Academic Program Review
University of Hawai‘i at Mānoa Computing-Related Programs

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November 13-14 2019

Scope of the review

The primary focus of this review is the University of Hawai‘i at Mānoa’s Information and Computer Sciences Department (ICS) and the Computer Engineering activity in the Department of Electrical Engineering (EE). At a secondary level we explored the Laboratory for Advanced Visualization and Applications (LAVA) and the Hawai‘i Data Science Institute (HI-DSI). In addition to speaking with faculty, staff, undergraduate students, graduate students, and administrators, we spoke with representatives of companies who hire these programs’ students, of University of Hawai‘i units with which these programs are (or might be) collaborating, of the external entrepreneurial community, and of the university’s Information Technology Services organization.

We thank all who participated in the preparation and execution of this review for their time, effort, thoughtfulness, and candor.

The Role of Computer Science

Computer Science has a unique role in the modern university and in the modern world.

Increasingly, the quality of universities is dependent on the quality of their Computer Science programs. Every field is becoming an information field. Thus, students in a wide range of fields need to be well versed in Computer Science. And researchers in a wide range of fields not only need to use the fruits of Computer Science, but also need to collaborate with computer scientists in order to be at the forefront.

Increasingly, the economic and social vitality of regions is driven by information industries, which are dependent on the ideas and people produced by Computer Science programs. And increasingly, advances in Computer Science are central to tackling our great societal challenges – ranging from education to health care to transportation to energy independence to national security. Excellence in Computer Science is essential to nations, states and regions, as well as to universities.

The importance of the computing programs at UH Mānoa to the future of Hawai‘i is even more significant, because of Hawai‘i’s distance from the mainland. Students from all across Hawai‘i rely on these programs for their education – mainland institutions are inaccessible both geographically and financially. Employers here, ranging from the National Security Agency (NSA) to technology companies to consulting organizations to startups, are dependent on the graduates of these programs – it’s extremely difficult to recruit from the mainland, and the “stickiness” of mainlanders is low. Government agencies rely on these programs for assistance in areas such as data analysis and visualization – UH Mānoa is “the only show in town” for

advanced information technologies. And entrepreneurship and innovation depend on education, research, technology transfer, and entrepreneurship in Computer Science.

It's a difficult time for Computer Science programs everywhere – we are *all* facing this. Student demand is increasing dramatically. These students have increasingly variable backgrounds. Particularly at public universities, the students also have increasingly variable abilities. Faculty recruiting is extremely difficult, as is faculty retention – more difficult than in other fields because of the wealth of opportunities outside academia. And faculty are pulled in many different directions – there are ever-increasing requests for interaction and collaboration in research, for supporting joint or overlapping educational programs, and for keeping up with the rapid pace of innovation in our own field. There are enormous opportunities for computing writ large to impact fundamental research across disciplines, to transfer research into commercial products, and to address important local, national and social challenges. But with these opportunities come ever-increasing demands on time. So it's a struggle. And a struggle shared by all computer science programs.

The Information and Computer Sciences Department

ICS at UH Mānoa has many positives:

- There are a number of outstanding faculty – some of them are truly world class. The students, both undergraduate and graduate, know and deeply appreciate these faculty.
- The administration, up to and including the President, understands the importance of Computer Science and is exploring ways to invest in order to make the university's computing programs stronger.
- There have been some outstanding faculty hires recently.
- Steps have been taken recently that have significantly reduced the attrition rate of undergraduates at all levels.
- UH Mānoa is a high-performing R1 university with excellent programs in many areas that are eager for collaboration: oceanography, astronomy, the cancer center, sustainability, population sciences, and many more.
- The entire state needs and wants Computer Science at UH Mānoa to excel – the public sector, the private sector, and students.

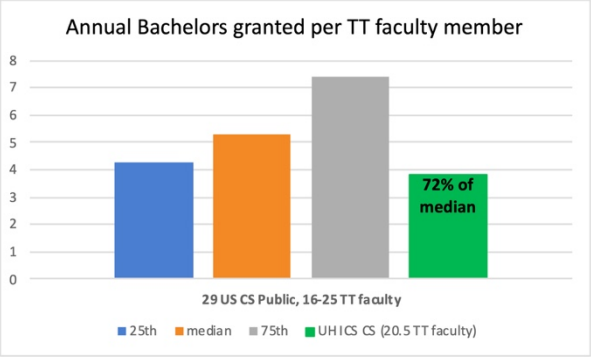
On the other hand, there are some significant issues. ICS is aware of many of them – they were identified in the final, "Reflections" section of the self-study. Among the faculty there is high variability in productivity, effectiveness, and commitment – "unmotivated" was a word that we heard more than once. There are also several faculty members who are widely regarded as disruptive. Leadership – both at the department level and at the College of Natural Sciences level – has strengthened recently, but overall has not dealt effectively with these issues; ICS faculty recruiting, for example, was described to us as "dysfunctional." The overall result is that ICS as a whole is under-performing similar programs.

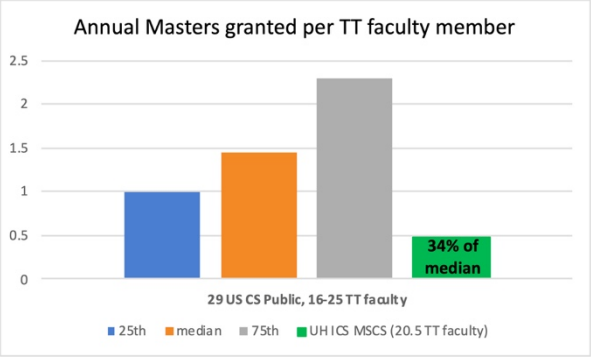
In an attempt to quantify this, we compared the data we were provided for ICS with the data reported in the Computing Research Association's 2018 Taulbee Survey[1] for 29 Computer Science programs at public universities with 15-25 faculty. (Note that many of these programs are not at R1 universities such as UH Mānoa, where one would expect a higher level of performance.) In comparing "per faculty member" measures, we considered only the 20.5

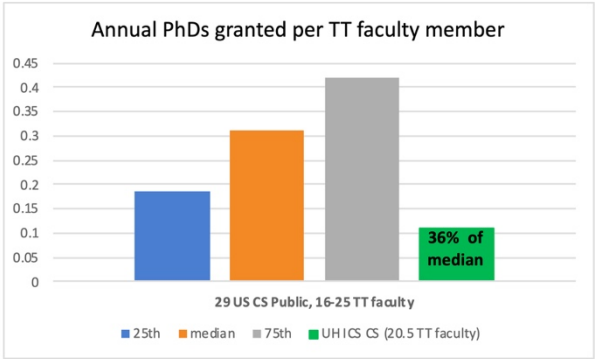
[1] https://cra.org/resources/taulbee-survey/

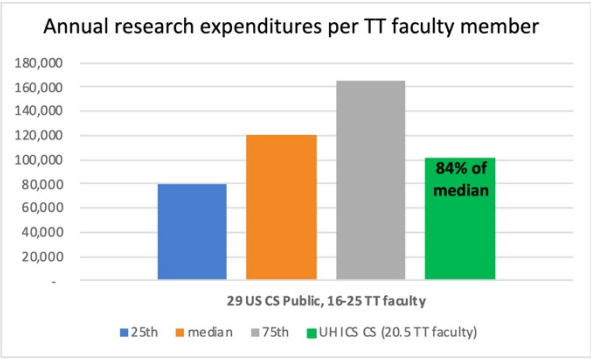
Computer Science faculty in ICS – not the 4.5 Library and Information Science faculty. We found:

- The number of Bachelors degrees granted annually per tenure-track faculty member in ICS (including the BS in CS and the BA in ICS) is 72% of the median of these other programs.
- Annual Masters degrees granted per tenure-track faculty member (including the MS in CS but not the MLISc) are only 1/3 of the median.
- Annual PhD degrees granted per tenure-track faculty member (including the PhD in CS and an appropriate proportion of the PhD in C&IS) also are roughly 1/3 of the median.
- Annual research expenditures per faculty member are 84% of the median, but this is largely due to only 3 faculty members. Half of the ICS faculty has not had *any* external research support in the past 5 years, and several others have had non-zero but very small levels of external support.









A number of ICS graduates work as software engineers at Amazon, Apple, Google, IBM, Microsoft, Tableau, and other mainland companies, in addition to local companies. However, we heard a consistent message from students, from employers, and from members of the university community who employ ICS students that the ICS Bachelors programs – BS and BA – produce too many students who are not prepared to practice: they are lacking the skills that employers expect of Computer Science graduates. Many courses are based on "book learning" and lack appropriate programming (skill-building) assignments/projects; the programming component tends to be delegated to optional senior-level courses where it might be too late for students to garner internships and compete in the job market. Courses in key areas such as Artificial Intelligence and Cybersecurity are sometimes outdated or not focused appropriately.

ICS must continue to take steps to address this. Importantly, the nation's better Computer Science programs manage to produce graduates who possess *both* practical skills and intellectual depth – it's not a case of "either/or."

Like students in other Computer Science programs nationwide, students in the Computer Engineering program in UH Mānoa's Electrical Engineering Department learn to design and build software systems. This program teaches foundations, but also gives students hands-on experience with software development; it has seized opportunities that ICS has not fully realized, such as a partnership with NSA in Cybersecurity. Employers inside and outside the university clearly recognize the differences in the capabilities of the graduates of the two programs.

Finally, we heard from external constituencies – from elsewhere in the university, and from the outside community – that engagement is limited. These external constituencies want greater engagement, and are willing to invest in achieving it.

At the graduate level, students feel they have few advisors to choose from. Because of the low level of research funding, new PhD students are supported as Graduate Teaching Assistants (GTAs), so don't have the opportunity to get involved in research early, delaying their maturity as researchers. GTAs feel that they are over-worked, leaving them little time for more creative/constructive activities.

As noted at the start of this section, there are a number of positives. However, there is a significant gap. The university and the state need a strong Computer Science program at UH Mānoa. They need *more* from ICS.

The Computer Engineering program in the Department of Electrical Engineering

The Department of Electrical Engineering is divided in to three groups: Computer Engineering, Systems, and Electrophysics. We met with all of the Computer Engineering faculty and two from Systems who work on optimization, information theory and signal processing related to Data Science.

As noted in the previous section, students in the Computer Engineering program receive an education that is at once both rigorous and practical. It covers mathematics and algorithms; architecture and systems; team project courses and capstone courses; etc. Team projects combining hardware and software are a particular strength of the program, giving students an integrated view of how real systems work. Students were uniformly positive about the major, the teaching, etc. Employers were positive regarding the capabilities of graduates relative to those from ICS.

The small number of faculty involved in the Computer Engineering program is a significant concern. The lower division core is taught by a single faculty member, a lecturer. The upper division core is taught largely by a single faculty member, except for the upper division software engineering course taught by ICS. Technical electives and project supervision are done by others, and one recent hire is beginning to contribute to teaching the core curriculum (and we agree that new hires should be given space to establish their research programs before taking on significant teaching load). But at the current time but only 3.5 faculty members are involved in the program. Additional faculty are required. We also noted that the division between the three groups with EE appeared somewhat more rigid than it needs to be. These groups make

sense and reflect research disciplines within EE, but teaching might be more fluid, e.g., having people from the Systems area teaching in Computer Engineering or vice versa.

The Laboratory for Advanced Visualization and Applications (LAVA) and the Hawai‘i Data Science Institute (HI-DSI)

HI-DSI and LAVA (which is a core laboratory of HI-DSI) are examples of the potential to build world-class science, engineering, and technology programs at UH Mānoa, and of the transformational impact of such programs.

LAVA is arguably the most impressive data visualization laboratory and program in the nation. Students from across the university participate: we met undergraduate and graduate students from ICS, Electrical Engineering, Art, Math, Architecture, and more. LAVA has attracted roughly $8 million in external funding in the past five years. There is tremendous community engagement – for example, LAVA is working with the Hawai‘i State Energy Office to help stakeholders understand the implications of various scenarios for deploying renewable energy. LAVA has deployed 18 interconnected Cyber-Canoe state-of-the-art visualization and collaboration systems – systems that LAVA designed and implemented – on two islands, with a third to be added by the end of the year. LAVA is closely engaged with the Academy for Creative Media, injecting technology into this program.

The ICS Library and Information Science program

The ICS Library and Information Science program was not a focus of this review, but it is a notable bright spot. It offers an American Library Association (ALA)-Accredited two-year professional Masters degree. The 1,730 graduates of this program serve in public, school, academic, and special libraries as well as archives – not only in Hawai‘i, where they make up two-thirds of the information professional workforce, but also in other states and overseas. The 4.5 faculty in this program perform at a high level, granting an average of 24 MLISc degrees annually over the past 5 years.

Recommendations

Our recommendations are made with the aim of achieving a number of outcomes:

1. Increase the number of Computer Science graduates from UH Mānoa.
2. Increase the employability of UH Mānoa Computer Science graduates, with emphasis on local private sector and public sector employers.
3. Increase interdisciplinary research collaboration by Computer Science faculty.
4. Increase engagement with external public sector and private sector entities.
5. Increase the faculty productivity in terms of PhD production, research expenditures, etc.
6. Increase entrepreneurial activities of CS faculty and students.

<u>Regarding the ICS curriculum</u>

- Modify the content of courses so that the undergraduate program produces students who are prepared to work as software developers. This can be done without sacrificing exposure to the fundamentals – it is not “either/or.” It is clear to us that there are jobs for such graduates; we consistently heard comments from employers such as “There are

plenty of jobs – just not for a lot of the graduates currently being produced." The concern was expressed that students also don't know algorithms, which suggests they are not absorbing even the more theoretical material in the ICS curriculum.

- Merge ICS courses with corresponding Computer Engineering courses – courses such as algorithms and operating systems – so that there is a single course, taught in the same way alternately by faculty from each program. Adopt the Computer Engineering approach to these courses.
- Embrace external offers of assistance – for example, from NSA and the FBI in Cybersecurity. (Cybersecurity is a tremendous regional opportunity that is being missed by ICS – but seized by EE's Computer Engineering program.)
- Establish an Advisory Board which periodically reviews the program curriculum, among other things, and identifies gaps and recommends changes to ensure graduates meet the needs of employers. Members of the Advisory Board could come from local industrial as well as non-industrial employers.
- Publish (and adhere to) a 3-year outlook for course offerings so that students and advisors can plan programs.
- Provide additional support for activities of the student ACM chapter that fill gaps, such as the mock interviews conducted by the GrayHat group.
- Use TAs appropriately – in appropriate amounts, for appropriate activities.
- Ensure that all tenure-track faculty feel responsibility for the undergraduate program, so that the courses fit together to address the educational objectives, and so that a fair and appropriate balance of teaching responsibility across all faculty is achieved.

<u>Regarding the ICS faculty</u>

- Continue with the institution of serious annual reviews of teaching, research, service, and commitment. Annual review of all faculty members should be mandatory. Putting "teeth" into these reviews is challenging, though; for example, it is a disservice to students to allocate extra teaching duties to less productive faculty members.
- Pay increased attention to student feedback about specific courses and specific instructors. Student course evaluations should be mandatory, and the Chair should have full visibility into these evaluations.
- Continue to recruit faculty with a practical orientation. This doesn't mean that they don't do research, or don't appreciate the fundamentals. Rather, it simply means that they are focused on graduating students with practical skills, and that their research is oriented towards putting Computer Science to work to better the world.

<u>Regarding ICS structure and leadership</u>

- Take steps to build a stronger sense of community at all levels – we discussed a number of approaches in response to questions at our out-brief.
- Exercise a stronger hand at the tiller. (As noted earlier, there are several faculty members who are widely regarded as disruptive, and faculty recruiting was described to us as "dysfunctional.")
- It's not obvious to us that the current structure – ICS in the College of Natural Sciences with an integrated Librarianship program, and Computer Engineering within Electrical Engineering in the College of Engineering – is the right structure for moving things forward. Some restructuring may be appropriate. However, we do *not* feel that it is appropriate to consider the creation of an independent School or College at this time. The costs would far outweigh any possible benefits.

Regarding the Computer Engineering program in the Electrical Engineering Department

- This program is considerably under-resourced in terms of faculty; there are multiple potential single points of failure.
- Consider accelerating the introduction to high-level programming – more Python (or Java) as an introductory course or in the first two years.
- Look for opportunities to connect with HI-DSI and other areas on campus. There may be opportunities to better connect the Data Science activities across campus through joint seminars or joint proposals. Some of this seemed to be happening, and the EE faculty are working on applications in medicine and elsewhere, but additional connections could both strengthen the algorithmic aspects of Data Science and increase the practical impact of the more theoretical work.

Institutional curricular issues

- Reduce the foreign language requirement from 2 years to 1 year. (We appreciate the importance of a broad education, including an understanding of the language, history, and culture of some other part of the world. But one year at the college level seems like enough, and is far more common.)
- We observe that UHM's introductory course sequences in mathematics and the physical sciences are longer than is typical at other institutions - for example, four semesters (two years) of Calculus, vs. two semesters or three quarters (one year), which is the norm. Is some compression possible, which would enable a combination of more diverse enrichment and more courses in the major? Variability in background is a common problem. The university may need to be flexible by allowing specific programs to replace some of the current general requirements with other courses. The review committee did not have sufficient time to study this in depth, but, for example, one might consider replacing the 4^{th} semester of calculus with discrete math and probability, or giving students more options for outside science specialization which might come later in the program.

The road ahead

The university and the state – its public sector, its private sector, and its students – need a strong Computer Science program at UH Mānoa, a program that performs at a high level in education, research, and engagement.

Because programs at UH Mānoa will inevitably be smaller than those at leading-edge mainland counterparts, efficiency must be high and redundancy must be low.

While the recommendations that we have made above are important, should be implemented, and will result in significant improvements, we urge university leadership to consider whether they will be sufficient to achieve the necessary improvements. Structural changes may be required; merely injecting additional resources into the current structure may not suffice.

Below are four options to consider. Please view these only as "food for thought and discussion." We sketch them in very general terms:

1. Preserve the existing structure. Make key courses (e.g., algorithms, operating systems) joint between EE and ICS, adhering to the more practically-oriented EE curricula. Ensure that ICS has a chair who is willing and able to provide strong leadership. Provide retirement incentives for under-performing and/or disruptive ICS faculty members. Provide additional

faculty positions that will be recruited to joint ICS/EE positions through a process separate from the current ICS and EE recruiting processes; exercise great care in selecting the members of the search committee.

2. Move pragmatically-oriented CS faculty from ICS to EE, perhaps transitioning EE to EECS. Allow ICS to continue as an Informatics and Librarianship program; faculty in ICS would continue to offer the BA in ICS degree (which would shift even further in the direction of an "informatics" degree) and would continue to collaborate in the PhD in C&IS degree, as well as offering the MLISc degree. The BS in CS degree would continue to be awarded by the College of Natural Sciences, but would be offered by EECS faculty.

3. Create a new department in the College of Engineering, "Computer Science & Engineering" (CSE). Move into it the Computer Engineering faculty, and the pragmatically-oriented CS faculty from ICS. Allow ICS to continue as an Informatics and Librarianship program, as in (2) above. CSE faculty would offer the Computer Engineering degree and the BS in CS degree which, as in (2) above, would be awarded by the College of Natural Sciences.

At this point we add an important note. The arrangements described in (2) and (3) above – an EECS or CSE department, housed in a College of Engineering, awarding a BS in Computer Engineering through the College of Engineering, and a BS in Computer Science through the College of Natural Sciences – is *precisely* the arrangement that exists at Berkeley and at the University of Washington. And in both of those cases, this arrangement arose just as we are suggesting here: through moving a Computer Science program from the College of Natural Sciences to the College of Engineering. In neither case was the strength of other units in the College of Natural Sciences diminished; in neither case did interactions decrease; Natural Science programs at each institution continue to expand their activities in numerically-oriented and data-oriented computational science (which overlaps with, but is certainly not the same as, Computer Science).

4. Create a new department in the College of Engineering, "Computer Science & Engineering" (CSE). Move into it the Computer Engineering faculty, and all of the CS faculty from ICS. Move the Librarianship faculty from ICS to the School of Education. ICS is then dissolved. Recruit a strong chair for CSE; empower this person to be more like a "head" than a "chair" in that s/he can suppress the disruption of certain ICS faculty (perhaps implemented by a strong hand on the part of the Dean), and, as in (1) above, provide retirement incentives for under-performing and/or disruptive former ICS faculty members. As in (3) above, the CSE faculty would offer the Computer Engineering degree and BS in CS degree which, as in (2) above, would be awarded by the College of Natural Sciences. The BA in ICS degree could continue to be offered but should probably be wound down; student interest appears to be decreasing and faculty interest, entirely appropriately, will shift in the Computer Science and Computer Engineering direction.

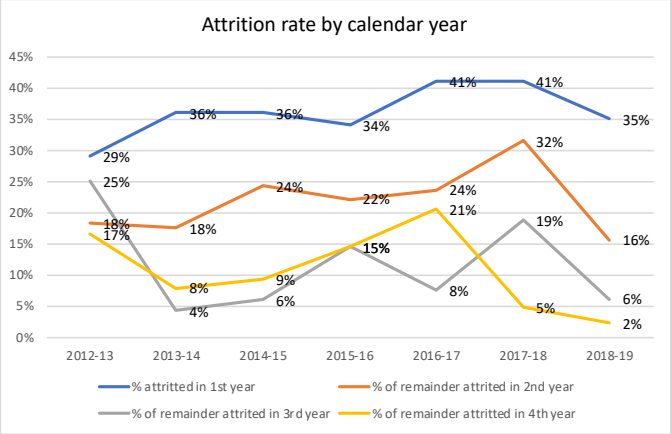
Addenda

Undergraduate attrition rate

We noted in the main body of the report that steps have been taken recently that have significantly reduced the attrition rate of undergraduates at all levels. To determine this, we viewed attrition in a way that differed from the charts we were provided in two ways:

- First, for any particular cohort (i.e., for students who arrived in a particular year), we computed the attrition in a particular year (e.g., the attrition in the third year) as a percentage of the students who entered that year, rather than as a percentage of the students who entered as freshmen.
- Second, for each calendar year, we looked at the attrition in students' first year, in students' second year, in students' third year, etc. This allowed us to look for changes in overall retention in a particular year.

The chart shown here illustrates that while the attrition rate among students in each year of their studies is quite high, the most recent year showed significant improvements across-the-board.



(Separately, we compared ICS attrition rates to those of other Natural Science and Engineering programs; ICS attrition rates are higher, but only modestly so.)

Review schedule and participants

Three items are attached: a schedule of the review, the names of University of Hawai'i at Mānoa participants (except those who participated in focus groups), and the names of participants from the external community.

Data products

Preparation for the review would have been facilitated by more accurate data. We encountered many inconsistencies in the tallies of research awards – probably due to the fact that faculty are associated with multiple units, and awards are attributed in different ways at different times. But we even had to dig in order to determine the active faculty in ICS.

Schedule for Campus Visit

Computer Science and Engineering Review Team Visit, University of Hawai'i at Mānoa

November 13 and 14, 2019

Time	Day 1 (Wed 11/13)	Time	Day 2 (Thur 11/14)
		7:00 AM	Taxi Service to Campus
		7:30 AM	Team Time HH 209
8:00	Taxi Service to Campus		
8:20	Greetings - Hawai'i Hall (HH) 209	8:30 - 9:20	Affiliated campus deans/directors B. Taylor, R. Holcombe, B. McLaren, C. Dodds HH 209
8:30 - 9:00	College of Engineering and College of Natural Sciences Deans - HH 209		
9:00 - 9:30	President Lassner and AVCAA Lyons HH 209	9:20 - 9:30	Break
9:30 - 11:00	**Concurrent 1 on 1 meetings & tours w/ Dept. Chairs** Comp Sci - S. Gupta - S. Robertson Comp Eng - K. Yelick - G. Sasaki LAVA/HI-DSI - E. Lazowska - J. Leigh/G. Jacobs	9:30 - 10:20	Research leaders V. Kameoka, C. Walton, S. Auerbach, and S. Yamada HH 209
		10:20 - 10:30	Break
11:00 - 11:15	Break	10:30 - 11:50	Report Writing - HH 209
11:15 - 12:15	Lunch Meeting: Undergrad Ed and Grad Div HH 209		
12:15 - 12:30	Break	11:50 -noon	Break
12:30 - 1:20	Concurrent Faculty meetings Comp Sci - Gupta - POST 318B Comp Eng - Yelick - Holmes 309 ITS - Lazowska - HH 209	12:00 - 1:00	Lunch and Debrief with President HH 209
1:20 - 1:30	Break		
1:30 - 2:20	Concurrent Undergraduate meetings Comp Sci - Gupta/Lazowska - POST 318B Comp Eng - Yelick - Holmes 309	1:00 - 2:00	Report Writing- HH 209
1:50 - 2:00	Break		
2:30 - 3:20	Comp Sci Graduate Students Gupta POST 318B / Advisors Yelick & Lazowska HH 209	2:00 - 2:30	Meeting Prep / Walk over to Webster
3:20 - 4:00	Break	2:30 - 3:30	Exit Report Webster 203
4:00 - 4:50	Community Groups HH 309		
5:00	Team Taxi Service to Ala Moana Hotel	3:30 - 4:00	Team Debriefing HH 209
6:00	Dinner at Mariposa in Neiman Marcus		
		4:15	Taxi Service to Hotel

indicates team is together	indicates team is separated

University of Hawaii participants

Last name	First name	Position/Dept	mtg time	mtg date
Robertson	Scott	Dept Chair, Computer Science	9:30 a.m.	11/13/19
Sasaki	Galen	Dept Chair, Computer Engineering	9:30 a.m.	11/13/19
Leigh	Jason	LAVA Lab	9:30 a.m.	11/13/19
Morioka	Brennon	Dean of College of Engineering	9:00 a.m.	11/13/19
Helminck	Aloysius (Loek)	Dean of College of Natural Sciences	9:00 a.m.	11/13/19
Cambra	Ron	Assist VC of Undergrad Ed	11:15 a.m.	11/13/19
Rodwell	Gary	IT Specialist, Aacdemic Development and Technology	11:15 a.m.	11/13/19
Aune	Krystyna	Dean, Graduate Division	11:15 a.m.	11/13/19
Maeda	Julie	Assoc. Dean, Graduate Division	11:15 a.m.	11/13/19
Jacobs	Gwen	ITS	12:30 p.m.	11/13/19
Yoshimi	Garret	ITS	12:30 p.m.	11/13/19
Ito	Jodi	ITS	12:30 p.m.	11/13/19
Taylor	Brian	Dean, School of Ocean, Earth Science, and Technology	8:30 a.m.	11/14/19
Holcombe	Randy	Director, Cancer Center	8:30 a.m.	11/14/19
McLaren	Bob	Interim Director, Institute for Astronomy	8:30 a.m.	11/14/19
Dodds	Curt	IT Manager, Institute for Astronomy	8:30 a.m.	11/14/19
Walton	Chad	Interim Asst. VC for Research	9:30 a.m.	11/14/19
Auerbach	Steve	Interim Director, Office of Innovation and Commercialization	9:30 a.m.	11/14/19
Yamada	Susan	Pacific Asian Center for Entrepreneurship	9:30 a.m.	11/14/19

Meeting with external community members, 11/13 4:00-4:50

Last Name	First Name	Title	Company
Clark	Daniel		NSA
Schlimm	John	Academic Engagement	NSA
Shibao	Kelli	Academic Engagement	NSA
Shawcroft	Paul	Technical Director	NSA
Trent	Jason	Hawai'i Research Liason	NSA
Ontai	Eddie	President	Data House
Sultan	Omar	Managing Partner	XLR8HI
Sakata	Steven	VP Business Development	eWorld Enterprise Solutions
Yamamoto	Karen	President and CEO	Decision Research
McElhaney	Les	VP Product and Technology	Decision Research
Tsuchiyama	Ray	DOE Consultant	
Dames	Peter	Exec. VP for Mobility Ventures & Technology	Servco