computational resources, 20% of the indirect-cost recovery (5% from each of the PI, department, college and provost) is allocated to the Center. These funds have been used to support various Center activities. Below is a summary of the Center’s finances over the past five years.

Starting in FY15, the CSCVR’s indirect cost allocation began growing substantially. The Directors (in consultation with members and COE Dean) have typically developed an annual spending plan. Care has been taken to avoid redundancy with other existing programs in the College and the University, such as the Provost’s travel grants. Briefly, the plan enabled spending the indirect cost revenue on CSCVR common hardware (repairs, enhancements, strategic investments), Center workshops, and member support (travel, student support, other unmet needs).

A breakdown of the expenditures appears below.

FY ’15 — ’16:

- Revenue — \$27,528.16
- Expenses — \$8,100.96

- Spending supported Center workshops (Fall luncheon, HPC Day), 2016 Interstellar event, and hardware supplies.

FY '16 — '17:

- Revenue — \$28,072.43
- Expenses — \$13,517.62
- Spending supported Center workshops (HPC Day), seed funds for members (mostly student support and conference travel), and hardware supplies.

FY '17 — '18:

- Detailed reporting is currently in processing. However, the outcome is expected to look very similar to previous years.

CSCVR Review Summary:

The summary of the review of the Scientific Computing and Visualization Research is broken into two parts – 1. Challenges faced by to the Center over the past five years and 2. The future of the Center.

Challenges: The Center faced many challenges and growing pains over the past five years.

- **Budget:** While the long-term goal has always been to make the Center fully self-supporting through the special allocation of indirect cost recovery from grants from Center members, the original proposal for the Center's budget included a request for a quarter-time secretary and part-time HPC technician. It also requested funding for two full graduate assistantships (for EAS/CSE doctoral students) and additional funds for external consultants. The Center has been supported by the College of Engineering, not through a direct budget allocation but through in-kind support such as a director stipend, EAS student RA support and ad-hoc allocation for specialized equipment purchases. The Center has had no administrative or technical support over the past five years. These were overcome to a great degree with significant efforts made by the Directors, COE office staff, Math & Physics Depts. staff, and CITS members.
- The Center initiated an annual state-wide "HPC Day" event that is held in late Spring. The event was run 3 times on-campus, each time bringing in over 100 computational science researchers from all over Massachusetts. This event gave the Center members and students a great opportunity to showcase their work. The event's success significantly helped the Center attain the high-level of regional recognition that it currently enjoys. Planning an on-campus event of that scale takes considerable effort in various distinct dimensions (marketing, organization, fundraising, reservations, food, transport etc.) and completely lacking staff support, these tasks were fully undertaken by the Directors, and the Math Dept. & COE support staff. Note that funds were raised every year to cover the expenses for the event; minimal, if any, university resources were needed. This year the event was held at Northeastern University in Boston.
- Lacking HPC technician support, the installation, care and maintenance of the Center's key computational hardware fell largely on the Directors and the Physics department's technician. Campus CITS contributed time as well, but only had limited expertise on the Center's highly-specialized equipment. As more equipment was added over the years, this challenge grew in magnitude. It is again worth noting that the work performed by individuals in the context of the

Center equipment was always done as an uncompensated overload. This again, is an ongoing issue that continues to-date.

- Campus support for research-equipment infrastructure has not kept pace with the growth in research faculty and focus on research. That also applies to the research equipment relevant to the Center i.e. large, complex supercomputing systems. The main infrastructure requirement to support supercomputing on-campus is adequate power and cooling. CITS's library data center is the main facility used by the Center (beyond the low-cost experimental container to host some unique equipment). That facility, while adequately powered, lacks robust cooling. Investments were made nearly a decade ago, with no funding available since. This tightly constrains the growth of Center's central computational resources — even when obtained via an external grant. This constraint has caused equipment currently in active use to be retired, when new equipment arrives. Other hosting locations do not have this issue but are far from ideal for different reasons.
- The Center and the University have benefited by being part of the Mass Green High Performance Computing Consortium (MGHPCC). The membership has given the center faculty exposure to great opportunities and a voice in shaping the MGHPCC computing clusters. While the membership itself has helped, the university's nearly \$2 million investment (since 2015) has not paid rich dividends. In the first few years of its formation, the campus and Center played a limited role in shaping the architecture and hardware configuration of the MGHPCC. Consequently, the MGHPCC's computational resources were of very limited use to campus researchers. In light of the campus' large contribution to the cost structure of the MGHPCC (UMass Dartmouth spends well over \$400,000 per year), this limitation led to significant frustration among the Center members. However, in the last couple of years, as their reputation grew within the Commonwealth and nationally, the Center has played a significant role in reshaping the MGHPCC computing resource configuration and governance. The two Center directors serve on the MGHPCC's Faculty Advisory Committee (FAC), with Dr. Khanna serving as a co-chair of this committee. The FAC, with representation from all UMass campuses, makes recommendations on configurations, purchases, upgrades, policies, etc. associated with the UMass shared cluster.

Future directions and opportunities for the Center:

The Center has achieved significant regional recognition in record time. A strong evidence in support of the growing reputation of the Center is that one of the Center Directors was selected to be included as the Co-PI for the entire UMass system on a \$60M proposal to establish a national supercomputer at the state's MGHPCC facility. The Center is poised to be recognized at a national level, but only if its current successful trajectory can be supported and accelerated.

The long-term vision for the Center includes it becoming a key player in the computational sciences nationwide, with an increasing international reputation. Eventually, it could serve as the basis for a new School of Computational Science on-campus with the ability to offer top academic programs at the undergrad and graduate levels and obtain very large external research funding. Computational science, already a strength at UMass Dartmouth, is an area of growth globally and modest investments in the near term are likely to result in significant returns in the future.

The Center for Scientific Computing and Visualization Research has been a model center at the University of Massachusetts Dartmouth with significant faculty and student engagements. There is significant

collaboration amongst its members leading to increased external funding. The Center has met its mission over the past five years and committee strongly recommends its continuation.