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(SECAF 2030) University of Utah Technical Listening Engagement Air Force 2030 Forum

Cynthia Furse
UNIVERSITY OF UTAH SALT LAKE CITY

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Air Force Research Laboratory
AF Office Of Scientific Research (AFOSR)/ RTB1
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Air Force Materiel Command

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University of Utah – Technical Listening Engagement Air Force Science and Technology 2030 Forum

1 CONTENTS

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Air Force Science and Technology 2030 Forum

2 SUMMARY

In September 2017, the Secretary of the US Air Force, Heather Wilson, launched an initiative to update the agency's science and technology (S&T) strategy to meet the challenges of the coming decade and beyond. In accordance with this mission, Secretary Wilson suggested that the Air Force community should "listen broadly for promising research directions," and importantly, she encouraged the Air Force Research Lab (AFRL) to engage with independent partners. Research has shown that independent civilian scientists and technical industry are essential in maintaining a healthy and vigorous approach to long-range technical forecasting[1]. True to this aim, the AFRL solicited proposals for a series of university listening engagements, professional society appearances, and informal gatherings throughout the United States. This effort resulted in a roster of strategic Science and Technology 2030 (S&T) events designed to engage, listen, and learn from the scientific community, higher education, and industry professionals nationwide.

Abstract: The University of Utah (UU) hosted the 6th S&T event at the SJ Quinney College of Law on the Salt Lake City campus over July 10-11, 2018. This workshop helped AFRL to engage with industry and academic partners throughout the United States, with an emphasis on the Southwest region. ***The objective of the workshop was to solicit and explore science and technology ideas that will be used to guide Air Force investments in basic and applied research over the next decade.*** In a broad sense, these efforts aspire to result in new capabilities for the Air Force in 2030 and beyond. Commensurate with this motivation, the UU proposes to provide a platform to connect Air Force interests with regional leaders in science and technological innovation from academia and industry.

[1] *Harnessing the Genie* by Michael H. Gorn

3 TECHNICAL THEME AND TOPICS

The S&T conference was organized around the overarching theme of *Game-Changing Technology*. This theme intersects with all five of the Core Functions of the Air Force[2], which are:

1) Global Mobility for the Joint and Coalition Force

2) Freedom of Maneuver

3) Detect and Identify Enemy Targets

4) Hold Global Targets at Risk

5) Global Command and Control

The areas of basic research that were covered during the workshop are listed below. There were two blocks (morning and afternoon) of six parallel breakout sessions (12 sessions total). The number (6) or breakout sessions was chosen, in part, because of the availability of 6 classrooms holding 50-75 participants each. Details of each session and the abstracts presented are included in section 10 Agenda, Topic Details, Breakout Sessions, page 17.

Table 1 Technical Workshop Topics. More details on each topic and abstracts of lightning briefs presented in each session can be found in section 10 Agenda, Topic Details, Breakout Sessions.

Morning Breakout Sessions	**Afternoon Breakout Sessions**
Data to Knowledge: How do you convert myriad data to actionable information? How can data be used in ways not even imagined today?e.g. Visualization, artificial intelligence, language processing, data mining, big data, novel uses of data, new types of data, IOT applications. Participants: 32 Abstracts: 9 Posters: 2	**Air-Borne and Space-Based Services 2030:** How can we deploy emerging technologies in novel ways to help see, sense, communicate, or understand? e.g. Remote sensing and imaging, communication, space weather, and more. Participants: 34 Abstracts: 6 Posters: 0
Novel Sensors and Sensing Strategies: What types of sensors and sensing strategies may be useful in the field? e.g. Biosensors, sensing threats (chemical, pollutants, nuclear, etc.), situational awareness. Participants: 51	**Next-Generation Energy:** What energy sources are on the horizon, or could be envisioned, that are smaller, lighter, more powerful, sustainable, available everywhere? e.g. Batteries and storage technologies, fuel sources, wireless power transfer, and more. Participants: 42

[2] S&T 2030 Strategic Themes

Abstracts:14 Posters: 1	Abstracts:6 Posters: 1
Human / Machine Performance: How can humans integrate more deeply with machines and devices? e.g. Robotics, neural implants, mind-machine melding, artificial intelligence, self-learning control systems, and more . Participants: 47 Abstracts:6 Posters: 0	**Enhancing the Warfighter:** How can the next generation Air Force be stronger, faster, smarter, and healthier? e.g. medical and behavioral enhancements, humans in extreme environments, technology for rapid detection, prevention, treatment. Participants: 46 Abstracts:7 Posters: 1
Revolutions in Global Integrated Communication: Communication that is consistent, secure, and reliable is key to the success of every mission. What new concepts and technologies can enable multi-domain, communication from ground-to-air-to-space that are agile, secure, and robust? Participants: 14 Abstracts:3 Posters: 0	**Cyber-Defense 2030:** Cyberspace will be a major battlefield of the 21st century, both at home and in the field. e.g. How to deter, detect, and overcome existing threats in new ways; what new threats can be anticipated, and how might we overcome them. Participants: 25 Abstracts:4 Posters: 0
Expeditionary Operations: With a military on the move, how could you build a support city in a day? (power, water/waste, communication, housing, air fields, etc.) Participants: 20 Abstracts:2 Posters: 0	**Zero-Cost Maintenance Challenge:** How could we dramatically reduce the cost of logistics and maintenance for future systems? e.g. novel low-cost platforms, self-healing structures, non-destructive testing, novel maintenance approaches. Participants: 18 Abstracts:2 Posters: 0
Rethinking the Nature of Aerospace Materials: What revolutions in materials are on the horizon, or could be imagined, and how could they be used in aerospace or warfighter applications? Participants: 41 Abstracts:2 Posters: 0	**Advanced Customized Manufacturing:** Rethinking manufacturing for low-rate, custom, specialty devices, particularly those for extreme aerospace applications; expeditionary manufacturing (building and repairing in the field). Participants: 34 Abstracts:4 Posters: 1

4 AGENDA:

USAF Science and Technology 2030 Workshop -- July 10-11, 2018

July 10 6-8 pm Industry Networking Reception, Utah State Capitol Rotunda (Sponsored by the UofU Vice President for Research (VPR) office and Utah's Science, Technology, and Research Initiative (USTAR). Bus was provided from the Guest House and Law School to the Capitol.

July 11 Workshop (University of Utah S.J. Quinney College of Law)

7-10 am	Shuttle running continuously from Guest House to Law School		
7:30 am	Registration and Light Breakfast opens		Law School, Level 6
8-9 am	Orientation and Introduction to S&T 2030		Moot Court Room, Rm 6200
	Conference Welcome	*Dr. Cynthia Furse*	
	University of Utah Welcome	*Dr. Dan Reed*	
	AFRL Welcome	*Dr. Michael Eismann*	
	Overview of Technical Themes	*Major Brook Bentley*	
915-1230 am	Morning Breakout Sessions		
	915-930	*Air Force Perspective and Needs for this Topic*	
	930-1030	*Exploration and Discussion (6-12 lightning presentations)*	
	1030-11	*Identifying Future Research Themes*	
	11-1115	*Break (Moot Court Room Lobby)*	
	1115-1230	*Ideation for Future Research Paths*	
1230 – 2 pm	Lunch and Poster Sessions		Moot Court Lobby/Terrace
2-515 pm	Afternoon Breakout Sessions		
	2-215	*Air Force Perspective and Needs for this Topic*	
	215-315	*Exploration and Discussion (6-12 lightning presentations)*	
	315-345	*Identifying Future Research Themes*	
	345-400	*Break (Moot Court Room Lobby)*	
	400-515	*Ideation for Future Research Paths*	
530-6	Where Do We Go From Here?		Moot Court Room
6-8	Networking & Poster Session		Moot Court Lobby/Terrace
5-830	Shuttle runs from Law School to Guest House		

5 BREAKOUT SESSIONS AND IDEATION

Morning and afternoon breakout sessions provided opportunities for idea exchanges and group ideation.

5.1 IDEATION EXPECTATIONS

There were several activities at this forum, but the core functions were the working ideation sessions. We were seeking the unique perspective of the participants through an open dialogue, building on each

emerging idea, grounded in mutual respect. We asked participants to think big, surprise us, help come up with unexpected ideas.

5.2 SUPPORT

Each session was supported by an academic chair (invited by the conference organizers), a professional facilitator to help move the discovery forward (from DSIAC, contracted through SURVICE), and 1-2 AFRL subject matter experts (SMEs), to frame Air Force needs and clarify questions, and 1-2 dedicated recorders to capture the process and outcomes.

We used the USAF ideation template to collect and document final ideas. In addition, we wrote the final ideas from each team on large (2x3') post it notes to share with the rest of the participants at the networking reception.

5.3 IDEATION PROCESS

5.3.1 Three Phase Process

At this workshop, there were 6 topic tracks of ideation in the morning session and 6 different topic tracks in the afternoon. For both the morning and afternoon ideation sessions, we moved through three phases of an ideation process: topic exploration, theme identification, and idea development.

5.3.2 Topic Exploration

We began each ideation by exploring the topic and its projected future trends through a series of short technical briefs. These briefings each contributed a unique perspective on the future challenges and opportunities ahead and prepare each topic cohort to join in the ideation process.

5.3.3 Theme Identification

Next, we asked participants to work in small groups to consider what emerging technologies and concepts may provide the best opportunity for the Air Force. Each group could nominate a theme, or a compelling opportunity space, and the cohort selected the most promising themes to carry forward.

5.3.4 Idea Development

In the final phase, participants selected the theme that best matches their skills and interests and worked in small teams to develop ideas that can enable the future Air Force. An idea template (see section 16 Appendix D: Ideation Template page 99) was provided to guide the development and documentation of the team's ideas.

LESSONS LEARNED: We felt this ideation process worked very well. Many of the participants gave verbal feedback that they enjoyed it very much, that they had not experienced something like this before, and that we ought to do more of it. We are planning to use this format for ideation around upcoming grant opportunities at the University. We will do this for one topic at a time, probably over lunch and an afternoon.

The professional facilitators were extremely effective. They were probably essential to obtaining the quantity of discussion, and hence the quantity of ideas that were shared at this workshop. In some cases, the academic chairs that we also defined also helped set the tone for their sessions. In others, they did

very little. Given this format, which was new to virtually all the participants, having the experienced facilitators made a huge difference to the success of the event. The recorders / scribes were also essential, as the ideas were flying fast and furious. The participants were generally too involved in discussions to do much if any documentation, so the recorders really were essential.

The quality of the ideation was clearly driven by the participants themselves (so a quality invitation list was essential). In some cases, particularly where people had common interests and had been working on an area for some time (were experienced scientists in this area), the ideation went particularly smoothly. Ideas that were already familiar to those in the community came out first, but more novel ideas seemed to come out after the existing scientific directions had been laid on the table.

Having the USAF subject matter experts in each breakout session was fantastic. Having them give perspective on the USAF needs both before (written descriptions of each breakout session, which are included in Section 10.6 Air Force 2030 Tech Ideation Workshop Breakout Sessions) as well as a brief introduction at the start of the session were very important to set the stage for discussions and ideation. Often, they were called upon mid-session to manage scope or direction. They also gave the strong appearance that the Air Force was listening to the ideas, which is perhaps the very most important reason to have them there in person.

The poster sessions over lunch and the networking reception seemed to work extremely well. The poster presenters were extremely busy in discussion with people visiting their posters, to the point they had to wait to eat afterwards. Having the posters right where the food was probably made a big difference. If they had been in a separate, out of the way space, this might not have been as effective. Most of the presenters were students, who were representing the work of their larger research group. They also commented that this was a very good experience for them.

We had some challenges, or so we thought, with some breakout sessions being large and others small. This was just based on the interests of the participants. We were concerned that the smaller breakout sessions would be less effective, but in fact, it is possible they were more effective than the larger sessions. In the larger sessions, there were many ideas to share, but each individual discussion group could still only ‘fit’ 6-8 people, so the scope of the discussions ended up still being relatively small. In the smaller groups, the whole group tended to participate, and the discussion went quite smoothly as well. My conclusion in the end was that both large and small groups worked. Large groups had challenges giving everyone who wanted to do a short presentation time to do so and therefore felt more rushed, so I would limit the size of groups in the future to about 30-35, and try to split up the larger groups into smaller subtopics to make it easier to manage. In some of the smaller groups, only a few of the participants wanted to give lightning presentations, which seemed like a problem at the time. In the end, though, around the tables, people were much more generous with their ideas, and much of what might have been brought out in a lightning talk actually came out around the tables.

Industry engineers were often limited on what they could share in lightning talks, etc. so most of the planned abstracts were from academics, not industry. For industry, the ability to submit proprietary information on line was important, and that question was reiterated throughout the day.

Although this format was new to most participants, it seemed to work out very well. I’m not sure if I’d change much of anything in the format of the workshop. It seemed to work quite well.

6 VENUE

6.1 UNIVERSITY OF UTAH S.J. QUINNEY COLLEGE OF LAW

The University Campus

The University of Utah is 15 minutes from Salt Lake International Airport, offering a broad range of economical flights from states in the Southwest region (Utah, Colorado, New Mexico, Nevada, California, Arizona). This is also a convenient location for the substantial industrial base in and around Salt Lake City. Many of these industries work in support of Hill Air Force Base, and therefore have business interests aligned with the Air Force.

The S.HJ. Quinney College of Law

The S.J. Quinney College of Law offered a spacious conference space including both large indoor and outdoor reception space and is convenient to local hotels, freeways, and public transportation (bus and light rail). The University of Utah Stadium, just across the street, offers extensive parking, particularly during the summer when fewer students are on campus. The law school does not hold summer classes, and therefore almost all of the classrooms and large spaces in this building were available to be used for this conference. AV equipment is already built-in, and the building is designed for basic security. It has only one public entrance, which is supervised by a front desk receptionist during business hours, and is locked after hours. A map of the areas used for the conference is included in section **Error! Reference source not found.** page **Error! Bookmark not defined.**.

6.2 INDUSTRY NETWORKING RECEPTION VENUE: UTAH STATE CAPITOL ROTUNDA

A reception for industry July 10, 2018 took place at the Utah State Capitol Rotunda. This reception was sponsored by the University of Utah VPR Office and USTAR.

LESSONS LEARNED: It was very beneficial having the industry reception in the early evening, in a place that was particularly convenient for freeway access. Local industry representatives came after work and many appreciated this convenience. It was also good having so many people from USAF there. It would have been helpful if we had better identified them with specific colored name tags or something like that.

6.3 LODGING

Lodging was arranged at the UU-University Guest House Hotel, which is located on the UU campus in Fort Douglas. The negotiated room rate was $120 per night.

LESSONS LEARNED: Because of the very short time frame for planning this workshop, some of the facilitators and SMEs were not chosen until about a week before the conference. They had therefore not registered or gotten rooms, and the hotel had released the rooms for general purpose and were no longer holding that room rate. We were able to get them to re-open the room block at the negotiated rate. If running another similar conference, it would be important to figure out not only how many USAF participants to expect, but especially how many facilitators, reporters, and SMEs, to be sure enough rooms are held at the end.

6.4 SHUTTLE

A university-operated shuttle connected the lodging facilities with the conference venue in the morning and evening of July 11, and a bus was provided from the guest house to the Capitol for the Industry Networking event July 10.

LESSONS LEARNED: The schedule of the shuttle helped keep out of town visitors present throughout the day (rather than participating in their primary session and then leaving.

7 LOCAL ORGANIZING COMMITTEE

7.1 CONFERENCE CHAIR

Dr. Cynthia Furse is the Associate VP for Research at the University of Utah and Professor of Electrical and Computer Engineering. www.ece.utah.edu/~cfurse Dr. Furse is a Fellow of the Institute for Electrical and Electronics Engineers (IEEE) and the National Academy of Inventors (NAI). Her technological innovations and 15 patents include development of a system to locate intermittent electrical faults on aging aircraft wiring, with which she founded a spin-off company, LiveWire Innovation. She is also a pioneering researcher in the development of telemetry antennas for medical implants, and fast methods for predicting the statistical variation in bioelectromagnetic applications. Dr. Furse teaches electromagnetics, wireless communication, computational electromagnetics, microwave engineering, and antenna design and is currently a leader in the flipped classroom teaching method. She works to interest young students, including women and minorities, in engineering and routinely volunteers in Utah's K-12 schools. She has received numerous teaching and research awards including the 2017 Governor's Medal for Science and Technology and the 2009 IEEE Harriett B. Rigas Medal for Excellence in Teaching.

LESSONS LEARNED: I received the chairmanship of this effort roughly 6 weeks before the date of the conference. This was an exceptionally tight time frame, so everything felt like a scramble. I greatly valued the support of the USAF team who had run conferences of this type and scale before, and their

list of all the things that needed to be done. The most important things were to identify key team members (listed below) who could help with all of the details needed, and then step back and get out of their way and let them do their work, and follow up regularly to be sure nothing was being left out. Delegate, delegate, delegate!

7.2 LOCAL ORGANIZING COMMITTEE

The following personnel will develop and coordinate the meeting content and logistics:

- Dr. Cynthia Furse, Associate Vice President for Research and Professor of Electrical and Computer Engineering, University of Utah
- Dr. Ivy Estabrooke, Executive Director, Utah Science Technology and Research Initiative (USTAR)
- Wayne Bradshaw, Utah Science Technology and Research Initiative (USTAR)
- Brian Somers, Utah Science Technology and Research Initiative (USTAR)
- Meghan Webb, CMP, Conference and Event Management, University of Utah
- Kris Monty, SJ Quinney College of Law, University of Utah

University of Utah Conference and Event Services (conferences.utah.edu, led by Meghan Webb) is a full-scale professional team that routinely organizes events from 50 to 5000 participants. For this event, they will provide:

- Registration website, pre-registration, and printing of the name-tags.
- Email support for invitations using Constant Contact software.
- Budget and planning support.
- Liaison and contracting with hotel and transportation (shuttle) providers.

College of Law Event Team (led by Kris Monty) is also a full-scale professional team that organizes events for the College of Law and for groups using the Law School venue for their event. For this event, they will provide:

- On-site registration support and coordination with the UU Conference Services, who will perform pre-event registration and name-tags.
- Audio-visual support, including photography.
- Day-of management of transportation (shuttles).
- Coordination with caterers, table and room setups.
- Coordination with University Police for uniformed security.
- Coordination with University Parking Services for parking moratorium and reserved spots.
- Coordination of boards for posters.

USTAR (led by Wayne Bradshaw) will arrange the July 10 Industry Networking event at their Innovation Center in Clearfield, Utah. For this event USTAR will:

- Coordinate catering, tent, tables, and AV.
- Coordinate with the UU Conference Services on the specifics of shuttle transportation to their event.
- Coordinate uniformed security for this event.
- Invite their network of local industries to both the July 10 and July 11 events.

LESSONS LEARNED: This team was exceptional. Get a really great team of experienced event planners, get out of their way, and let them do their job. If the Air Force or other groups wishes to do similar conferences in the future, funding for these event planners is absolutely essential to the success and sanity of the event. There is no way any one person could organize and pull off an event like this. It took an experienced team. Professors are not event planners.

7.3 APPROXIMATE PLANNING TIMELINE

LESSONS LEARNED: It would have been useful to keep a detailed log of the planning timeline, but I didn't. So this is an estimate of what we did and when. I'll label the most critical items red.

Week Minus 6: Planning Begins.

- Weekly telecons with USAF team were essential for success.
- Create To-Do List and Team
- Needed to move the date (originally July 26, didn't work for USAF reporting schedule, or local hotel bookings)
- Needed: Registration (website, abstract submission, etc.), On-site registration, hotel/travel info, invitee list, method to do invites, shuttles/local transportation, catering, agenda, topics, security, parking, AV, etc.
- Lessons Learned: Yikes, I'm just starting to figure out what sort of event this is supposed to be. Figure out WHO can help me.

Week Minus 5: Team in Place. Clarify needs.

- Weekly telecons with USAF team were essential for success, now also need additional individual telecons (particularly for defining topics for the workshop).
- The Ever-expanding To-Do List and Team
- Date set (July 10-11), workshop venue moved, industry networking event venue up in the air, but assigned to USTAR team.
- Needed:
    - Registration (website, abstract submission, travel details, breakout session choices, food allergies, wow there is a lot of stuff that goes into a conference website that I never thought about before. UofU Conference Services was already set up to do this.
        - Lessons Learned: Ask if it is ok/Nok to share contact information after the event).
    - On-site registration. Conference Services was booked July 10-11, so could not do on-site registration. Recommended College of Law Event Team for that part.
        - Lessons Learned: From here on out, it was essential to keep frequent and detailed communication between the two planning teams so things didn't fall through the cracks.
    - Hotel/travel info. Conference Services arranged this.
        - Lessons Learned: Let a pro handle hotel contracts. Don't do this yourself.
    - Invitee list, method to do invites. USAF provided several lists, plus we utilized local networks for industry contacts, and contacted our deans of science and engineering

(they each had lists for their equivalents at other schools), and VPRs (had to get this from searching each individual schools' website).
        - Lessons Learned: Needed staff help early to do this. It took many hours. VPR staff did this work. Conference services had a good method for sending out email, but people responded better when it came from me.
    - Shuttles/local transportation. Conference Services had good and easy contacts here. UofU shuttles for local transportation, motorcoach for 'other'.
    - Catering. Law School took this part, since they would be supporting 'day of' and knew the details of how catering works best in their venue. Lessons Learned: They asked me many questions about what I wanted specifically, but it was better not to just leave them to choose these details. I did not have time for details.
    - Security. Law School arranged for campus police. Still needed security for industry venue (not yet defined).
    - Parking. Law School arranged for campus parking.
    - AV. Law School used their internal teams, very good idea.
    - Agenda, Topics. !!!!!!! This was the key stress at the moment. We needed to choose topics, get them well defined, and get support materials developed to clarify them in time to put out the registration website the following week.
    - Lessons Learned. Agenda was really ON FIRE this week. I pulled together local ideas as rapidly as possible, from VPRs, deans, etc. at Utah's schools, plus USTAR's ideas. (Back to the theme of Figure out who can help me…) I didn't really have a lot of knowledge about what the USAF would be interested in, so got some help there from Angie Tchimofinick. Then, when I had preliminary ideas, Reid Mellville was exceptional at helping refine them. The venue basically defined how many/how large the breakout sessions could be, and therefore how many ideas we could support.
- Week Minus 4:
    - Entire team was now in place.
    - Website was under construction, invitations and invitee list in final preparation.
    - Agenda timing was set. Ideation plan in place. This timing was communicated to parking, security, caterers, etc.
    - Final topics were chosen. Reid Mellville was coordinating with ARFL subject matter experts to get written ½-1 page descriptions that gave the AF perspective (these are attached in section 10).
- Week Minus 3:
    - Website went live.
    - Invitations were sent out via website, personal contacts, linked in, facebook, etc. Lesson learned: Personal contact was key to soliciting the participation of many people.
    - Coordination with DSIAC to get facilitators and recorders.
- Week Minus 2:
    - Additional emails sent out via USTAR.
    - Initial collection and organization of abstracts.
    - Additional solicitation of abstracts for smaller sessions.
    - Selection / solicitation of session chairs.
    - Final coordination on catering, security, parking, signage, etc.
    - Putting the agenda packets together.

    - Lesson learned: At this point, everyone on the team was working well together. Delegate and then get out of their way. I only ended up doing the few things I didn't' assign to someone else (technical session organization, mainly).
    - Final speakers from USAF and UofU chosen and coordinated.
- Week Minus 1:
    - Lessons learned: Although I anticipated a final scramble on almost everything, that didn't happen. Most things were already set in place, and there were just a few loose ends to be tied up. Trust your team, and go with it.

8 ADVERTISING AND INVITATIONS

A promotional registration website (https://www.regonline.com/USAFST2030-UofU) was developed specifically for the workshop that included the following conference information:

- Mission, goals, and expected outcomes
- Technical research interest areas
- Registration, utilizing UU's conference registration system
- Agenda
- Procedural instructions and web-portal for submitting presentation abstracts
- Lodging and transportation information
- Local organizing committee contact details
- We intended to include a downloadable workshop schedule and PDF of presentation abstracts, but this was technically more difficult than we anticipated. Instead, we emailed the schedule and workshop details to registered participants prior to the workshop. The presentation abstracts were included in the day-of-event handouts, and the presentations were uploaded to the website after the event.

Invitations were emailed to the following (a complete list can be found in section 13 page 64):

- Vice President-level contacts (35), Deans of Science (19) and Engineering (32), and technology commercialization offices (10) for all major research universities in UT, CO, AZ, NM, CA, NV encouraging them to share the email with their faculty and local businesses. These lists we created from our own contacts. The deans had email lists from their national deans' meetings, and we searched the web for the university-level contacts.

- At the University of Utah we sent emails to all faculty in the Colleges of Science, Engineering, Mines, and Social and Behavioral Sciences, plus targeted researchers in basic medical sciences. We also publicized this in our faculty online newsletter that goes to all researchers and their staff.

- To reach industry, we sent emails to all firms who had indicated interest in science or engineering in our Technology Venture Commercialization Office data base. We also had the Utah Technology Council include this event in their newsletter. USTAR sent an email

to the companies in their database as well. We felt it was more difficult for us to reach local industry, and almost impossible to reach industry outside of our area.

- Minority Serving Institutions (379), Authors who have published in AFRL interest areas (200), national targeted researchers (42), researchers (435) who have previously done business with the Air Force. These lists were provided by AFRL.

LESSONS LEARNED: We sent emails through the online registration system (which come anonymously) and also through Dr. Furse's (the conference chair) personal email. The personal email appeared to generate more response. This email was sent once a week for 3 weeks. It would have been better to have more time to send invitations and for people to plan on coming. Some deans were very good at getting the word out to their faculty and even offered to support their travel. Others didn't send it on. Consider expanding the invitation list to department chairs (is there a better way other than internet searching to create this list?).

9 PARTICIPANTS

Participants were drawn mainly from the Southwest Region of the United States, which includes Arizona, California, Colorado, New Mexico, Nevada, and Utah, however attendees from any state were welcome to participate. The final attendee list is included as section 14 Appendix B: Final Attendee List page 91.

9.1 SUMMARY OF ATTENDANCE:

Number of Registrations:	241 (32 did not attend)	
From Utah	146 (25 did not attend)	
Other states represented:	AK, AL, AZ, CA, CO, FL, GA, ID, MA, MD, MO,NJ,NM,NV,NY, OH, OK, OR, SC, TX, UT, VA, WA, WI, WY	
USAF participants	39 (1 did not attend)	
Industry	54 (7 did not attend)	
Total attendees:	209 (87% of registrants)	
From Utah	121	
USAF	38	
Non-USAF	161	
Industry	47	(29% of non-USAF attendees)
Attendees at Industry Reception:	202	

Demographics? (unfortunately full demographics were not collected for this event)

Many attendees attended both the July 10 and 11 events.

LESSONS LEARNED: We had excellent participation, particularly considering the July date (vacation season) and short time frame (first invitations went out 5 weeks before the event).

The biggest difference that I think would have happened if we had had more time, is we could have gotten the invitations out earlier, thus likely increasing participation.

We were surprised that such a high percentage (87%) of registrants actually attended, based on lower percentages at other S&T 2030 events. I cannot say why this happened, and we were glad the caterers brought plenty of food.

We were shooting for 50% industry participation. We think we reached that number, based on the USTAR industry reception. Unfortunately, we cannot be certain, as full demographics were not collected on the registration for that event. Reaching the industry participants was more difficult than reaching the academic participants. We used personal contacts, industry groups, USTAR contacts, and university contacts, but still we know there were many industry folks who never heard about this event. Small businesses are often not affiliated with any of the larger groups, and thus didn't receive emails about the event. In many cases, the emails were passed multiple times before reaching industry participants, so a little more time might have enhanced this networked contact process.

10 Agenda, Topic Details, Breakout Sessions

USAF Science and Technology 2030 Workshop -- July 10-11, 2018

10.1 Industry Networking Event (July 10)

We held a networking reception at the Utah State Capitol July 10 from 6-8pm. A bus was provided from the Guest House and Law School to the Capitol and back. Most local attendees drove. The following companies had posters: Optisys, ExEon, USU Propulsion Team, Conductive Compositives, Turner Imaging, Vaporsens, BYU Booth on Autonomy, Coreform. Only two groups opted to have a table (Vaporsens and Autonomy). Speakers from USTAR and USAF welcomed participants, described the entrepreneurial culture and support in Utah, and described the importance of the idea sharing to the USAF mission.

Lessons Learned: Holding this event after work in a location that was very easy for people to access from the freeway brought industry engineers from both north and south. This worked out well.

10.2 Workshop Agenda (July 11)

July 11 Workshop (University of Utah S.J. Quinney College of Law)

7-10 am	Shuttle running continuously from Guest House (east entrance) to Law (east entrance)	
7:30 am	Registration and Light Breakfast opens	Law School, Level 6
8-9 am	Orientation and Introduction to S&T 2030	Moot Court Room, Rm 6200
	Conference Welcome	*Dr. Cynthia Furse*
	University of Utah Welcome	*Dr. Dan Reed*
	AFRL Welcome	*Dr. Michael Eismann*
	Overview of Technical Themes	*Major Brook Bentley*
915-1230 am	Morning Breakout Sessions	
	915-930	*Air Force Perspective and Needs for this Topic*

930-1030 Exploration and Discussion (6-12 lightning presentations)
1030-11 Identifying Future Research Themes
11-1115 Break (Moot Court Room Lobby)
1115-1230 Ideation for Future Research Paths

1230 – 2 pm Lunch and Poster Sessions Moot Court Lobby/Terrace

2-515 pm Afternoon Breakout Sessions

2-215 Air Force Perspective and Needs for this Topic
215-315 Exploration and Discussion (6-12 lightning presentations)
315-345 Identifying Future Research Themes

Morning Breakout Sessions 9:15-12:30	**Afternoon Breakout Sessions 2:00-5:15**
Data to Knowledge, Room 6619	Air-Borne & Space-Based Services, Room 6613
Novel Sensors and Sensing Strategies, Room 6623	Enhancing the Warfighter, Room 6623
Rethinking the Nature of Aerospace Materials, Room 6613	Cyber Defense 2030, Room 5614
Human / Machine Teaming, Room 6500	Zero-Cost Maintenance Challenge, Room 5600
Revolutions in Global Integrated Communications, Room 5610	Next Generation Energy, Room 6619
Expeditionary Operations, Room 5614	Advanced Customized Manufacturing, Rm 6500

345-400 Break (Moot Court Room Lobby)
400-515 Ideation for Future Research Paths
530-6 Where Do We Go From Here?
Moot Court Room
6-8 Networking & Poster Session
Moot Court Lobby/Terrace
Look for stations for Street Tacos, Asian Fusion, Sliders, Gourmet Ice Cream
5-830 Shuttle runs from Law School (east side) to Guest House

10.3 Air Force 2030 Strategy Initiative: Technical Idea Life Cycle

The following is information provided in the agenda packet regarding the ideation process.

AF 2030 Campaign

The Secretary of the Air Force has called for a study to take a fresh look at our technical priorities for science and technology, to assure we meet the security challenges of 2030 and beyond. The Air Force Research Laboratory is fueling this study with a national campaign to find new partners and new ideas.

Collecting Ideas Online and Face-to-Face

AFRL has created a website with a standing invitation to submit ideas (www.afresearchlab.com) to anyone that is willing to register as an idea partner with the US Air Force. AFRL is looking for ideas for leveraging emerging technologies. To accelerate the technology ideation process, AFRL has embarked on a national campaign of technical ideation forums. There are six events scheduled, each in a different region of the country and each with a different focus and approach.

Processing Every Idea

Every idea collected, either submitted online by an individual or developed by ideation teams at a forum, will be reviewed and considered. AFRL has called up more than 400 internal reviewers to make sure that each idea receives multiple reviews from qualified scientists and engineers. The ideas that are well endorsed will be forwarded to an external panel of experts with relevant technical expertise.

Research Priorities for 2030

The ideas that hold the greatest promise for enabling the future Air Force will be considered by a panel chaired by the Chief Scientist of the Air Force. Some highly enabling opportunities will be chosen to be featured as new research priorities for the Air Force. In September, these will be documented in a report to the Secretary of the Air Force to shape Air Force research investments over the next decade.

10.4 Expectations for Technical Ideation Forums

Welcome!

We're glad that you have joined AFRL for an exciting and vital excursion. We need experts just like you, with experience and passion for science and technology. We need your help to envision a future where the US Air Force can continue to secure peace and prosperity in the face of rapidly evolving technology and new threats. Help us discover what we don't know, so we can see further and clearer together.

Ideation Expectations

There will be several activities at this forum, but the core functions are the working ideation sessions. We hope you can listen and learn, but we really hope you can share your unique perspective. We'll mix it with other thoughts, sustain an open dialogue, build on each emerging idea, and always stay grounded in mutual respect. So, think big, surprise us, we are looking for unexpected ideas. With a decade of dedicated research funding we can make even the improbable part of an amazing future Air Force.

Support for You

Gathering teams of experts for dynamic ideation is an exciting and daunting prospect. That is why we have assembled a deep support staff to help make the most of these ideation opportunities. Each session will have professional facilitators to help move the discovery forward, experts to frame Air Force needs and clarify questions, and dedicated recorders to capture the process and outcomes.

Ideation Outcomes

The first purpose of this forum is to produce ideas that can help us shape the future Air Force. These ideas are rooted in the collective experience of the ideation team and their expectations for the emerging technology landscape. Most importantly, these ideas need to point the way for the Air Force to meet and overcome the challenges of the future. To help define outcomes, we'll use an ideation template to focus on defining the enabling technology concept, the Air Force need, and the expected advantages. This allows us to carry the ideas directly into our review process for strategy consideration.

Networking Outcomes

The second purpose for these forums is to expand our national network of experts. We are traversing the country with invitations to all comers, in hopes of finding key thinkers to help us with the Air Force science and technology mission. We want to raise awareness and build a stronger, tech-savvy network that appreciate both the challenges and opportunities for the future US Air Force. We also expect that along the way you'll meet and interact with other experts that open you to broader possibilities.

10.5 Ideation Process at the University of Utah Workshop

Three Phase Process

At this workshop, there will be 6 topic tracks of ideation in the morning session and 6 different topic tracks in the afternoon. For both the morning and afternoon ideation sessions, we'll move through three phases of an ideation process: topic exploration, theme identification, and idea development.

Topic Exploration

We'll begin each ideation by exploring the topic and its projected future trends through a series of short technical briefs. These briefings will each contribute a unique perspective on the future challenges and opportunities ahead and prepare each topic cohort to join in the ideation process.

Theme Identification

Next, we'll ask participants to work in small groups to consider what emerging technologies and concepts may provide the best opportunity for the Air Force. Each group can nominate a theme, or a compelling opportunity space, and the cohort will select the most promising themes to carry forward.

Idea Development

In the final phase, participants will select the theme that best matches their skills and interests and work in small teams to develop ideas that can enable the future Air Force. An idea template will be provided to guide the development and documentation of your team's ideas.

Thank You!

We appreciate your willingness to dedicate a couple of days to our ideation initiative. We would not succeed without this generous participation. We hope it is valuable and rewarding for you as well.

10.6 AIR FORCE 2030 TECH IDEATION WORKSHOP BREAKOUT SESSIONS

10.6.1 Data to Knowledge

Morning Breakout Session 9:15-12:30 Room 6619

Chair: Chris Johnson (Scientific Computing Institute, University of Utah)

Facilitator: Tierah "Bob" Chorba (DSAIC)
Recorders: Kaitlyn Moretz (DSIAC)

"[Today], the Air Force has access to a wealth of data collected from a vast number of sources. However, it remains limited in its physical ability to process and integrate the sheer volume of data into actionable information in a timely manner." [Air Force Future Operating Concept]

The last decade has seen the advent of Big Data, typically associated with the 5 V's of volume, velocity, variety, veracity, and the most recent - value. Similar concepts in favor included information management strategies of data in motion, data at rest, and data in use. Finally, a recent push was focused on data-to-decisions (D2D); whereas others have focused on decisions-to-data. Each of these concepts centered on the ability to utilize data to provide knowledge in support of contextual awareness. Transformation of data into information developed with advances in machine learning, data fusion, and information management; where at each manipulation of the data, the goal is to compress the data, reduce uncertainty, and create meaning – hence value. Knowledge engineering has made strides in the last four decades, building on the capabilities from data and information results, towards providing results to queries (aka getting the right information at the correct time). Currently, the move from big data to artificial intelligence (3rd wave) seeks to move from contextualized information to that of explainable results – or rather - seeking wisdom. Whereas knowledge accumulates facts, data, and results for awareness, wisdom requires discernment to assess, judge, and understand what is true, pervasive, and applicable. The challenge is to harness the knowledge for understanding, wisdom, and insight for knowing what, why, and how situations arise.

The Air Force must engage the large corpus of data to better understand situations and respond appropriately in 2030 and beyond. Data must be coupled with collection devices, scientific models, information management, and user coordination; to support knowledge. The technology developed from physics-based sensing and processing needs to be combined with human-derived messaging and reporting to permit knowledge discovery, meaning making, and context prediction. Knowledge building offers unique challenges with variations in situation assessment, awareness, and understanding. Situation understanding from data alone requires innovation beyond deep learning (data-intensive task learning)

towards artificial intelligence (knowledge-based action reasoning). The plethora of data, models, and experiences need to be observable, indexed, and retrievable to support on-demand autonomy. Data-to-Knowledge (D2K) is a key strategic enabler for the Air Force of 2030+ to face a diverse and adaptive adversary.

Visualization: A Bridge to Knowledge
Chris Johnson, University of Utah (crj@sci.utah.edu)

Visualization is useful for detecting patterns, assessing situations, and prioritizing tasks. Visualization facilitates the reasoning process by supporting the human capacity to perceive, understand, and reason about complex large-scale data and enables researchers to derive knowledge from data.

Voluminous Aerial System Traffic

Thomas C. Henderson, University of Utah (tch@cs.utah.edu)

The FAA & NASA are developing a UAS traffic management framework, and the UAS industry is developing platforms with sense and avoid capability, but there is little understanding of how to operate and coordinate a large-scale UAS system. A myriad of unmanned autonomous systems will operate daily in urban environments with potential benefit and harm. Large datasets must be exploited to understand system state & achieve effective control. We propose an AI-based traffic management system, along with UAS platform & communication requirements, and real-time aircraft state estimation & geo-fencing.

Validating Your Business Idea and Developing Your Business Model

Steve Grizzell, InnoVentures Capital (steve@innoventures.com)

I have completed over 100 investments exceeding $25 million dollars in early stage businesses. Over the course of the last year I have developed a training course that helps entrepreneurs validate their business ideas and develop a business model. The Lean Startup Approach is used for this process, using a variety of the cutting edge business model tools.

Speed up Distributed Machine Learning in Large Scale System using Codes

Mingyue Ji (mingyue.ji@utah.edu), Rong-Rong Chen, Nicolas Woolsey, Xiang Zhang, University of Utah

In distributed machine learning, gradient updates are computed at workers and are synchronized at the master node. When the data batches are large, it is intractable to evaluate the gradient and classical methods becomes impossible. Among the significant challenges, problems of communication overhead and stragglers have recently received significant attentions. In this research project, we intend to make progresses on both data shuffling and straggler bottlenecks via low complex coding techniques, which are designed by levering the system topologies under the security and privacy constraints.

Intelligence Amplified: Nexus of Machine Learning and Analytics

Pratt Rogers, University of Utah (ratt.rogers@utah.edu)

Machine learning (ML) and analytics are often treated independently disrupting the data to wisdom process. ML algorithms identify key correlations and causations, but do no inherently change the decision making culture of an organization. Analytics provide these change agents tools, but lack the predictive elements needed for modern complex processes.

Securing Cyber-Physical and IoT Systems in Smart Living Environments

Sajal K. Das

Missouri University of Science and Technology

Our daily lives are increasingly dependent on smart cyber-physical infrastructures, e.g., smart cities and,

smart energy and transportation. Alongside, smartphones and sensor-based IoTs are empowering humans with fine-grained information and opinions about events of interest. However, CPS and IoT systems are extremely vulnerable to failures, attacks and security threats. This talk will highlight unique research challenges in securing such systems, followed by novel defense mechanisms.

Using multiplayer virtual reality to analyze complex fluid-structure interactions

C.G. Farmer (farmer@biology.utah.edu), Mark Howell, Bob Cieri, University of Utah

We are simulating fluid flow in deformable meshes with complex topographies that change in time. To enhance our ability to analyze the meshes and simulations, and to facilitate collaborations with colleagues at other institutions, we are using the multiplayer capacity of the game development platform Unity to visualize our simulations in virtual reality. This novel tool can be applied to a range of problems involving fluid-structure relationships, from visualizing heat and gas exchange in fuel cells to analyzing the aerodynamic performance of a wing.

Big Data Analysis of Time and Spatially Varying Data

Jerome Soller, PhD, CogniTech Corporation (soller@cognitech-ut.com)

Future Air Force systems will need to model and analyze data that varies both in time and in space. Data for the same entity may need to be observed or simulated in multiple ways. These different sources of information will need to be fused into a common operating picture, including representations of multiple entities over time and space. Big data solutions enable such capabilities through their support for distributed data management, fault tolerance, and scalable computation. This talk will discuss some of the challenges and future directions for managing and analyzing these types of data.

Data to Knowledge: Modernizing Political Event Data for Big Data Social Science Research (also see Poster)

Latifur Khan, PhD (lkhan@utdallas.edu), Patrick Brandt PhD, Jennifer Holmes PhD, School of Economic, Political and Policy Sciences, University of Texas at Dallas

We have developed the software and big data infrastructure to provide machine coded event data from news reports from historical and real-time inputs from the web. The project is ongoing and will produce coded news reports based on NLP applications across English, Spanish, and Arabic news reports. Human annotations and validations are conducted for data validation and cross-lingual support. Geo-location of the events is also improved for better spatial resolutions.

Poster: Interpretable Clustering via Semantics Recovery

Hongfu Liu, Brandeis University (lhf.hongfu@gmail.com)

Here we consider Interpretable Clustering via Semantics Recovery, where the missing semantic attributes are recovered to explain the uncovered clusters with only visual features. To achieve this, auxiliary source data containing visual features, semantic attributes and labels are employed to facilitate the target data clustering. Then we propose a novel dual-level transfer learning method to extract the knowledge from the instance-level and partition-level for the target data recovery and clustering.

Poster: Dissecting change of causal influence in coupled dynamical systems

Violet Mwaffo* (violet.mwaffo@colorado.edu), Jishnu Keshavan*, Tyson Hedrick**, and Sean Humbert*; *Department of Mechanical Engineering,

University of Colorado, Boulder; **Department of Biology, University of North Carolina at Chapel Hill, Chapel Hill

Dissecting the dynamics of the causal influence in lieu of simple correlations is more relevant for several applications including switching interaction between neurons, cascade failures, or the propagation of diseases. Such dynamics cannot be fully captured by most existing tools. We propose a method to infer intermittent switching of the causal influence combining network theory and a data-driven measure of causality. We demonstrate our approach on synthetic and real-world data-sets. Our method is expected to enrich the toolbox to infer the dynamics of networks.

10.6.2 Novel Sensors and Sensing Strategies

Morning Breakout Session 9:15-12:30 Room 6623

Chair: Tatsuo Itoh, UCLA

Facilitator: Kevin Felix (DSIAC)
Recorders: Erin Crawley (AFOSR) and Devon O'Connell (DSIAC)

"The Air Force must build an integrated network of air, space, and cyberspace-based sensors, as well as leverage joint contributions from all domains. This integrated network and architecture will enable more rapid and effective decisions from the tactical to the operational level." [Air Superiority 2030]

The idea of a globally connected world and concept of the Internet-of-Things (IoT) where devices, vehicles, buildings and other items are embedded with electronics that are connective via a network to enable these objects to collect and exchange data – will require sensors to create the data. And in many cases, these sensor are small, low cost and distributed on very large scales. This is a fundamental shift in the way the Air Force can acquire and use information. No longer limited to a small number of pristine and high cost sensors, the Air Force can leverage the disaggregated, diversified sensing architectures that are beginning to appear in the commercial world – along with the applications that utilize these new sensors and architectures. Along the way, we may find altogether new types of data to sense that lead us to different classes of sensors.

The sensors, and the systems to connect them to decision makers, are new in ways that were barely comprehensible twenty years ago. Not only does an app on your phone tell you the temperature inside your house and show you a video of your cat in white light or infrared illumination, it can also tell you when its network or power were interrupted and interpret whether the motion it sensed was a burglar or just the cat. It's not much of a leap to imagine that in a few years, that sensor autonomously learns the cat is howling because of the dog barking next door, and messages the sensor system next door to let the dog out.

The way we think about the sensors themselves is also changing. Nature has produced extraordinary sensory systems in biological species that exceed the capabilities of a broad range of man-made sensors. Understanding the physical, chemical, and biological processes that are responsible for these sensory abilities may produce a blueprint for replicating or reconstructing them in man-made devices. The development of new sensor technology can be seen as bridging the field between researchers

from biology, materials science, engineering, chemistry and physics. This presents an opportunity for academia to partner with the Air Force to develop new technologies by exploiting nature's designs and achievements for advanced sensor systems.

Advanced Electromagnetic Devices in Front End

Tatsuo Itoh, UCLA (itoh@seas.ucla.edu)

This presentation illustrates present state of art in millimeter and THz front end technologies and future advances in desirable and possible transformable technologies and applications in 2030.

Warfighter Protection: Spatial Sensing using Thin Film Sensors + Tomography

Kenneth J. Loh, C San Diego (kenloh@ucsd.edu)

Operational readiness of the human asset and warfighter can be achieved by monitoring their health. The objective is to validate that materials-based sensors coupled with tomographic techniques provide damage information across vast spatio-temporal scales. First, nanocomposite thin film sensors were designed. Second, using electrical impedance tomography, spatial impact, crack, pH/corrosion, and strain monitoring were achieved. Finally, noncontact, subsurface, spatial sensing was achieved by embedding passive sensing elements and interrogating them using electrical capacitance tomography.

A New Type of Spectrometer Using Point-Spread Function Engineering

Jason Martineau, Erik Jorgensen, Jordan Gerton, Department of Physics and Astronomy, University of Utah

Conventional spectroscopy is done using dispersive elements that array the intensities of different wavelengths of an electromagnetic signal along one dimension of a photo-detector. This wastes sensitivity since modern photo-detectors are two dimensional arrays of pixels. We therefore propose the development of a new type of spectrometer using a phase element -- a dielectric plate or deformable mirror -- placed in the Fourier plane of an imaging system that would array spectral information in two dimensions of a photo-detector. Our design could be adapted directly to the human eye.

Noninvasive Ultrasound Measurements of Temperature Distributions and Heat Fluxes in Structures

Mikhail Skliar, University of Utah (mikhail.skliar@utah.edu)

We outline a novel approach to measurements of temperature distributions and heat fluxes in solid structures which are essential in defining safety and performance of processes and vehicles. We use structural elements as waveguides and interpret time-of-flight measurements of ultrasound pulses to reconstruct internal and surface temperature distributions and heat fluxes along the ultrasound propagation path. We report test results this technology and discuss the potential of structure-integrated sensing in other high-temperature applications and extreme environments of hypersonic vehicles.

Engineered Nanomaterial/ Microdevice Sensing Platform for Point-of-Use Detection of Biological and Chemical Analytes

Swomitra Mohanty, University of Utah (swomitra@chemeng.utah.edu)

A major issue in addressing global chemical and biological contaminant challenges is the lack of portable, low-cost, technologies to detect potential threats. This work will show a platform technology designed to produce innovative, cost-effective, point of use sensing methods that can be used for applications such as disease diagnosis and environmental pollution detection.

Bioelectrocatalysis for Biosensors and Energy Conversion

Matteo Grattieri (matteo.grattieri@utah.edu), Shelley D. Minteer, University of Utah

In bioelectrocatalysis the capability of specific biological entities to catalyze a reaction is coupled with the exchange of electrons that take place with an electrode surface. As a result, bioelectrocatalysis has several outcomes, spanning from self-powered biosensor to energy conversion. One of the biggest challenges is to establish the electrochemical communication between biological entities and electrode, which is at the basis of the process. Our group develops technologies to tackle this issue, opening for several new and exciting applications of bioelectrocatalysis.

Novel label free biosensors

Yunshan Emily Wang, University of Utah (yunshan.wang@utah.edu)

My research group is currently developing label free biosensors that are portable and simple to use. Our sensors detect intrinsic fluorescence of biomolecules without the need for labeling. This is challenging due to the small quantum yield of biomolecules. In my research, computational and experimental techniques are combined so to search for the best plasmonic materials and structural designs in the UV range to enhance quantum yield.

3D Printing for Microfluidics

Gregory P Nordin (nordin@byu.edu), Adam Woolley, Brigham Young University

While there is great interest in 3D printing for microfluidic device fabrication for biosensor applications, the challenge has been to achieve feature sizes that are in the truly microfluidic regime (100 µm). The fundamental problem is that commercial tools and materials have not been developed to address the unique needs of microfluidic device fabrication. Consequently, we have created our own stereolithographic 3D printer and materials that are specifically tailored to meet these needs. We demonstrate flow channels as small as 18 µm x 20 µm, and active elements such as valves and pumps.

Organic Nanofiber Sensors for Handheld and Networkable Detection of Chemicals

Ling Zang, University of Utah (lzang@eng.utah.edu)

Shape-defined nanofibers have been fabricated from various building block molecules through solution phase self-assembly. These nanofibers possess unique optoelectronic properties that are suited for development as photo-chemiresistive sensor enabling chemical vapor detection in unprecedented efficiency (down to ppb or even ppt level). In collaboration with Vaporsens (a University of Utah spinoff), the nanofiber sensors have now been incorporated into handheld and networkable devices for quick vapor detection of toxic chemicals, CWAs, explosives, fuels (leaking), and air pollutions.

Scanning Frequency Comb Microscopy A new method in Scanning Probe Microscopy

Mark J. Hagmann, NewPath Research L.L.C (newpathresearch@gmail.com)

When a mode-locked laser is focused on the tunneling junction of a Scanning Tunneling Microscope (STM) with a metal sample, hundreds of microwave harmonics are generated at integer multiples of the laser pulse repetition frequency. Each harmonic sets the present state-of-the-art for a narrow-linewidth microwave source to enable a signal-to-noise ratio greater than 20 dB even at attowatt power levels [1]. We are pursuing applications to the nondestructive profiling of

semiconductors with true sub-nm resolution [2]. However, with semiconductor samples the microwave power has been measured with a

Lightweight compact real-time computational hyperspectral video imaging

Monjurul Meem*, Fernando Vasquez-Guevara,*,** Rajesh Menon* (rmenon@eng.utah.edu), * University of Utah, **Lumos Imaging, Inc.

By combining advanced computational optics with a novel diffractive-filter array (DFA), we report the development of a new multi-spectral camera that is able to create video images at the native sensor frame rate. The DFA is an engineered mult-level diffractive optic that is placed in close proximity to any sensor array. It is engineered to disperse the light in a pre-determined fashion. The raw sensor data is computationally de-multiplexed to obtain spatial and spectral information with minimal loss in resolution. The approach enables the same hardware to trade-off spatial and spectral resolutions and also enables the modification of spectral bands without any change in hardware.

Topological semimetals: developments at the University of Utah

Berardi Sensale-Rodriguez (Berardi.sensale@utah.edu), Mike Scarpulla, Sriram Krishnamoorthy, Ajay Nahata, Vikram Deshpande, University of Utah

We discuss fundamental aspects of topological semimetals that make this emerging class of materials attractive for applications of interest of the USAF relevant e.g. to all-weather communications and sensing. Our recent efforts are focused in large-area synthesis of these materials as well as preliminary device development in the THz band. Our results showcase performance metrics relevant to high-frequency and plasmonic applications that are superior than those in any other materials systems. We also discuss novel device concepts that might find key applications such as in quantum computing.

Advanced Sensing with XOnano Smartfoam

Jake Merrell (jake.merrell@xonano.com), Sam Wilding, XOnano

XOnano Impact Smartfoam technology transforms regular foam into an impact sensing material. When the foam is impacted, it generates a measurable voltage. Higher impact means higher voltage. Impact can be simultaneously mitigated and measured. Impact Smartfoam can also be used to measure vibration, allowing vibration to be dampened and monitored at the same time with a single material.

Ultra low power wake up sensor network

Hanseup Kim, University of Utah (hanseup@ece.utah.edu)

To enable a “power-efficient” and “chemical sensing” WSN for defense and security, the development of an ultra-low-power and compatible chemical sensor is critical. Existing chemical sensors technology has not simultaneously fulfilled the requirements of power, reliability in defense and security fields and compatibility for WSN schemes yet. Thus, the development of an event-driven wake-up chemical sensor network will solve key bottleneck to practical deployment of wireless sensor network especially in the defense and security sectors where human access is difficult.

Poster: Point-of-Use Sensors

Christina Willis, Yalda Saffary, Lani McKinnon, Shruti Hegde, Jonathan Grubb, Hsuan-Yu Leu, Kerry Kelly, Jaye Magda, Mano Misra, Swomitra Mohanty (swomitra@chemeng.utah.edu), University of Utah

There is a major need for rapid point of use sensors to address environmental and health issues world-wide. The Advanced Materials and Microdevices Laboratory at the University of Utah focuses on

engineering new materials for sensing that are deployed in a variety of microdevice formats including autonomous microfluidics, rapid gas sensing, and immersible water sensors. This poster will highlight the platform sensing technologies, including molecularly imprinted hydrogels, metal functionalized titania nanostructures, and electrocatalytic sensors. Examples of analytes that have been detected by the lab are, perfluorinated compounds (APOS) in water, chlorinated solvents in water, volatile organic compounds associated with disease and contaminated food, and environmental air pollution contaminants such as benzene, ethanol, and toluene.

10.6.3 Human / Machine Teaming

Morning Breakout Session 9:15-12:30 Room 6500

Chair: Charles (Cap) Smith (Colorado State University)

Facilitator: Brady Redfearn (DSIAC)
Recorders: Cayley Dymond (711 HPW) and Rob Leighton (DSIAC)

Modern warfare calls for optimizing human and machine teaming performance as more autonomous technologies are being introduced across multiple domains. *Optimizing* physical and cognitive performance in human-machine teaming, human-human coordination, and behavioral assessments in this arena has been identified as a critical topic across the DoD. Air Force S&T guidance and policy has called for increased emphasis and understanding of the individual warfighter in these contexts as a challenge area for successful autonomous systems and cyber security. Identifying and validating the drivers of successful human-machine and human-human interactions could be key attributes of future Air Force initiatives. How can humans integrate more deeply with machines and devices (robotics, neural implants, mind-machine melding, artificial intelligence, self-learning control systems, and more)?

The warfighters are often required to function in high-tempo, high-workload, and ambiguous environments. A key to the success of the warfighters in these environments is understanding the bio-psycho-social aspects of both the individual warfighter and the environment in which they must operate. Research that leads to solutions- maximizing the effectiveness of the human element in these environments is critical to success. Maximizing human performance must incorporate the biological factors (i.e. biochemical, genetic etc.), psychological factors (i.e. personality, behaviors, cognition, etc.) and social factors (i.e. cultural, socioeconomic, environmental) impacting the warfighter. The Air Force seeks novel topics that include, but are not limited to, maximizing the human aspects of man-machine teaming.

Human-AI Collaboration in Dynamic Decision Environments

Cap Smith (capsmith@colostate.edu), Chris Wickens, Ben Clegg, Jessica Witt, Colorado State University

In this paper we elaborate multiple potential levels of decision support for the JTAC task, ranging from advances in hardware to completely autonomous solutions based on machine learning algorithms. At each discrete level, we discuss the challenges posed to the human partner in this collaborative effort. Finally, we develop prescriptions for systems specifications at varying levels of automated support, and suggest avenues for future research to resolve as yet unaddressed issues related to successful Human-AI collaboration.

Quantifying the Quality of Human Performance in Immersive Environments

Balakrishnan Prabhakaran, University of Texas at Dallas (bprabhakaran@utdallas.edu)

Psychometric evaluations are generally used to understand the Quality of Experience (QoE) of human performance in immersive environments produced using augmented/mixed/virtual reality. In this talk, we address two related questions: (1) Can we identify metrics that can objectively quantify human performance in an immersive environment? (2) Can we use the above objective performance metrics to understand the possible user QoE without the need for subjective user study or with minimal user study?

Remotely Piloted Aircraft Operational Enhancement

Ralph Wege (benanci@icloud.com)

Enough sophisticated sensors are available to enable a drone pilot to both fly and operate its weapon or sensors much as is done in piloted aircraft.

Multi-Robot Enhanced MANET Intelligent Routing at Uncertain and Vulnerable Tactical Edge

Hao Xu, University of Nevada, Reno (haoxu@unr.edu)

This work investigates the problem of intelligent resilient routing in a multi-autonomous robot enhanced network at uncertain and vulnerable tactical edge. To increase the network interoperability, existing network protocols integrated social network into network through utilizing social mobility and opportunistic algorithms. We propose a Game Theoretic Situation-aware Robot Enhanced MANET routing protocol that adopt the online game theoretic reinforcement learning to design the mobility of multi-robot as well as handle the uncertainty and potential physical and cyber attack at tactical edge.

Altitude Exposure in Air Force Pilots: Hypobaric vs. Hypoxic Effects

Shami Kanekar, University of Utah (shami.Kanekar@hsc.utah.edu), Perry F. Renshaw, Salt Lake City Veterans Administration, Rocky Mountain MIRECC, & University of Utah

Poor cognition and depression is noted at altitudes 5000ft, and depression/suicides increase with hypobaric hypoxia (HH). Commercial pilots fly in cabins at 6,000ft exhibit depression and cognitive loss. U-2 pilots experience hypobaria alone (flying oxygenated in cabins, 30,000ft) yet they can develop brain structural damage typically seen in aging, increasing depression/cognitive risk. Our studies point to HH-induced biochemical imbalances We now propose to study hypobaria vs. hypoxia in our model, towards improving air crew performance and reducing altitude-related brain damage.

Fault-Tolerant Control of Multirotor Aerial Vehicles

Marc Bodson, University of Utah
(marc.bodson@utah.edu)

Multirotor aerial vehicles are agile aerial vehicles with the ability to hover. Reconfigurable control methods could be used to ensure continued operation after total or partial failure of one or more rotors, while achieving the highest feasible performance. Advanced estimation methods would monitor forces produced by the rotors through motor voltages and currents. This information would be used to improve state estimation of drones in GPS-denied environments and to detect rotor and motor failures. With such a method, it would also be possible to measure the effects of rain and snow on drone dynamics, or the weight and weight distribution of loads, and to leverage this information for developing robust flight controllers**.**

Poster: Knowledge Transfer for Few-Shot Image Understanding

Zhengming Ding, Indiana University – Purdue University Indianapolis (allanding@ece.neu.edu)

Modern recognition systems still need thousands of examples of each class to saturate performance. This is impractical in cases where one does not have enough resources to collect large training sets or that involve rare visual concepts. We aim to explore the data augmentation and knowledge transfer learning to solve the few-shot image understanding.

10.6.4 Revolutions in Global Integrated Communication

Morning Breakout Session 9:15-12:30 Room 5610

Chair: Zoya Popovic, University of Colorado, Boulder

Facilitator: John Ontiveros (DSAIC)
Recorders: Jeff Cline (DSIAC)

Gone are the days where communication systems were designed and built for each specific need that resulted in a black-box modem (the radio) and your own slice of spectrum. Advances in digital technology and the dawning of the Internet-of-things (IoT) and big-data are fundamentally changing the way we think about and design communications. Like the cloud, communications are being viewed as a "service". We don't care where the communications are, what band it's in or the modulation technique – we want the data and we want it now. These trends will create revolutions in global communications that will be integrated. In addition, advances in communications and time to market by the commercial world make the use of commercial systems for military applications and ever increasing objective – not in just capability such as increased throughput/data rates but also from a cost perspective. For the Military, we will be just one of thousands of users on the globally integrated communications grid.

This also presents unique challenges for the military as one of its primary functions is national security and hence, military data over communications is sensitive and sometime highly sensitive. However, commercial entities will argue their data is sensitive and this presents a unique parallel where protection of information over a globally integrated communications grid will be of importance to all users, not just the Military. The key is how does the military leverage and co-exist in the new environment.

The factors of a globally connected world, the IoT and big-data will drive revolutions in communications we have yet to see. The opportunity here is for academia to partner with the Air Force in discovering and driving the revolution yet to happen.

Multifunctional RF sensor transmitters

Zoya Popovic, University of Colorado, Boulder

(zoya@colorado.edu)

RF/microwave radar sensors are often power and space constrained. This talk will discuss methods for increasing the power-area product of radar transmitters. The challenges associated with reducing thermal dissipation while increasing radiated power will be discussed and methods to increase efficiency while simultaneously increasing spectral confinement will be presented. Specific examples of X-band (10GHz) GaN transmitters with dynamic power supplies offer the advantage of average efficiencies exceeding 50% for amplitude-modulated radar pulsed waveforms. This approach can enable multi-functional efficient transmitters for radar as we all communication signals, and enable more compact phase array transmit modules through monolithic integration.

Discrete-Time MIMO OFDM-Based Orthogonal Time Frequency Space Modulation

Rong-Rong Chen (rchen@ece.utah.edu), Ahmad Rezazadeh Reyhani, Arman Farhang, Mingyue Ji, Behrouz Farhang-Boroujeny, University of Utah

Orthogonal Time Frequency Space (OTFS) is a novel modulation scheme designed in the Doppler-delay domain to fully exploit time and frequency diversity of general time varying channels. In this work, we present a novel discrete-time analysis of OFDM-based OTFS transceiver with a concise and vectorized input-output relationship that clearly characterizes the contribution of each underlying signal processing block in such systems. The proposed formulation enables practical low-complexity receiver design for communications over high mobility channels.

POWDER: Testbed, or next-gen communication infrastructure?

Kobus Van der Merwe, University of Utah (kobus@cs.utah.edu)

I will describe the POWDER platform, a mobile and wireless testbed being developed at the University of Utah. To enable a broad range of research, the POWDER platform requires flexibility, which is achieved by making the testbed software-defined in an end-to-end manner. The need for flexibility and evolvability extends beyond research testbeds and “softwarization” is a well-established trend. As such POWDER can be considered a prototype next generation communication infrastructure. I will touch on the challenges associated with realizing communication infrastructures in this manner.

10.6.5 Expeditionary Operations

Morning Breakout Session 9:15-12:30 Room 5614

Chair: Robert McCoy, Geophysical Institute, University of Alaska

Facilitator: Greg Bowen (DSAIC)
Recorders: Joan Ward (DSIAC)

Over the last few decades the United States Air Force has positioned themselves at main operating bases with large logistical footprints, viewing these locations as places of sanctuary. However, this is no longer the case. To address this issue the 2018 National Defense Strategy[3] identifies the need to "transition from large, centralized, unhardened infrastructure to smaller dispersed, resilient, adaptive basing that include active and passive defenses". In support this the USAF is developing a resilient adaptive, non-enduring basing strategy.

To achieve this the USAF is seeking the development of expedient and expeditionary capabilities to rapidly deploy, establish and restore dynamic airbase operations. Doing so requires optimization of current basing technologies and equipment for expeditionary operations to include navigation aids, runway repair, security forces, power generation, fuel pumps, aerospace ground equipment (AGE), water purification, and communication systems. Optimization should focus reduced logistical foot print to include reduced weight, size, and personnel required to support.

This resilient adaptive, non-enduring basing strategy will be significantly enhanced by acquiring commercial-off-the-shelf (COTS)/government-off-the-shelf (GOTS) equipment and processes with limited modification. These efforts will place the emphasis on lean, agile, expeditionary capabilities over large, efficiency minded main operating bases.

[3] Summary of the 2018 National Defense Strategy of the United States of America, Sharpening the American Military's Competitive Edge

Arctic Research & Operations at The Geophysical Institute at the UAF

Robert McCoy, Geophysical Institute, University of Alaska (rpmccoy@alaska.edu)

The Geophysical Institute, the newest UARC, performs research in 7 Arctic geophysical disciplines including: volcanology; seismology; snow, ice and permafrost; space physics and more. The GI downlinks data from polar orbiting satellites, launches sounding rockets and UAS, & monitors Alaskan volcanoes & earthquakes. The GI operates HAARP for ionospheric research & applications. From Kodiak, small satellites are launched into polar orbit with new small/low-cost rockets. The Arctic is becoming the most geostrategic theater for the USAF.

Developing Sustainable, Secure, and Resilient Distributed Water and Wastewater Systems

Steve Burian, Krista Carlson, Ramesh Goel, Jennifer Weidhaas, University of Utah

The University of Utah Water Center helps researchers connect, and then identify, conduct, and promote their research. A focal area of interdisciplinary water research at the University of Utah has been the development and testing of distributed water/wastewater systems for point of use/generation, small communities, and in the form of micronets in large cities. Additional research has supported the sustainable, secure, and resilient deployment of the systems by developing sensing capacity and conducting risk and resilience assessments using laboratory, analytical, and computer modeling tools. Technology transfer have led to implementation of solutions in India, Pakistan, and the United States.

10.6.6 Rethinking the Nature of Aerospace Materials

Morning Breakout Session 9:15-12:30 Room 6613

Chair: Ranji Vaidyanathan, Oklahoma State University

Facilitator: Andrea Young (DSIAC)
Recorders: Molly LaChance (AFOSR) and Gabrielle O'Neal (DSIAC)

Over a hundred years ago, the pioneers of aviation took flight in no small part due to material innovations that ranged from novel casting of aluminum engine blocks to judicious selection of natural materials. Unquestionably, the future of aerospace will look as different from today as the Wright Flyer and Curtiss June Bug differ from the F-35 and the Falcon Heavy. The role of materials though will remain unchanged – they will be the crucial ingredients that enable these future capabilities to push beyond the performance envelope. However, the process of discovery, development and manufacture of materials must radically accelerate, reducing the time from concept to use from decades to years. In parallel, a revolution in how materials are integrated into the system design process must occur, moving from static property specifications to engineered, site-specific properties where the distinction between materials and sub-components blur. Finally, the economics of manufacturing extreme high-performance material systems must be rethought to embrace variability, risk-tolerance, rapid iteration, and customization. Solutions to these Grand Challenges lie at the convergence of many emerging fields, such as synthetic biology, quantum technology, nanotechnology, data science, decision science, artificial intelligence, additive manufacturing, forecasting, robotics, automation, autonomy, and human-machine teaming.

Graphene based "Electromagnetically Responsive Composites

Ranji Vaidyanathan (vaidyan@okstate.edu), Raman Singh, Oklahoma State University

The inclusion of electrically conductive fillers is an approach for creating light weight electrically conductive composites for EMI and lightning strike mitigation. Our on-going work has led to a simple process to manufacture flexible and conductive films using safe and affordable graphene fillers and blends of polymers for high through-thickness conductivity. These films can be applied on the composite surface as well as placed between layers to increase the conductivity as well as toughness of the composite without compromising the mechanical properties.

Design of multi-functional low density Ti-Ti3Al metallic-intermetallic laminate (MIL)

Pankaj Kumar (pankajkumar.mse@gmail.com), University of Nevda, Reno, Manoranjan Misra, University of Nevada, Reno, Reaz Choudhary, University of Utah

Multifunctionalization of MIL composites is a promising approach to enable weight reductions while simultaneously increasing the performance and functions. The objective is to develop Ti-Al3Ti composite having excellent structural properties with the integration of potential to perform the non-structural functions. The Ti-Al3Ti MIL in particular has excellent specific stiffness. Good fracture toughness with the specific hardness equivalent to many ceramic materials is a unique advantage of this materials. We are proposing to conduct a multiscale modelling for design, and fabrication by ARB.

10.6.7 Next Generation Energy

Afternoon Breakout Session 2:00-5:15, Room 6619

Chair: Larry Baxter, Brigham Young University

Facilitator: Tierah "Bob" Chorba (DSAIC)
Recorders: Kaitlyn Moretz (DSIAC)

"Transforming the way the Air Force uses energy—including investing in innovation and building an energy-secure force—is critical to ensuring it is equipped to sustain the mission priorities of today while planning for the challenges of the future." - USAF Energy Flight Plan 2017 – 2036

Energy is core to every aspect of military operations, and flying operations are the leading consumer. Air operations account for 71% of the DoD energy budget and all USAF operations combined represent 48% of the total DoD energy budget. Annually, this AF tally is two billion gallons of aviation fuel and 64 trillion BTUs, as well as significant amounts of greenhouse gas emissions**.** Energy advances yield increased range, endurance, and payload for Air Force platforms, as well as power for communication, sensing, and defensive capabilities. As the USAF considers technology advances to meet the security challenges of 2030 and beyond, each new concept brings additional expectations and vulnerabilities in regard to operational energy. *"The ability of these new systems to meet their performance parameters frequently assumes an assured supply of energy, despite larger operating areas, flat or declining fuel logistics capacity, and increasing threats to energy infrastructure."* - DoD 2016 Operational Energy Strategy.

To prepare for 2030, the USAF needs to pursue new thinking, new technology, and new approaches to the operational generation, storage, distribution, management, and consumption of energy. Novel ideas are sought for sustainable and supportable energy generation from a diversity of energy suppliers to reduce risk. Logistics risk will reduce with more efficient and resilient concepts for energy distribution, combined with aggressive energy harvesting at the edge of operations. The Air Force in 2030 can move forward with revolutionary leaps in power and energy densities to extend capabilities for airborne and space-based operations. Join us for this exploration of how new energy solutions might sustain our Air Force and our global security.

Abstract Baxter

(larry_baxter@byu.edu)

Understanding Defects in Ga2O3 for High Breakdown Electronics

Mike Scarpulla (mike.scarpulla@utah.edu), Berardi Sensale-Rodriguez, Sriram Krishnamoorthy, Kelvin Lynn, University of Utah

β-Ga2O3 is an ultra-wide bandgap material with promise for next-generation high voltage power devices. A rigorous understanding of doping, defects, interfaces and electronic transport under extreme environments is critical to unlock the full potential of β-Ga2O3. This MURI project will investigate and control defects in Ga2O3 through unique material growth and characterization techniques. This MURI project will uncover the fundamental potential and limitations of β-Ga2O3 for kilovolt-class lateral power switch operation and megavolt-class vertical switches.

Microwave conversion of waste to carbon-rich fuel

Zoya Popovic, University of Colorado, Boulder

(zoya@colorado.edu)

To reduce the impact of troops on the move, microwave conversion of waste to carbon-rich fuel is investigated. Currently, either no waste recycling is used, or waste is incinerated with syngas as a by-product, in large volumes ~30m^3, leaving ash. When waste with carbon content is subjected to volume power densities on the order of 0.25W/cm^3 at GHz frequencies, it can convert to highly caloric fuel, leaving little or no trace. For an efficient process, a uniform 0.9/2.45-GHz electric field density is needed. An adaptive scalable microwave cavity with multiple solid-state sources for uniform volumetric power combining is developed.

Micro-structured Flexible Solar Cells Integrated with Textile Antenna

Heayoung Yoon (Heayoung.yoon@utah.edu), University of Utah, Reyhan Baktur (Utah State University), Cynthia Furse (University of Utah)

We present a high-performance solar cell assembly that can be innovatively integrated with emerging smart systems. Advancements in this area will enable a wide range of new technologies, including self-powered internet-of-things. The flexible photovoltaic/antenna system is comprised of a metallic strip (antenna), and a bottom-up integrated photovoltaic (PV) thin-films. The PV layers are selectively etched to enhance the mechanical flexibility. This PV/antenna prototype can readily be transferable for future mobile communications integrated with clothing, tents, awnings, and other textiles.

RF Heating Power Converter

David Paul Riddle, Electron Heat, (dpr@byu.net)

The process of manufacturing composite materials is a slow and costly process. With the use of RF energy the cycle time can be dramatically reduced; currently 12 hours up to 100 hours to less than an hour, will have a major impact on energy consumption and time. The early stage prototype of the RF Power Converter of an advanced new curing technology has been developed. A solid state Power Converter reduces weight and size by ten-fold. Off world and in situ applications for remote repair and fabrication become practical.

Nitrogenase Electrochemistry for Ammonia Production

Rong Cai, Chemistry Department, University of Utah (cairong1009@hotmail.com)

Nitrogenases are the only enzymes known to reduce N2 to NH3. By coupling nitrogenase with electrochemistry, we made a fuel cell that is able to produce NH3 from H2 and N2, while simultaneously producing an electrical current under atmosphere and room temperature. Broader application of nitrogenases is impeded by the high consuming of ATP and O2 sensitivity. We aim to design materials to realize electroenzymatic reduction of N2 (air) to NH3 in absence of ATP. Bioelectrosynthesis of NH3 could be a promising alternative for the energy-intensive Haber-Bosh process.

Achieving Aerial Excellence using Non-Volatile RRAM based Multiplexer Structures (also please see POSTER)

Pierre Emmanuel Gaillardon

(pierre-emmanuel.gaillardon@utah.edu), Xifan Tang, Ph.D., University of Utah, Mr. Natan Chetrit

ReRouting LLC is developing a novel Resistive-RAM (ReRAM) FPGA SoC for advanced low-power applications. Its transformative FPGA architecture can enable aerial superiority to the United States Air Force. ReRAM-based routing circuits enable 1) a 5x power reduction, 2) non-volatility and 3) all at no-performance compromise even when operated a low supply voltage. ReRouting will provide the Air Force an added edge in the sky, enabling computing-intensive operations previously unavailable to tight power budgets, advancing sensor networks performance, and providing a radiation tolerant solution.

Poster: The Many Roles of Amines in CO2 Recycling Schemes

Cheryl Mathis (mathiscl@chem.utah.edu), Moumita Bhattacharya, University of Utah

The Saouma group is interested in understanding how to deliver electron/ proton equivalents to CO2 thereby catalytically converting it to value-added feedstocks. Target reactions include: conversion to CO, formic acid, and methanol. Towards achieving this goal, we are investigating the role that amines play in achieving these catalytic processes under mild and selective conditions.

10.6.8 Enhancing the Warfighter

Afternoon Breakout Session 2:00-5:15 Room 6623

Chair: Sheng Xu (Department of Nanoengineering at UC San Diego)

Facilitator: Kevin Felix (DSAIC)
Recorders: Erin Crawley (AFOSR) and Devon O'Connell (DSIAC)

Any war-winning strategy relies upon Airmen leveraging cutting-edge technology to achieve Global Reach, Global Power, and Global Vigilance! Human performance provides the differentiator in these military missions in a technologically flat world. As a nation, we require a forward-looking research portfolio which exploits biological and cognitive science and technology to enable, enhance and sustain the Airman's capabilities to fly, fight, and win in air, space, and cyberspace. Revolutionary, transformational concepts which give our Airmen a mission performance advantage will be the difference-maker in a conflict with a technological near-peer. A survey of emerging technology areas which may substantially impact the Airman's advantage includes *Personalized Performance and Protection* – technologies that will optimize individual human physical and cognitive performance across the challenging environments in which the Air Force is called to excel. A common vision is to leverage the explosion in the human sciences, including personalized health, neuroscience, biosciences and wearable devices. A vision of using new technologies for rapid detection, prevention, and treatment of cognitive and physical decrements and injury has emerged, driven by anticipated needs in personnel performance and protection for combat and other operations. The domains of application may include cognitive performance and enhancement for operations, command and control; personnel protection from extreme environments such as directed energy weapons; and medical support of the warfighter across the spectrum of military operations.

The 2015 *Air Force Operating Concept* notes that the era in which the United States can project power globally, essentially uncontested, has ended. Without investment in the human, there may be no other advantage in a globalized technological society. We look to your insight for solutions in the year 2030 and over that horizon!

Wearable ultrasonic transducers for noninvasive vital sign monitoring below the skin

Sheng Xu, University of California, San Diego (Shengxu@ucsd.edu)

Wearable electronics represent an important trend for wellness and behavior monitoring. Existing studies have mostly focused on acquiring vital signs above or close to the skin. My group developed a protocol that allows integrating wearable ultrasonic transducers that launch ultrasound waves into regions well underneath the skin, adding a third dimension to the detection range of conventional wearable electronics. The ultrasound waves can capture blood pressure and blood flow waveforms in central vessels. This technology holds profound implications for enhancing the warfighters' performance.

Enhancing Warfighter thru Human Performance & Resiliency Monitoring: from Molecules to Environments

Esther M. Sternberg, MD, University of Arizona (esternberg@email.arizona.edu)

UA IPWP develops methods/devices providing actionable information to optimize performance/resiliency according to stress challenges, tasks, environments. With Lockheed Martin/IARPA RAAMP2 & GSA WB2, we use existing wearable devices to monitor stress responses via HRV, activity, cognitive function, behavior, sleep, environmental attributes in real-life settings. With AFRL, UAIPWP Stress Challenge/Sweat Collection/Stress Correlation lab, we measure sweat biomarkers under stress challenges & environments to develop devices/correlate established biometrics with molecular biomarkers in real-time.

SANTOS: The Human Simulator

Karrim AbdelMalek, Kevin Kregel, The University of Iowa (amalek@engineering.uiowa.edu)

Creating a human avatar that comprises biomechanics, physiology, and cognition is a daunting task. Significant progress has been made with the SANTOS human model, understanding motion, predicting behavior, and quantifying fatigue. This human simulator is poised to make a significant impact on design, testing, evaluation, and procurement of large systems.

Replacement of 115 year old technology

James Nelson, Dr. Jerry R. Nelson, Nelson Laboratories (james@powerwiper.com)

The technology currently used on all Air Force ground vehicles to accomplish vehicle windshield visibility is 115 years old.

What About Increasing the Functionality of Devices Rather Than Scaling Them?

Pierre-Emmanuel Gaillardon, University of Utah (Pierre-emmanuel.gaillardon@utah.edu)

Exploiting unconventional physical properties, several nanodevices showed an alternative to Moore's Law by the increase of their functionality rather than the pure scaling. I will introduce Three-Independent-Gate Field Effect Transistors (TIGFETs), a novel class of computation devices, that can, depending on the bias applied to its gate, achieve different modes of operations usually not achievable in a single device.

Propofol for rapid treatment of military personnel with severe depression

Brian J. Mickey (brian.mickey@utah.edu), Scott C. Tadler, University of Utah

Severe depression strikes tens of thousands of active-duty military personnel each year, and suicide rates have doubled since 2001. Novel, rapidly-acting treatments are needed. Our recent work suggests that propofol -- a commonly used general anesthetic -- can be used to induce a special electrical state in the brain and rapidly resolve depression. This emerging treatment has the potential to restore airmen to health and enhance the next generation of Air Force personnel.

Ingestible Gastric Resident Electronics

Yong Lin Kong, University of Utah (yong.kong@utah.edu)

We present a gastric resident electronic (GRE) system that leverages the anatomical space offered by the gastric environment to enable residence of an orally delivered platform within the human body. The GRE is capable of directly interfacing with personal electronics. In contrast to the passive day-long gastric residence achieved with prior ingestible electronics, advancement in 3D printing enables the GRE to reside in the hostile gastric environment for a maximum of 36 days and maintain 15 days of wireless electronics communications as evidenced by our studies in a porcine model.

10.6.9 Air-Borne and Space-Based Services 2030

Afternoon Breakout Session 2:00-5:15 Room 6613

Chair: Dr. David Barnhart (USC Information Sciences Institute)

Facilitator: Andrea Young (DSAIC)
Recorders: Molly LaChance (AFOSR) and Gabrielle O'Neal (DSIAC)

Military operations have always sought out the high ground to provide services to the warfighter. While millennia ago this meant literally higher ground, in the last century it has evolved to mean primarily air, and has extended to space. From the high ground of air and space, joint forces receive intelligence, surveillance, and reconnaissance products that identify enemy targets and initiate counterterrorism operations. Soldiers, sailors, and airmen rely on GPS and communications services provided from space. A centerpiece of our strategic posture is our missile warning and nuclear detonation detection architectures. These critical warfighting capabilities are under increasing threat; freedom of action is no longer guaranteed in any domain. The air and space services provided to the warfighter in 2030 must evolve to meet continuously evolving threats from an array of adversaries that range from electronic jamming to kinetic kill, and include a variety of cyber attacks. These architectures must continue to provide critical services in an uninterrupted fashion even in the face of loss of capability or action by a foe.

Finally, we must take full advantage of the developments of science and technology to envision the next generation of such services. GPS originated from atomic physics research decades ago; what research today will underpin the next great revolutionary technology? Quantum effects for communications, computing, and encryption? Clean, cheap, renewable sources of propulsion for aircraft and satellites? Breakthroughs in lightweight, robust materials? Nanotechnology, processing, and power management changing how we build sensors and perform remote sensing? The Air Force is relying on your ingenuity and innovation to create and field the next game-changers which will continue to provide the high ground for the U.S. military.

From small to super-large: Potential Future for Aero and Space Systems using Aggregation

David Barnhart (barnhart@isi.edu), USC Information Sciences Institute

In recent years drone technology for air-based systems and "small" satellites in space operations has exploded. Driven by low cost and democratization of development to the individual level, it is emerging to challenge conventional transport and information delivery platforms held by legacy large platforms. But physics still reigns, and "small" apertures in satellites for example, still provide small performance relative to the large cousins. But…what if these small platforms could aggregate into something far larger than can be launched or flown independently? Examples from the past and today show this is not just possible, but the economics of mass produced small things aggregating to far outweigh performance may lead new on-demand deployable capabilities that enable both military and commercial systems new performance. These type elements will be presented to seed the discussion on this exciting new transformative capability.

Super Resolution and Non-Line-of-Sight Imaging with photon Time of Flight

Andreas Velten, University of Wisconsin-Madison (velten@wisc.edu)

I will introduce two imaging Time of Flight methods developed in my lab: Time Encoded Remote Aperture Imaging allows for the reconstruction of target geometries purely from their time response. Reconstruction resolution is not dependent on distance to the target, allowing for target identification and tracking over large distances. Non-line-of-sight Imaging allows for the reconstruction of targets from indirect light or "around a corner". This enables imaging of the inside of buildings or other structures from the air or street and aids navigation.

Planar optics and photonics for ultra-lightweight imaging systems

Rajesh Menon (rmenon@eng.utah.edu), Monjurul Meem, Apratim Majumder, University of Utah

Micro- and nanostructures have recently been widely applied to enhance the performance of optical components and systems. Computational techniques, such as nonlinear optimization, coupled with electromagnetics modeling can drive the designs of novel optical and photonic components and systems. Applying these techniques at the microscale has resulted in flat super-achromatic lenses with, planar spectrum-splitting solar concentrators, and ultra-high efficiency displays. Here, we will describe our work in flat optics enabling large field of view with extremely low weight and thin form factor.

Bio-Inspired Aircraft

Doug Hunsaker, Utah State University (doug.hunsaker@usu.edu)

Bio-Inspired aircraft have several benefits over current aircraft, including increased stealth, efficiency, controllability, and maneuverability with decreased noise. Because of these and other benefits, the Department of Defense has put significant resources into the development of bio-inspired aircraft. Many of these resources have focused on low-Reynolds-number, high-flapping-frequency airframes, which have been met with very limited success. The proposed approach provides a promising path to highly efficient bio-inspired airframes that can perform critical missions.

Big Data Analytics for Cyber Operations

Latifur Khan, University of Texas at Dallas, (lkhan@utdallas.edu)

Data streams are continuous flows of data. Examples of data streams include network traffic, sensor data, call center records and so on. Data streams demonstrate several unique properties that together conform to the characteristics of big data (i.e., volume, velocity, variety and veracity) and add challenges to data stream mining. In this talk we will present an organized picture on how to handle various data mining techniques in data streams and apply in cyber operation domains. More specifically, we will present a number of stream classification applications such as website fingerprinting, real time monitoring, evolving insider threat detection and cyber threat report classification.

Electric hybrid VTOL aerial vehicle

Billy Neff, Neff Aeronautics

billyneff@hotmail.com

Developing a ~15-25 kW GenSet, a lightweight high power-to-weight ratio engine that is integrated with a generator/alternator to create a ~15-25 kWh electric power source to power propeller motors and/or recharge a battery pack mid-flight. Developing scaled up prototype of propeller-in-wheel design increasing quadcopter versatility as it is enabled to travel in air and on ground. Projecting to 2030, Military applications in: Quick insertation/extraction vehicles; CAS (close-air-support) operations; Meeting supply/logistics demands to remote areas. Civilian applications: Daily commuter (Traffic congestion cost U.S. $160 billionannually). Transformative Future Applications: Military application – changing the dynamics of the modern battlefield with versatile and agile ground-and-airvehicles; Police, Fire, Ambulance, Search & Rescue, and Life-Flight; Air-taxis and Traffic-free commuting; Farming – precision agriculture; Recreational

10.6.10 Cyber Defense 2030

Afternoon Breakout Session 2:00-5:15 Room 5614

Chair: Zvonimir Rakamaric, University of Utah

Facilitator: Greg Bowen (DSAIC)
Recorders: Joan Ward (DSIAC)

The Air Force operates its networks within the Department of Defense Information Network and is transitioning to the Joint Information Environment. These globally interconnected information systems are needed for the collection, processing, storage, dissemination, and management of on-demand information for AF warfighters, policy makers, and support personnel. These capabilities include owned and leased communications, computing systems and services, software, data, security services and other associated services, and national security systems.

- We can seek to **deter** adversaries by increasing their level of effort required to achieve their objectives. Further, **attribution** may allow us to deter adversaries by imposing consequences through prosecution or other sanctions. Without attribution, the U.S. is unable to execute internationally lawful actions to contain or shunt adversarial cyber attacks, nor is it able to do so within meaningful timeframes.
- We can **protect** systems from successful attack by creating systems that are highly resistant to malicious activities. This is done through well-structured and verifiable system security engineering practices. The goal is to prevent any successful attacks by an adversary.
- We can try to **detect** any attempted or successful attacks. This ensures that owners and users of systems have knowledge and understanding of any ongoing malicious activities, including the ability to attribute actions to specific actors.
- Based on that situational awareness (SA), we should **adapt** to any malicious cyber activity by improving our ability to protect the systems or, when necessary, to recover from any successful attacks that degrade system capabilities. We must achieve "operational resilience"

Technical means such as machine learning and "big data" analysis are potentially fruitful directions to aid in achieving these goals. What new applications of autonomy, machine learning, game theory, or artificial intelligence might be employed to enhance cyber security? How can we improve cyber situation awareness, defensive and deterrence operations, course of action development, and prediction of effects in real time, to decrease the Air Force's decision loop by factor of 100x to 1000x?

Enhancing Cyber-Defense Through Software Verification

Zvonimir Rakamaric, University of Utah (zvonimir@cs.utah.edu)

Software defects lead to security vulnerabilities that are leveraged by attackers. Software verification aims to completely remove whole classes of defects since it is based on automated rigorous proofs. Less defects means less vulnerabilities, thereby offering better protection. Software verifiers are already used in the industry to improve software security. Going forward, verification tools will be common components of a software development process, just like compilers and debuggers today. It is of utmost importance for our national security to stay ahead of the game in this area.

Security Threats in Emerging Neuromorphic Computing

Koushik Chakraborty (Koushik.chakraborty@gmail.com), Sanghamitra Roy, Utah State University

This project will systematically investigate emerging security vulnerabilities and their effective countermeasures in neuromorphic computing and hardware. With neuromorphic hardware expected to form the backbone of life-critical systems in healthcare, military and automotive industries, it is paramount that we carefully consider emerging threats in such a paradigm as a forethought. Highly connected and parallel neuromorphic architecture, communication of neuronal spikes and synaptic weights, govern the functionality and precision of systems. Covert insertion of malicious circuits and backdoors along the supply chain to disrupt this communication can sabotage the confidentiality, integrity and availability (CIA) of neuromorphic systems on a large scale.

Autonomic Cyber Security

Salim Hariri, AVIRTEK, Inc. and University of Arizona (salim.hariri@avirtek.com)

AVIRTEK is developing Autonomic Cyber Security technologies and services that can self-protect your networks, computers, applications, and data with little involvement of users or system administrators. A true alternative to existing cybersecurity solutions that tend to be manual-intensive, signature based and they use many isolated network management and security tools.

Big Data Analytics for Cyber Operations

Latifur Khan, University of Texas at Dallas, lkhan@utdallas.edu

Data streams are continuous flows of data. Examples of data streams include network traffic, sensor data, call center records and so on. Data streams demonstrate several unique properties that together conform to the characteristics of big data (i.e., volume, velocity, variety and veracity) and add challenges to data stream mining. In this talk we will present an organized picture on how to handle various data mining techniques in data streams and apply in cyber operation domains. More specifically, we will present a number of stream classification applications such as website fingerprinting, real time monitoring, evolving insider threat detection and cyber threat report classification.

10.6.11 Zero-Cost Maintenance Challenge

Afternoon Breakout Session 2:00-5:15 Room 5600

Chair: Charles Vono, Retired USAF

Facilitator: John Ontiveros (DSAIC)
Recorders: Jeff Cline (DSIAC

Keeping the Air Force's diverse, highly capable, and technologically advanced fleet of aircraft, spacecraft, and munitions ready for operations comes at a cost. These systems must be maintained to ensure safe and reliable operation for decades of service over a wide range of ever-changing missions, often in severe environments. The cost of fielding cutting-edge technology to meet warfighter needs is often manifested in less-than-ideal system maintainability and reliability. The toll of high operational tempos, high-severity operations, and operations in extreme environments is paid in the form of field maintenance burdens driven by accelerated degradation and reduced reliability. The price of operating systems beyond their initial design service lives is paid in an increase in the need for heavy maintenance, repair, and overhaul (MRO) and significant replacement-part availability challenges. As sustainment costs rise, budget and manpower limitations drive a reduction in system availability, which directly impacts the Air Force's ability to execute its mission. Furthermore, as sustainment costs rise, the availability of funds for acquiring new systems is jeopardized. Hence, the Air Force seeks innovative solutions to reduce the cost of maintaining required system readiness levels.

The Zero-Cost Maintenance Challenge invites ideas for eliminating, radically reducing, or re-engineering all or subsets of the maintenance activities the Air Force currently conducts. Solutions could focus on: new concepts of operation or new vehicle concepts which fundamentally reduce maintenance requirements; novel approaches to supply chain planning/operations which drastically reduce cost and downtime due to parts availability; efficient maintenance planning and execution concepts which considerably reduce the manpower required to conduct maintenance; innovative life prediction, assessment, and management methods which ensure maintenance is only performed when absolutely needed; or design configurations, materials, or coatings which explicitly reduce or eliminate the need for maintenance.

Fundamentals of Complex System Sustainment

Charles Vono, Retired USAF (charlesvono@comcast.net)

DAU provides important information on how to successfully execute the deployment, sustainment, and disposal periods of a weapon system's life without breaking the law or ignoring directives. But this model starts with first principles and provides a domain of knowledge that helps keep the sustainment team focused on what is important to achieve this day, this month, this year.

Applications of Data Science to Reduce Maintenance Cost

Jerome Soller, PhD, Cognitech Corporation (soller@cognitech-ut.com)

Air Force missile systems and aircraft contain multiple components whose aging, changes in behavior over time, failure, and service life need to be predicted. These events or processes can impact decisions on human resources, parts, and the scheduling of repairs. Historical data, as well as models and simulations, can play an important role in aircraft maintenance. Synergy between scheduling systems, logistics systems, modeling and simulation, data management, and data mining will move the Air Force towards reduced maintenance costs, replacement cost, and down time.

10.6.12 Advanced Customized Manufacturing

Afternoon Breakout Session 2:00-5:15 Room 6500

Chair: David Paul Riddle, Brigham Young University

Facilitator: Brady Redfearn (DSAIC)
Recorders: Cayley Dymond (711 HPW) and Rob Leighton (DSIAC)

The Air Force requires a manufacturing capability that is more responsive, agile, and affordable than ever before. New approaches to weapons system design, such as low cost attritable systems, are driving the development and adaptation of novel methods to transform the traditional aerospace manufacturing paradigm. As with most other technology-driven areas, manufacturing is being revolutionized by rapid advances in digital technologies on, above, and beyond the shop floor. Additionally, the convergence of engineering disciplines through the emergence of digital engineering is providing numerous opportunities across the weapon system life cycle. These will result in more rapid design and manufacture of components as well as create a digital thread of knowledge about components and systems that not only informs the maintenance of a weapon system, but provides feedback to the materials engineer and design engineer on the suitability and accuracy of predictive models of performance. Along with these opportunities that enable more rapid manufacture of hardware at reduced cost and risk come challenges in creating a secure digital network through the vendor supply chain for the transmittal of rich, digital technical data packages that capture the envisioned evolving complexity of materials and components.

Electron Heat: rapid curing system for composites

David Paul Riddle, Brigham Young University (dpr@byu.net)

Electron Heat a process using RF energy to heat and curing composite materials. There are three elements using the Electron Heat process: Power Converter (custom design RF generator) Additive (a nano heater premixed into the composites) Tooling that focuses the energy in the composite affording an effective energy transfer and accelerated heating or curing. Several resins and curing methods have been tested with Electron Heat. Curing can be accomplished in minutes or seconds that normally require hours or days in an oven or autoclave. Thick and thin product cured, tested, and validated.

U-splines: Next-gen CAD and simulation for additive manufacturing

Matthew Sederberg, Coreform (matt@coreform.com)

$100 millions are spent annually to transition CAD design data to CAE simulations in auto/aero/defense. Additionally, no suitable CAD description exists to fully exploit the frontiers of additive manufacturing and advanced materials. U-splines is a new technology suitable for both CAD and CAE that can allow for advanced descriptions of variable material properties for use in additive manufacturing.

Additive Manufacturing: Detection/Placement of Contaminant Particles

Amber Dalley, RJ Lee Group, Inc. (adalley@rjleegroup.com)

Additive Manufacturing (AM) for high performance applications needs high purity Powder Metal (PM) feedstock. Contaminants in PM can create fatigue cracks, porosity, and deleterious phases. They can be identified/quantified using separation methods and specialized SEM. By 2030, 50% of metal components may be AM-fabricated. Protecting USAF PM feedstock from intentional or accidental contamination is essential. Every PM lot (new/used), needs to be qualified. Understanding effects on properties can allow seeding contaminants into PM feedstock to deliberately affect performance.

Direct 3D Printing of Biomaterials Inside of the Body

Huanan Zhang, University of Utah Chemical Engineering (zhang@chemeng.utah.edu); Cynthia Furse, University of Utah Electrical Engineering

The ability to create in vivo 3D structures without extensive surgical procedures could transform the field of medical implants, stimulate many potential applications, and improve patient experiences. We are working on an entirely new 3D printing modality for medical treatment. First, we will design a low-temperature cross-linkable polymer that the crosslinking process can be controlled spatially and temporally. We will then develop a focused, steerable heat distribution system to cross-link the polymer.

Additive Manufacturing of Ultra-High Temperature Materials

Ming C. Leu, Missouri University of Science and Technology (mleu@mst.edu); William G. Fahrenholtz, Missouri University of Science and Technology

Advanced aerospace systems will be required to operate at extremely high flight speeds. The increase in flight speed will result in high heat fluxes at the leading and trailing edges, requiring thermal protection systems to withstand very high temperatures. Also, the increased propulsion will

result in very high temperatures on combustors, propulsion nozzles, etc. Advanced additive manufacturing processes will be needed to produce components from monolithic and graded ceramics and cermets with necessary mechanical and thermal properties (after sintering) at elevated temperatures.

Additive manufacturing through direct-write functional nanofibers

Jiyoung Chang, University of Utah (Jy.chang@utah.edu)

This research aims to develop a next generation electrohydrodynamic printing process based on additively manufacturing functional nanofibers. The functional fibers, including piezoelectric, chemical sensing and mechanical strain sensing, can be incorporated to build micro/nanoscale structures in three-dimensional space. By utilizing extremely low applied voltage (50V), the platform has potential to be miniaturized as a portable device. This project will enable scalable, on-demand and customizable manufacturing of micro/nanoscale functional structures at low cost.

Poster: 3D Printing Inside the Body

Eric Lindstrom (eric_lindstrom@msn.com), Eldon Pe'a, Jordan Gardner, Dylan Zdunich, Kaitlin Hall, Hossein Mehpourbernety, Cynthia Furse, Huanan Zhang, University of Utah

3D printing has revolutionized various industries, including medicine. Currently, artificial joints, stents, and implantable electronics are 3D printed outside the body and then surgically implanted, at least somewhat invasively. The continuing objective of this research project is to design a system that will 3D these objects directly into a patient's body, almost completely avoiding any invasive procedures. This system will use a coaxial cable to administer a polymer which reacts with enzymes to create a biologically safe semi-solid structure, ideal for soft tissue recoveries or implants.

USAF Science & Technology 2030 Visioning workshop

Summary of Poster Session (July 11, 2018) – By Dr. Zhengming Ding, Department of Computer, Information and Technology, Indiana University-Purdue University Indianapolis

The poster session was held during 12:30pm and 2pm on July 11, 2018. There are more than 10 posters from various institutes on different sessions. During the one and half hours, the poster session attracts a lot of attentions, especially the later one hour after the participants finish their lunch. The participants and poster reporters have a very impassioned discussion. There are several topics much more popular, e.g., big data analysis, multi-sensor knowledge fusion, and cyber security. The following are detailed posters.

Interpretable clustering via semantics recovery: the goal of this work is to discover new objects which are not seen before. This is much related to air force thus many participants discuss around the poster. Since soldiers and drones take the task outside, it is very essential to understand the surrounding environments and anomalies. This poster is also related to **Knowledge Transfer for Few-Shot Image Understanding.** Both attract a lot of discussion.

Point-of-Use Sensors: This is the poster from the Advanced Materials and Microdevices Laboratory at The University of Utah. The lab explores many new materials or sensing. Since different sensors would generate different views of the data and provide better understanding of the data, it is very helpful to explore different materials. This also attracts many attentions from the multi-sensor data analytics, since the focus on designing novel algorithms to learn the data from multiple sensors.

3D Printing Inside the Body: This topic is very interesting, and the participants are very curious about how to take the 3D printing inside the body, which is really helpful to avoid any invasive procedures. This technique could be widely used during the treatment and rehabilitation of patients.

Overall, it is a very successful and helpful poster session to share creative ideas and different expertise. The brainstorming is beneficial to come up with new ideas for air force.

List of Posters:

- **Data to Knowledge: Modernizing Political Event Data for Big Data Social Science Research**

  Latifur Khan, PhD (lkhan@utdallas.edu), Patrick Brandt PhD, Jennifer Holmes PhD, University of Texas at Dallas

  We have developed the software and big data infrastructure to provide machine coded event data from news reports from historical and real-time inputs from the web. The project is ongoing and will produce coded news reports based on NLP applications across English, Spanish, and Arabic news reports. Human annotations and validations are conducted for data validation and cross-lingual support. Geo-location of the events is also improved for better spatial resolutions.

- **Interpretable Clustering via Semantics Recovery**

  Hongfu Liu, Brandeis University (lhf.hongfu@gmail.com)

  Here we consider Interpretable Clustering via Semantics Recovery, where the missing semantic attributes are recovered to explain the uncovered clusters with only visual features. To achieve this, auxiliary source data containing visual features, semantic attributes and labels are employed to facilitate the target data clustering. Then we propose a novel dual-level transfer learning method to extract the knowledge from the instance-level and partition-level for the target data recovery and clustering.

- **Dissecting change of causal influence in coupled dynamical systems**

Violet Mwaffo (violet.mwaffo@colorado.edu), Jishnu Keshavan*, Tyson Hedrick**, Sean Humbert*; * UC Boulder; ** UNC Chapel Hill*

Dissecting the dynamics of the causal influence in lieu of simple correlations is more relevant for several applications including switching interaction between neurons, cascade failures, or the propagation of diseases. Such dynamics cannot be fully captured by most existing tools. We propose a method to infer intermittent switching of the causal influence combining network theory and a data-driven measure of causality. We demonstrate our approach on synthetic and real-world data-sets. Our method is expected to enrich the toolbox to infer the dynamics of networks.

- **Point-of-Use Sensors**

Christina Willis, Yalda Saffary, Lani McKinnon, Shruti Hegde, Jonathan Grubb, Hsuan-Yu Leu, Kerry Kelly, Jaye Magda, Mano Misra, Swomitra Mohanty (swomitra@chemeng.utah.edu), University of Utah

There is a major need for rapid point of use sensors to address environmental and health issues world-wide. The Advanced Materials and Microdevices Laboratory at the University of Utah focuses on engineering new materials for sensing that are deployed in a variety of microdevice formats including autonomous microfluidics, rapid gas sensing, and immersible water sensors. This poster will highlight the platform sensing technologies, including molecularly imprinted hydrogels, metal functionalized titania nanostructures, and electrocatalytic sensors. Examples of analytes that have been detected by the lab are, perfluorinated compounds (APOS) in water, chlorinated solvents in water, volatile organic compounds associated with disease and contaminated food, and environmental air pollution contaminants such as benzene, ethanol, and toluene.

- **Knowledge Transfer for Few-Shot Image Understanding**

Zhengming Ding, Indiana University – Purdue University Indianapolis (allanding@ece.neu.edu)

Modern recognition systems still need thousands of examples of each class to saturate performance. This is impractical in cases where one does not have enough resources to collect large training sets or that involve rare visual concepts. We aim to explore the data augmentation and knowledge transfer learning to solve the few-shot image understanding.

- **Achieving Aerial Excellence using Non-Volatile RRAM based Multiplexer Structures**

Pierre Emmanuel Gaillardon (pierre-emmanuel.gaillardon@utah.edu), Xifan Tang, Ph.D., University of Utah, Mr. Natan Chetrit

ReRouting LLC is developing a novel Resistive-RAM (ReRAM) FPGA SoC for advanced low-power applications. Its transformative FPGA architecture can enable aerial superiority to the United States Air Force. ReRAM-based routing circuits enable 1) a 5x power reduction, 2) non-volatility and 3) all at no-performance compromise even when operated a low supply voltage. ReRouting will provide the Air Force an added edge in the sky, enabling computing-intensive operations previously unavailable to tight power budgets, advancing sensor networks performance, and providing a radiation tolerant solution.

- **The Many Roles of Amines in CO2 Recycling Schemes**

Cheryl Mathis (mathiscl@chem.utah.edu), Moumita Bhattacharya, University of Utah

The Saouma group is interested in understanding how to deliver electron/ proton equivalents to CO2 thereby catalytically converting it to value-added feedstocks. Target reactions include: conversion to CO, formic acid, and methanol. Towards achieving this goal, we are investigating the role that amines play in achieving these catalytic processes under mild and selective conditions.

- **3D Printing Inside the Body**

Eric Lindstrom (eric_lindstrom@msn.com), Eldon Pe'a, Jordan Gardner, Dylan Zdunich, Kaitlin Hall, Hossein Mehpourbernety, Cynthia Furse, Huanan Zhang, University of Utah

The objective of this research project is to design a system that will 3D these objects directly into a patient's body. This system will use a coaxial cable to administer a polymer which reacts with enzymes to create a biologically safe semi-solid structure, ideal for soft tissue recoveries or implants.

- **Streamlined Weapon Systems Programs**

Ralph Wege, USAF (retired), (benanci@icloud.com)

As a part of the AF2030 effort, the SECAF asked for driving down costs by accepting more risk and making the time from workbench to flightline faster. Responses will be to build up a qualified and specialized civilian technical workforce and to better track technical officer personnel to lead design and test teams more efficiently.

11.1.1 Networking

The workshop format fostered the cultivation of cooperative networks among the Air Force and its potential civilian partners. Representatives from small business, academia, and the USAF engaged in conversation to highlight where transformative technological advances appear most promising. The local organizers anticipate that the participants assembled for the workshop will provide added value as they return to their respective institutions and share their experiences and ideas gained through the workshop process with mentors, colleagues, and students.

11.1.2 Abstracts

Abstracts were collected online and organized into a single handout included in the packets for attendees at the time of registration.

11.1.3 Research themes and ideas

At the midpoint of each breakout session, major potential research themes were collected onto poster paper. The ideation segment of each session produced specific research ideas around these themes. These ideas were added to the poster paper and prioritized or fleshed out by the participants. In addition, they were displayed around the networking room at the end of the day for participants to peruse ideas from sessions they did not attend, and to add notes or additional ideas with markers available.

11.1.4 Value to Air Force

The conference at the University of Utah was the 6th event in a series of listening engagements taking place as part of the Air Force's Science and Technology 2030 Strategy Technical Workshops. The Utah workshop represents an area meeting for the Southwest Region, and participation came from all six states in this geographic group, plus more. The stated purpose for S&T workshop series is to "Provide guidance that prepares the Air Force for the national security challenges of 2030 and beyond and insures our technological advantage"[4]. The proposed UU-hosted workshop will be designed to help identify strategic research areas suitable for the 2030 timeframe and beyond, and to determine mechanisms and frameworks to optimize Air Force engagement with its academic and industry partners, with special attention to the opportunities in the Southwest Region.

Broadly, the proposed workshop will address technical areas aligned with USAF BAA fundamental and applied research areas, including Engineering and Complex Systems, Information and Networks, the Physical Sciences, and Chemistry and the Biological Sciences. The proposed workshop centers on the theme of *Game-Changing Technology*, which intersects with all five of the Air Force's stated Core Functions.

[4] Air Force 2030 Strategy Charts, January 2018

Funds were requested to support the proposed S&T workshop. The proposed budget was calculated for 300 workshop attendees and 150 Industry Networking event attendees. The proposed budget is shown in black, and the actual budget in **red.** Final (actual) numbers are still being collected and will be provided in the final report.

	Proposed	Actual
Total Estimated Cost:	**$203,532**	**$194,361.38**
Space Rental	**$4,410**	$4,410
SJ Quinney Law School Building	$4,410	$4,410

The rental contract for the SJ Quinney Law School Building provided access to a large forum room for the opening and closing sessions (Moot Courtroom, 350 capacity), six large classrooms (circle table seating for 20-50) for breakout sessions, a large foyer (for registration, lunch, posters, and wrap-up reception), plus two smaller classrooms and a kitchen area for general organizational use.

Utah State Capitol Rotunda	$0	$0

We held an evening industry networking reception incidental to the conference (including industry technology demonstration tables) July 10. This was held at the Utah State Capitol Rotunda, for which there was no charge. The other expenses for this reception were covered by the University of Utah Vice President for Research Office (VPR), as noted below.

Travel Support	**$7,200**	**$6,000**

Funds were requested to supported travel expenses for 12 out-of-state key speakers, i.e. one from each topical area. Each participant will receive $600 travel stipend. 10 travel awards were given to the faculty listed in Appendix C: Travel Funds on page 97.

Ideation Facilitation	**$120,000**	**$120,000**

Funds are requested for six Professional Facilitators and six recorders to support each of the 6 parallel breakout sessions. Each facilitator/recorderpair will support one morning and one afternoon session. Estimates are $20,000 for each team, for a total of $120,000. Experienced facilitators and recorders were contracted from DSIAC through SURVICE. The facilitators and recorders for each breakout session are listed in section 10.6 Air Force 2030 Tech Ideation Workshop Breakout Sessions.

Office Supplies for Ideation		*$978.48*

We did not originally budget for this expense, but found out after the proposal went in that these items would be needed for each table in the ideation sessions: large 3M post-it pads, white board markers, post-it markers, small post it pads, small note pads, ink pens, copies of ideation sheets.

Conference Services and Materials

Website portal and abstract registration	*$9,900*	$5,368

Cost included generating website platform for workshop advertising, conference registration, abstract submission and gathering, and printing of nametags at a rate of $22/participant. The

University of Utah Conference services provided pre-event support including registration website, arrangement of transportation, etc.

Onsite Registration *$3,000* *$2,250*

Contractor service includes folder and swag preparation as well as personnel for handling, in-person onsite registration. The cost is $10/participant. The Law School Event team provided support for on-site day-of needs including on-site registration, AV, parking, transportation management, and coordination for catering.

AV Services and Photography *$350* *$52.50*

The Law School AV Team provided turnkey audio-visual services, including amplification for all workshop presentations. Troubleshooting services, as needed, were included. The rate was $35/hour for 10 hours = $350.

Still photographs were taken by University of Utah Vice President for Research Office (VPR) communication staff at no charge to USAF.

AV services were also required at the July 10 industry event. These services were covered by the VPR Office at no charge to USAF.

Printing *$2,862* *$857.90*

University of Utah Print Services delivered full-color printing of conference program, including formatting, assembly, and associated packaging. Actual costs depend on program page count, budget reflects 30 pages at a rate of $9.54 per unit.

Additional black and white printing of the agenda packets was done by the VPR Office staff.

Nametags *$69* *$0*

Breakaway lanyards were provided to conference participants by the Air Force (for USAF staff) and Conference Services (all others). Cost Includes required, one-time setup and color matching service for $69.

Workshop Security *$1,500* *$1,250*

Security costs originally budgeted for the USTAR Innovation Center for the Industry Networking Reception at $50/hour for 10 hours, totaling $500, were not needed. When we moved the event to the Capitol, this came with 3 Utah Highway Patrol security officers at no charge

Security for the July 11 workshop were provided by two uniformed officers from the University of Utah Police Department (UUPD). The UUPD is a full-service law enforcement agency that serves the UU community. The budget for security was based on a rate of $50/ hour for two officers.

Transportation *$740* $629

A shuttle bus ran continuously during the meeting and to connect the UU Guest House hotel with the meeting venue. For July 11, a 10-hour window was budgeted at a rate of $74/hour, totaling $740.

For the Industry Event on July 10, the transportation was $110/hour/motorcoach with 4 hour minimum, totaling $440. The motorcoach accommodated up to 55 guests, and it was full. This cost was covered by the VPR.

Parking	*$390*	*$450*

Costs include 10 reserved priority spaces for USAF personnel at a total of $60. Additionally, a formal parking moratorium will be established in the vicinity of the Law School Building and roadway signage were printed and posted to aide in routing workshop participants to approved parking areas at a cost of $330.

Logistics Management	*$1,500*	

Cost was for the Law School Event Team to coordinate onsite support staff including caterers, AV service, security, parking, registration, and other ancillary tasks.

Catering	**$18,927**	**$18,927**

The July 11 catering service was performed at the SJ Quinney Law School Building. Food and beverages were provided by LUX Catering and Even Stevens, which are two of the SJ Quinney College of Law's preferred catering contractors. Services included morning beverages (coffee, tea, juices) with light breakfast (oatmeal, pastries, fruit), two snack refreshments (a.m.: yogurt, granola; p.m.: hummus, veggies), lunch (sandwiches with vegan and veg options, salad, chips, dessert), and an evening wrap-up reception and poster session with light refreshments ($63.09/person, budgeting for 300 attendees).

Cost of refreshments for the July 10 industry event, were covered by the VPR. Alcohol for the July 11 reception was provided by the University of Utah Vice President for Research Office at no charge to the Air Force.

Organization and Reporting	**$13,294**	**$13,294**
Dr. Cynthia Furse	*(9,775)*	
Benefits	*(3,519)*	

Dr. Furse oversaw and directed the local organizing committee and prepared key deliverables, specifically this report. This included:

- Coordinating the overall event planning and implementation.
- Coordinating with USAF to select topics and set the technical agenda.
- Managing the budget and contracts.
- Coordinating the invitations to academics and industry.
- Coordinating abstract submission, review/acceptance, and author notification.
- Collecting the final ideation reports from facilitators and recorders, and draft the final report.
- Directing staff in the Vice President for Research Office to provide incidental support, coordinating with Print Services for conference folder materials, with UofU public relations for PR support, and with invitations and answering pre-conference questions from prospective attendees.

Actual time spent organizing this conference far exceeded the support charged.

Facilities and Administrative (Overhead) costs	**$19,890**	**$19,890**

The university normally charges 47.5% overhead, which would be $87,299, however in light of the value of this conference to the Air Force and technical community, we will charge a reduced amount of $19,890 for this event.

13 APPENDIX A: INVITATION LIST

Name	Institution Name
Brezinsky, Kenneth	University of Illinois at Chicago
Dutta, Mitra	University of Illinois at Chicago
Erricolo, Danilo	University of Illinois at Chicago
Stroscio, Michael	University of Illinois at Chicago
Akcakaya, Mehmet	University of Minnesota-Twin Cities
Balas, Gary	University of Minnesota-Twin Cities
Candler, Graham	University of Minnesota-Twin Cities
Dhople, Sairaj	University of Minnesota-Twin Cities
Ferry, Vivian	University of Minnesota-Twin Cities
Frisbie, Carl	University of Minnesota-Twin Cities
Gagliardi, Laura	University of Minnesota-Twin Cities
Georgiou, Tryphon	University of Minnesota-Twin Cities
Hemati, Maziar	University of Minnesota-Twin Cities
Jalan, Bharat	University of Minnesota-Twin Cities
James, Richard	University of Minnesota-Twin Cities
Li, Mo	University of Minnesota-Twin Cities
Linares, Richard	University of Minnesota-Twin Cities
Luo, Zhi-Quan	University of Minnesota-Twin Cities
Luskin, Mitchell	University of Minnesota-Twin Cities
MAHESH, KRISHNAN	University of Minnesota-Twin Cities
Pederson, Bill	University of Minnesota-Twin Cities
Schwartzentruber, Thomas	University of Minnesota-Twin Cities
TRUHLAR, DONALD	University of Minnesota-Twin Cities
Holcomb, John	Cleveland State University
Allen, Matthew	University of Wisconsin Colleges
Andrew, Trisha	University of Wisconsin Colleges
Behdad, Nader	University of Wisconsin Colleges
Booske, John	University of Wisconsin Colleges
Crim, Fleming	University of Wisconsin Colleges
Eom, Chang Beom	University of Wisconsin Colleges
Eom, Chang-Beom	University of Wisconsin Colleges
GRAHAM, MICHAEL	University of Wisconsin Colleges
Hamers, Robert	University of Wisconsin Colleges

Kats, Mikhail	University of Wisconsin Colleges
Lee, John	University of Wisconsin Colleges
Liu, Kaibo	University of Wisconsin Colleges
Nathanson, Gilbert	University of Wisconsin Colleges
Nowak, Robert	University of Wisconsin Colleges
Pfleger, Brian	University of Wisconsin Colleges
Robinson, Stephen	University of Wisconsin Colleges
Velten, Andreas	University of Wisconsin Colleges
WANG, XUDONG	University of Wisconsin Colleges
Yavuz, Deniz	University of Wisconsin Colleges
Zanni, Martin	University of Wisconsin Colleges
Zhou, Shiyu	University of Wisconsin Colleges
Popov, Alexander	University of Wisconsin-Stevens Point
Soref, Richard	University of Massachusetts-Boston
Sun, Greg	University of Massachusetts-Boston
Gottlieb, Sigal	University of Massachusetts-Dartmouth
Li, Yifei	University of Massachusetts-Dartmouth
Sun, Greg	University of Massachusetts-Dartmouth
Eckstein, Jonathan	Rutgers University-Newark
Bikson, Marom	CUNY City College
Braunschweig, Adam	CUNY City College
Gerry, Christopher	CUNY City College
Greenbaum, Steve	CUNY City College
Tamarego, Maria	CUNY City College
Tu, Raymond	CUNY City College
Ulijn, Rein	CUNY City College
Vittadello, Michele	CUNY City College
Cartwright, Natalie	State University of New York at New Paltz
,	SUNY Buffalo State
Crassidis, John	SUNY Buffalo State
Jornet, Josep	SUNY Buffalo State
Mitin, Vladimir	SUNY Buffalo State
Pados, Dimitrios	SUNY Buffalo State
Patra, Abani	SUNY Buffalo State
Prasad, Paras	SUNY Buffalo State
Singh, Tarunraj	SUNY Buffalo State

Singla, Puneet	SUNY Buffalo State
Stefanone, Michael	SUNY Buffalo State
Balazs, Anna	University of Pittsburgh-Pittsburgh Campus
BRIGHAM, JOHN	University of Pittsburgh-Pittsburgh Campus
Daley, Andrew	University of Pittsburgh-Pittsburgh Campus
Givi, Peyman	University of Pittsburgh-Pittsburgh Campus
Hutchison, Geoffrey	University of Pittsburgh-Pittsburgh Campus
Levy, Jeremy	University of Pittsburgh-Pittsburgh Campus
LIU, HAITAO	University of Pittsburgh-Pittsburgh Campus
Liu, Wensheng Vincent	University of Pittsburgh-Pittsburgh Campus
MEENAKSHISUNDARAM, RAVI SHANKAR	University of Pittsburgh-Pittsburgh Campus
Prokopyev, Oleg	University of Pittsburgh-Pittsburgh Campus
Trenchea, Catalin	University of Pittsburgh-Pittsburgh Campus
Araya, Juan	University of Puerto Rico-Mayaguez
Katiyar, Ram	University of Puerto Rico-Rio Piedras
Warma, Mahamadi	University of Puerto Rico-Rio Piedras
Asundi, Sharanabasaweshwara	Tuskegee University
Green, Hadiyah-Nicole	Tuskegee University
Mirov, Sergey	University of Alabama at Birmingham
Reichert, William	University of South Alabama
Mortazavi, Mansour	University of Arkansas at Pine Bluff
Tyagi, Pawan	University of the District of Columbia
Liu, Jinjie	Delaware State University
Rana, Mukti	Delaware State University
Belay, Kalayu	Florida Agricultural and Mechanical University
Chi, Hongmei	Florida Agricultural and Mechanical University
Kumar, Rajan	Florida Agricultural and Mechanical University
Xu, Chengying	Florida Agricultural and Mechanical University
Miller, Warner	Florida Atlantic University
Ouyang, Bing	Florida Atlantic University
Boesl, Benjamin	Florida International University

Chen, Jiuhua	Florida International University
Dulikravich, George	Florida International University
Georgakopoulos, Stavros	Florida International University
Larkins, Grover	Florida International University
Pissinou, Niki	Florida International University
Abouraddy, Ayman	University of Central Florida
Ahmed, Kareem	University of Central Florida
Chen, Bo	University of Central Florida
Chini, Michael	University of Central Florida
Dogariu, Aristide	University of Central Florida
Gaume, Romain	University of Central Florida
Jha, Sumit	University of Central Florida
Leuenberger, Michael	University of Central Florida
Neupane, Madhab	University of Central Florida
Richardson, Martin	University of Central Florida
Wu, Shin-Tson	University of Central Florida
Bishop, Robert	University of South Florida-Main Campus
Jacobson, David	University of South Florida-Main Campus
Licato, John	University of South Florida-Main Campus
Oleynik, Ivan	University of South Florida-Main Campus
Yucelen, Tansel	University of South Florida-Main Campus
Shen, Kai	Savannah State University
Tomlinson, Aimee	University of North Georgia
Darwish, Abdalla	Dillard University
Zhao, Guang-Lin	Southern University and A & M College
Williams, Conrad	Morgan State University
Cronin, Thomas	University of Maryland-Baltimore County
Shih, Yanhua	University of Maryland-Baltimore County
Balachandran, Balakumar	University of Maryland-College Park
BHATTACHARYYA, SHUVRA	University of Maryland-College Park
BRUCK, HUGH	University of Maryland-College Park

Childs, Andrew	University of Maryland-College Park
Eichhorn, Bryan	University of Maryland-College Park
Fefferman, William	University of Maryland-College Park
Gelfand, Michele	University of Maryland-College Park
Gorshkov, Alexey	University of Maryland-College Park
Hafezi, Mohammad	University of Maryland-College Park
Hu, Liangbing	University of Maryland-College Park
Hubbard, James	University of Maryland-College Park
Jones, Anya	University of Maryland-College Park
Kim, Kiyong	University of Maryland-College Park
Kofinas, Peter	University of Maryland-College Park
Krishnaprasad, P	University of Maryland-College Park
Larsson, Johan	University of Maryland-College Park
Laurence, Stuart	University of Maryland-College Park
Lett, Paul	University of Maryland-College Park
	University of Maryland-College Park
Marcus, Steven	University of Maryland-College Park
Martin, Maria	University of Maryland-College Park
MARTIN, Marie	University of Maryland-College Park
Martins, Nuno	University of Maryland-College Park
Milchberg, Howard	University of Maryland-College Park
Paglione, Johnpierre	University of Maryland-College Park
Paley, Derek	University of Maryland-College Park
Rolston, Steve	University of Maryland-College Park
Shamma, Shihab	University of Maryland-College Park
Sterbing-D'Angelo, Susanne	University of Maryland-College Park
Swingle, Brian	University of Maryland-College Park
Waks, Edo	University of Maryland-College Park
Wereley, Norman	University of Maryland-College Park
Yu, Kenneth	University of Maryland-College Park
Tu, Shuangzhang	Jackson State University

Azoulay, Jason	University of Southern Mississippi
Wiggins, Jeffrey	University of Southern Mississippi
Gbur, Greg	University of North Carolina at Charlotte
Schmidt, Peter	University of North Carolina at Charlotte
Ferguson, Chip	Western Carolina University
Quinn, Byron	Langston University
Hassanali, Samina	Claflin University
Anton, Steven	Tennessee Technological University
Combs, Christopher	The University of Tennessee-Chattanooga
Barton, Kevin	Our Lady of the Lake University
Droopad, Ravi	Texas State University
Green, Micah	Texas Tech University
Hase, William	Texas Tech University
Idesman, Alexander	Texas Tech University
Chudoba, Bernd	The University of Texas at Arlington
Deng, Yue	The University of Texas at Arlington
Huang, Haiying	The University of Texas at Arlington
Johnson, Taylor	The University of Texas at Arlington
	The University of Texas at Arlington
Schizas, Ioannis	The University of Texas at Arlington
Zhou, Weidong	The University of Texas at Arlington

Bronson, Arturo	The University of Texas at El Paso
Echegoyen, Luis	The University of Texas at El Paso
Kumar, Vinod	The University of Texas at El Paso
Maldonado, Theresa	The University of Texas at El Paso
Prabhakar, Pavana	The University of Texas at El Paso
Roberson, David	The University of Texas at El Paso
Santos, Eunice	The University of Texas at El Paso
Alaeddini, Adel	The University of Texas at San Antonio
Cao, Yongcan	The University of Texas at San Antonio
CHABANOV, ANDREY	The University of Texas at San Antonio
Millwater, Harry	The University of Texas at San Antonio
NASH, Kelly	The University of Texas at San Antonio
Wilkerson, Justin	The University of Texas at San Antonio
Choutapalli, Isaac	The University of Texas Rio Grande Valley
Mao, Yuanbing	The University of Texas Rio Grande Valley
Chu, Ching-Wu	University of Houston
Chu, Paul C. W.	University of Houston
Ghasemi, Hadi	University of Houston
Lee, T. Randall	University of Houston
Onofrei, Daniel	University of Houston
Qiu, Jingmei	University of Houston
White, Kenneth	University of Houston
Lyons, Donald	Hampton University
Noginov, Mikhail	Norfolk State University
Bliss, James	Old Dominion University
Gurevich, Alex	Old Dominion University

Jiang, Chunqi	Old Dominion University
Schoenbach, Karl	Old Dominion University
Vernier, Thomas	Old Dominion University
Fallen, Christopher	University of Alaska Fairbanks
Debray, Saumya	University of Arizona
Fasel, Hermann	University of Arizona
Hao, Qing	University of Arizona
Hariri, Salim	University of Arizona
	University of Arizona
Jacobs, Jeffrey	University of Arizona
Jessen, Poul	University of Arizona
Jones, R Jason	University of Arizona
Khitrova, Galina	University of Arizona
Kieu, Khanh	University of Arizona
Kolesik, Miroslav	University of Arizona
Koshel, R. John	University of Arizona
Little, Jesse	University of Arizona
Lysecky, Roman	University of Arizona
Moloney, Jerome	University of Arizona
Peyghambarian, Nasser	University of Arizona
Polynkin, Pavel	University of Arizona
Schaibley, John	University of Arizona
Son, Young-Jun	University of Arizona
Tumin, Anatoli	University of Arizona
Wygnanski, Israel	University of Arizona
Xin, Hao	University of Arizona
Rodriguez, Jose	California State University-Los Angeles
Gilles, Jerome	San Diego State University

Holland, Gregory	San Diego State University
Jacobs, Gustaaf	San Diego State University
Shoemaker, Patrick	San Diego State University
Chen, Zhigang	San Francisco State University
Matsumoto, David	San Francisco State University
Anandkumar, Animashree	University of California-Irvine
Capolino, Filippo	University of California-Irvine
Esser-Kahn, Aaron	University of California-Irvine
Figotin, Aleksandr	University of California-Irvine
Gamero-Castano, M	University of California-Irvine
Gorodetsky, Alon	University of California-Irvine
Hochbaum, Allon	University of California-Irvine
Narens, Louis	University of California-Irvine
Ritz, Thorsten	University of California-Irvine
sirignano, william	University of California-Irvine
Solna, Knut	University of California-Irvine
Taborek, Peter	University of California-Irvine
Vershynin, Roman	University of California-Irvine
Yang, Jenny	University of California-Irvine
Kim, Arnold	University of California-Merced
LiWang, Andy	University of California-Merced
MA, YANBAO	University of California-Merced
MARTINI, ASHLIE	University of California-Merced
Scheibner, Michael	University of California-Merced
Abu-Ghazaleh, Nael	University of California-Riverside
Gabor, Nathaniel	University of California-Riverside
Kisailus, David	University of California-Riverside
Wheeldon, Ian	University of California-Riverside

Awschalom, David	University of California-Santa Barbara
Bleszynski Jayich, Ania	University of California-Santa Barbara
Bowers, Michael	University of California-Santa Barbara
Bullo, Francesco	University of California-Santa Barbara
Meinhart, Carl	University of California-Santa Barbara
Metiu, Horia	University of California-Santa Barbara
Mezic, Igor	University of California-Santa Barbara
Mishra, Umesh	University of California-Santa Barbara
Palmstrom, Christopher	University of California-Santa Barbara
Schuller, Jon	University of California-Santa Barbara
Speck, James	University of California-Santa Barbara
Teel, Andrew	University of California-Santa Barbara
Van de Walle, Christian	University of California-Santa Barbara
Weld, David	University of California-Santa Barbara
Young, Andrea	University of California-Santa Barbara
Hunter, Lisa	University of California-Santa Cruz
Milanfar, Peyman	University of California-Santa Cruz
Rolandi, Marco	University of California-Santa Cruz
Sanfelice, Ricardo	University of California-Santa Cruz
Venturi, Daniele	University of California-Santa Cruz
Hunter, Lisa	University of Hawaii at Manoa
Jefferies, Stuart	University of Hawaii at Manoa
Juarez, Ruben	University of Hawaii at Manoa
Kaiser, Ralf	University of Hawaii at Manoa
Kobayashi, Marcelo	University of Hawaii at Manoa
Maberry, Michael	University of Hawaii at Manoa
Pavlovic, Dusko	University of Hawaii at Manoa
Yepez, Jeffrey	University of Hawaii at Manoa
Browning, Jim	Boise State University

CANTLEY, KURTIS	Boise State University
Fohtung, Edwin	New Mexico State University-Dona Ana
Gross, Andreas	New Mexico State University-Dona Ana
McAteer, R.T. James	New Mexico State University-Dona Ana
Stochaj, Steven	New Mexico State University-Dona Ana
Zollner, Stefan	New Mexico State University-Dona Ana
Becerra Chavez, Francisco	University of New Mexico-Main Campus
Brinker, Jeffrey	University of New Mexico-Main Campus
Brueck, Steven	University of New Mexico-Main Campus
Christodoulou, Christos	University of New Mexico-Main Campus
	University of New Mexico-Main Campus
Grey, John	University of New Mexico-Main Campus
Habteyes, Terefe	University of New Mexico-Main Campus
Hussey, Thomas	University of New Mexico-Main Campus
Krishna, Sanjay	University of New Mexico-Main Campus
Lipinska, Kristina	University of New Mexico-Main Campus
Prasad, Sudhakar	University of New Mexico-Main Campus
Prasad, Sukhakar	University of New Mexico-Main Campus
Schamiloglu, Edl	University of New Mexico-Main Campus
Sheik-Bahae, Mansoor	University of New Mexico-Main Campus
Taha, Mahmoud	University of New Mexico-Main Campus
Xu, Luoyu	University of New Mexico-Main Campus
Candler, Graham	University of Minnesota-Twin Cities
Cortes, Pedro	Youngstown State University
Lagally, Max	University of Wisconsin Colleges
Ma, Zhenqiang	University of Wisconsin Colleges
Zanni, Martin	University of Wisconsin Colleges

Li, Yifei	University of Massachusetts-Dartmouth
Peng, Jing	Montclair State University
Bikson, Marom	CUNY City College
Ren, Yuhang	CUNY City College
Ulijn, Rein	CUNY City College
Majji, Manoranjan	SUNY Buffalo State
Mitin, Vladimir	SUNY Buffalo State
Prasad, Paras	SUNY Buffalo State
Levy, Jeremy	University of Pittsburgh-Pittsburgh Campus
Ramakrishnan, Subramanian	Florida Agricultural and Mechanical University
Agarwal, Arvind	Florida International University
Georgakopoulos, Stavros	Florida International University
Chang, Zenghu	University of Central Florida
Christodoulides, Demetrios	University of Central Florida
Richardson, Kathleen	University of Central Florida
Schulzgen, Axel	University of Central Florida
Finin, Timothy	University of Maryland-Baltimore County
Antonsen, Thomas	University of Maryland-College Park
Greene, Richard	University of Maryland-College Park
Hafezi, Mohammad	University of Maryland-College Park
Hubbard, James	University of Maryland-College Park
Huth, Paul	University of Maryland-College Park
Jones, Anya	University of Maryland-College Park
Julienne, Paul	University of Maryland-College Park
Leishman, John	University of Maryland-College Park
Losert, Wolfgang	University of Maryland-College Park

Martin, Pino	University of Maryland-College Park
Milchberg, Howard	University of Maryland-College Park
Paglione, Johnpierre	University of Maryland-College Park
Yu, Kenneth	University of Maryland-College Park
Windsor, Leah	University of Memphis
Deng, Yue	The University of Texas at Arlington
Huang, Haiying	The University of Texas at Arlington
Roberson, David	The University of Texas at El Paso
Chu, Paul C. W.	University of Houston
Lee, T. Randall	University of Houston
Jiang, Chunqi	Old Dominion University
Pakhomov, Andrei	Old Dominion University
Fallen, Christopher	University of Alaska Fairbanks
Debray, Saumya	University of Arizona
Fasel, Hermann	University of Arizona
Krunz, Marwan	University of Arizona
Madenci, Erdogan	University of Arizona
Moloney, Jerome	University of Arizona
Peyghambarian, Nasser	University of Arizona
Xin, Hao	University of Arizona
Ho, Nhut	California State University-Los Angeles
Holland, Gregory	San Diego State University
Matsumoto, David	San Francisco State University
Gorodetsky, Alon	University of California-Irvine
Abu-Ghazaleh, Nael	University of California-Riverside
Kisailus, David	University of California-Riverside
Awschalom, David	University of California-Santa Barbara
Bleszynski Jayich, Ania	University of California-Santa Barbara
CHENG, TIMOTHY	University of California-Santa Barbara
Schamiloglu, Edl	University of New Mexico-Main Campus
Sheik-Bahae, Mansoor	University of New Mexico-Main Campus
Taylor, Gregory	University of New Mexico-Main Campus
Lee, Tae-Kyu	Portland State University

Author List

Pal Partha	BBN Technologies
Michael Atighetchi	BBN Technologies
Peng Liu	Pennsylvania State University
Erik Blasch	Air Force Research Lab
Nathan Bos	Johns Hopkins University
Genshe Chen	Intelligent Fusion Technology, Inc.
Yu Chen	Binghamton University
Gregory Conti	Army Cyber Institute
Xiuzhen (Susan) Cheng	George Washington University
Sanjay C. Jain	George Washington University
Insup Lee	University of Pennsylvania
Thomas E. Mallouk	Pennsylvania State University
Maurizio Porfiri	New York University
Carl H. Zweben	Zweben Consulting
Brian S. Thompson	Michigan State University
Horacio D. Espinosa	Northwestern University
Krzysztof Matyjaszweski	Carnegie Mellon University
Paula T.Hammond	Massachusetts Institute of Technology
Jason A. Burdick	University of Pennsylvania
David W. Ada	Naval Research Laboratory
Santiago Ontañón	Drexel University
Ryan Yager	Iona College
Amir H. Gandomi	Stevens Institute of Technology
Vijay Devabhaktuni	University of Toledo
Roman V. Yampolskiy	University of Louisville

Kilian Q.Weinberger	Cornell University
Haibo He	University of Rhode Island
Karim Abdel-Malek	University of Iowa
Patricia Deuster	Uniformed Services University
Ash M.Genaidy	WorldTek, Inc
Jeffrey Lubin	Sarnoff Corporation
Steve Beck	SantosHuman
Sidney K. D'Mello	University of Notre Dame
Kenneth R. Koedinger	Carnegie Mellon University
John E. Laird	University of Michigan
Christian Lebiere	Carnegie Mellon University
Herbert A. Simon	Carnegie Mellon University
Stuart A. Binder-Macleod	University of Delaware
Harry Asada	Massachusetts Institute of Technology
Victor R.Lesser	University of Massachusetts
Katia Sycara	Carnegie Mellon University
Manuela M. Veloso	Carnegie Mellon University
TuomasSandholm	Carnegie Mellon University
Edmund H. Durfee	University of Michigan
H. Van Dyke Parunak	Soar Technology, Inc.
Shlomo Zilberstein	University of Massachusetts
John Yen	Pennsylvania State University
Keith S. Decker	University of Delaware
Max Tegmark	Massachusetts Institute of Technology
Jiawei Han	University of Illinois at Urbana-Champaign
Dhabaleswar K. (DK) Panda	Ohio State University
Geoffrey Charles Fox	Indiana University Bloomington

Agrawal Gagan	Ohio State University
Naren Ramakrishnan	Virginia Tech
Srinivasan Parthasarathy	Ohio State University
Shaowen Wang	University of Illinois at Urbana-Champaign
Ioan Raicu	Illinois Institute of Technology, Argonne National Laboratory
Wu Feng	Virginia Tech
Beth Plale	Indiana University Bloomington
Chase Qishi Wu	New Jersey Institute of Technology
Lakshmi Dasi	Ohio State University
Amay Jairaj Bandodkar	Northwestern University
Arturo Casadevall	Johns Hopkins University
John A. Rogers	Northwestern University
Youngqun O. He	University of Michigan
Weibo Cai	University of Wisconsin
Robert S. Langer	Massachusetts Institute of Technology
Chunhua Weng	Columbia University
Daniel G. Anderson	Massachusetts Institute of Technology
Mehmet Remzi Dokmeci	Harvard University
Xiuzhen Cheng	George Washington University
Sherali Zeadally	University of Kentucky
Nirwan Ansari	New Jersey Institute of Technology
Shelia R.Cotten	Michigan State University
Peter F.Sweszek	University of Rhode Island
Deborah L. Thurston	University of Illinois at Urbana-Champaign
Judy M. Vance	Iowa State University
Susan Wyche	Michigan State University
Sae Woo Nam	NIST

Adriana Lita	NIST
Dale P. McMorrow	Naval Research Laboratory
Stephen P. Büchner	Naval Research Laboratory
Stanley M. Kaye	Priceton Plasma Physics Laboratory
Stefan Gerhardt	Priceton Plasma Physics Laboratory
Rajesh Maingi	Priceton Plasma Physics Laboratory
Jonathan E. Menard	Priceton Plasma Physics Laboratory
Steven A. Sabbagh	Columbia University
Antonio C. Ting	University of Maryland College Park
Philippe Piot	Northern Illinois University
Alexander Thomas	University of Michigan
Jay Anderson	University of Winsconsin_-Madison
Dirk R. Englund	Massachusetts Institute of Technology
Karl K. Berggren	Massachusetts Institute of Technology
Paul G. Kwiat	University of Illinois at Urbana-Champaign
Alan Migdall	NIST
Kartik Srinivasan	NIST
Richard Mirin	NIST
Jeffery Shapiro	Massachusetts Institute of Technology
Paul Lozano	Massachusetts Institute of Technology
Olivier de Weck	Massachusetts Institute of Technology
Christopher Cadou	University of Maryland
John Foster	University of Michigan
Deborah Levin	University of Illinois
Ayusman Sen	Pennsylvania State University
Sedwick Ray	University of Maryland
George H. Miley	University of Illinois
Richard Yetter	Pennsylvania State University

Alec D. Gallimore	University of Michigan
Iain D. Boyd	University of Michigan
Lin Ma	Virginia Tech
Kazhikathra Kailasanath	Naval Research Lab
Michael Keidar	George Washington University
James F. Driscoll	University of Michigan
Giorgio Rizzoni	Ohio State University
Alireza Khaligh	University of Maryland
Arijit Banerjee	University of Illinois at Urbana-Champaign
James L. Kirtley Jr.	Massachusetts Institute of Technology
Steven Leeb	Massachusetts Institute of Technology
Adel Nasiri	University of Wisconsin Milwaukee
Robert A. Canfield	Virginia Tech University
Inderjit Chopra	University of Maryland
Haibo Dong	University of Virginia
Javid Bayandor	University at Buffalo
Jeffrey A. Hoffman	Massachusetts Institute of Technology
Konstantin Matveev	Washington State University
Anouck Girard	University of Michigan
Peretz P. Friedmann	University of Michigan
Mark L. Psiaki	Virginia Tech University
Rajnikant Sharma	University of Cincinnati
Zaven Arzoumanian	Goddard Space Flight Center
Keith C. Gendreau	Goddard Space Flight Center
Demetrios N. Matsakis	US Naval Observatory
Boris S. Pervan	Illinois Institute of Technology
Chuck DeMets	University of Wisconsin-Madison

Charles Toth	Ohio State University
Anthea Coster	Massachusetts Institute of Technology
Chris Ruf	University of Michigan
Yu Gu	West Virginia University
Frank Van Graas	Ohio University
Dorota Grejner-Brzezinska	Ohio State University
J. Michael Ruohoniemi	Virginia Tech University
Arthur Kramer	University of Illinois at Urbana-Champaign, Beckman Institute for Advanced Science
Raquel Gur	University of Pennsylvania, Department of Psychiatry
Ruben Gur	University of Pennsylvania, Department of Psychiatry
Paul Henry Lysaker	Indiana University School of Medicine Indianapolis, Department of Psychiatry
Yaakov Stern	Columbia University Medical Center, Cognitive Neuroscience Division
John Q Trojanowski	VA Medical Center, Parkinson's Disease Research
Charles Hillman	Northeastern University, Department of Psychology
William Kraemer	Ohio State University, Department of Human Sciences
Greg Lewin	University of Virginia
Dalila Megherbi	University of Massachusetts Lowell
Joshua Semeter	Boston University
Leszek Lilien	Western Michigan University
Laura Humphrey	Air Force Research Laboratory
Marjorie Darrah	West Virginia University
Edgar J. Fuller	West Virginia University
Mark S. Sherriff	University of Virginia
Ram Narayanan	Penn State University
T.J Walls	Naval Research Laboratory
Ranjeev Mittu	Naval Research Laboratory
Charles Hsu	Trident Systems
Thomas A. Mazzuchi	George Washington University

Shahram Sarkani	George Washington University
Jahred Adelman	Northern Illinois University, Department of Physics
Steve Ahlen	Boston University, Department of Physics
Angerami	Columbia University in the City of New York, Nevis Laboratory
Giorgi Arabidze	Michigan State University, Department of Physics and Astronomy
Oliver Baker	Yale University, Department of Physics,
Oliver Courty	Pennsylvania State University, Department of Mechanical and Nuclear Engineering
Arthor Motta	Pennsylvania State University, Department of Mechanical and Nuclear Engineering
Samuel G. Lambrakos	Naval Research Laboratory
Gonzalo R. Arce	University of Delaware
Anna Gilbert	University of Michigan
Yoram Bresler	University of Illinois Urbana-Champaign
Anantha P. Chandrakasan	Massachusetts Institute of Technology
Leslie Ying	University at Buffalo
Richard W. Longman	Columbia University
Brian M. Sadler	Army Research Lab
Marco F. Duarte	University of Massachusetts Amherst
Aurel A. Lazar	Columbia University
Ram Narayanan	Pennsylvania State University
Dimitris A. Pados	University at Buffalo
Zhi (Gerry) Tian	George Mason University

Researchers	
Taghi M. Khoshgoftaar	Florida Atlantic University
Milind Tambe	University of Southern California
Dinggang Shen	The University of North Carolina at Chapel Hill
Peter Stone	University of Texas at Austin
Heng Huang	University of Pittsburgh

Yun (Raymond) Fu	Northeastern University
Ajith Abraham	MIR Labs
Jiebo Luo	University of Rochester
Tuomas W. Sandholm	Carnegie Mellon University
Patricia Anne Deuster	Uniformed Services University of the Health Sciences
Bradley Charles Nindl	University of Pittsburgh, Neuromuscular Research Laboratory/Warrior Human Perf Center
Karim A. Abdel-Malek	University of Iowa, Virtual Soldier Research Program
Jasbir S. Arora	University of Iowa
Karl E. Friedl	University of California
Yujiang Xiang	University of Alaska Fairbanks
Jurgen Graf	Universitat Marburg
Philippa Helen Gander	Massey University
Wei Ren	University of California
Milind Tambe	University of Souther California
Zongli Lin	University of Virginia
Peter Stone	University of Texas at Autin
Kagan Tumer	Oregon State University
Magnus B. Egerstedt	Georgia Institute of Technology
Tansel Yucelen	University of South Florida
Jonathan P. How	Massachuetts Institute of Technology
Yongcan Cao	University of Texas at San Antonio
Ramazan Asmatulu	Wichita State University
Uday Vaidya	The University of Tennessee Knoxville
Tsuhsi Chang	HetInTec Corp.
John A. Rogers	Northwestern University
Zheng Yan	University of Missouri

Cato T. Laurencin	University of Connecticutt
K. I. Chandrashekhara	Missouri University of Science and Technology
Rozaliya Barabash	Oak Ridge National Laboratory
Hsinchun Chen	University of Arizona
Shouhuai Xu	University of Texas at San Antonio
Kshetri Nir	The University of North Carolina at Greensboro
Hasan Cam	US Army Research Laboratory
Lingfeng Wang	University of Wisconsin Milwaukee
Jeffrey M. Voas	National Institute of Standards and Technology
Gary E. McGraw	Synopsys Incorporated
Sherali Zeadally	University of Kentucky

VPRS/ AVPRS

Ann M. Arvin	Stanford University
Randy H. Katz	University of California Berkeley
Patrick Schlesinger	University of California Berkeley
Cameron S. Carter	University of California, Davis
Pramod Khargonekar	University of California, Irvine
Roger Wakimoto	University of California, Los Angeles
Michael Pazzani	Univesrity of California, Riverside
Sandra Brown	University of California, San Diego
Miroslav Krstic	University of California, San Diego
Joe Incandela	University of California, Santa Barbara
Tim Sherwood	University of California, Santa Barbara
Scott A Brandt	University of California, Santa Cruz
Quentin Williams	University of California, Santa Cruz
Randolph Hall	University of Southern California
Samuel Traina	University of California, Merced
W. Timothy Hushen	San Diego State University

Alan Rudolph	Colorado State University
Hank Gardner	Colorado State University
Terri Fiez	University of Colorado Boulder
Sethuraman Panchanathan	Arizona State Univeristy
Gabriel Lopez	University of New Mexico Albuquerque
Patricia Henning	University of New Mexico Albuquerque
Mary Croughan	University of Nevada Las Vegas
Zachary Miles	University of Nevada Las Vegas
Lori Oflafson	University of Nevada Las Vegas
Mridul Gautam	University of Nevada Reno
Ana De Bettencourt-Dias	University of Nevada Reno
Mark McLellan	Utah State University
Scott Bates	Utah State University
Jeff Broadbent	Utah State University
Gene R. Larson	Brigham Young University
Debbie Silversmith	Brigham Young University
Andy Weyrich	University of Utah
Cynthia Furse	University of Utah
Engineering Deans	
Dr. Kyle Squires	Arizona State University
Dr. Michael A. Jensen	Brigham Young University
James Porter	Brigham Young University
Dr. Forouzan Golshani	California State University, Long Beach

Dr. Kevin L. Moore	Colorado School of Mines
Dr. David McLean	Colorado State University
Dr. Sylvester A. Kalevela, P.E.	Colorado State University, Pueblo
Dr. Ronald Madler	Embry-Riddle Aeron. Univ
Dr. Clyde Scandrett	Naval Postgraduate School
Dr. Lakshmi Reddi	New Mexico State University
Dr. Morteza Monte Mehrabadi	San Diego State University
Dr. Godfrey Mungal	Santa Clara University
Dr. Jennifer Widom	Stanford University
Dr. Jeff Goldberg	University of Arizona
Dr. S. Shankar Sastry	University of California, Berkeley
Dr. Jennifer Sinclair Curtis	University of California, Davis
Dr. Gregory N. Washington	University of California, Irvine
Dr. Jayathi Y. Murthy	University of California, Los Angeles
Dr. Mark Matsumoto	University of California, Merced
Dr. Sharon Walker	University of California, Riverside
Dr. Albert P. Pisano	University of California, San Diego
Dr. Rod C. Alferness	University of California, Santa Barbara
Dr. Alexander Wolf	University of California, Santa Cruz
Dr. Marc Ingber	University of Colorado Denver
Dr. Bobby Braun	University of Colorado, Boulder
Dr. Dan Dandapani	University of Colorado, Colorado Springs
Mr. JB Holston	University of Denver
Dr. Rama Venkat	University of Nevada, Las Vegas
Dr. Emmanuel "Manos" Maragakis	University of Nevada, Reno
Dr. Joseph L. Cecchi	University of New Mexico
Dr. Yannis C. Yortsos	University of Southern California
Dr. Jagath Kaluarachchi	Utah State University

TVC Directors

Mike Alder	Brigham Young University
Christian Iverson	Utah State University
Bryn Rees	Colorado State University Boulder
Todd Headley	Colorado State University
Doug Hockstad	University of Arizona
Jen Dyer	University of Southern California
Amir Naiberg	University of California, Los Angeles
Carol Mimura	University of California, Berkeley
Karin Immergluck	Stanford

College of Science Deans

James Porter	Brigham Young University
Shane Reese	Brigham Young University
Maura Hagan	Utah State University
David Matty	Weber State University
Joaquin Ruiz	University of Arizona
Patrick J. Kenney	Arizona State University
James W.C. White	University of Colorado
Janice L. Nerger	Colorado State University
Ginger Carney	University of Idaho
Tony Roark	Boise State University
Mark Peceny	University of New Mexico
Enrico Pontelli	New Mexico State University
Eric L. Chronister	University of Nevada, Las Vegas
Jeffrey S. Thompson	Univeristy of Nevada, Reno

Miguel A. Garcia-Garibay	University of California, Los Angeles
Anthony J. Cascardi	University of California, Berkeley
Steve Boggs	University of California, San Diego
Richard Saller	Stanford University
Amber D. Miller	University of Southern California

Additional Links

Henry White

Richard Brown

Eric Eddings

Diane Pataki

Dan Reed

Ryan Smith

Barb Nash

Darryl Butt

keith marmer

Paul Gabrielsen

Lisa Potter

Ivy Estabrooke

Wayne Bradshaw

Linda Cabrales

Jillian Hunt

Brian Somers

Gay Cookson

Neil Holt

Neil Holt

Ryan Reeves

Ludger Scherliess

David Geller

Doug Hunsaker

Mia Leonelli

Bob Schunk

Angie Tymofichuck

Bill Doe

USAF

Mr. Brian McJilton

Laura Barnes

Maj. Anthony Polito

Lenell Kern

Ashley kelly

Benjamin Carpenter

Dr. Reid Melville

Lauren McCarty

Mikee Miller

Penny Axelrad

14 APPENDIX B: FINAL ATTENDEE LIST

(red highlights indicate registered by did not attend.

First Name	Last Name	Company/Organization	US State/Canadian Province
Karim	AbdelMalek	University of Iowa	IA
Vinamra	Agrawal	Auburn University	AL
Frank	Albanese	AFRL/XPO	OH
Scott	Anderson	University of Utah	UT
Bob	Angell	Cognitech	UT
A.K.	Balaji	The University of Utah	UT
David	Barnhart	University of Southern California	CA
Larry	Baxter	Brigham Young University	UT
Isaiah	Beh		UT
Josh	Bennett	Technology and Venture Commercialization	UT
Brook	Bentley	Air Force Research Laboratory	FL
Michael	Bentley	University of Utah	UT
Jerome	Berg	Northrup Grumman Innovation Systems	UT
Ryan	Berke	Utah State University	UT
Dan	Berrigan	US Air Force	OH
Moumita	Bhattacharya	University of Utah	UT
Antoinette	Blair	University of Utah	UT
John	Blitch	U.S. Air Force Academy / 711 HPW AFRL	
Lexington	Blood	Hedge Fund	UT
Marc	Bodson	University of Utah	
Tamal	Bose	Univeristy of Arizona	AZ
Charles	Botello	Air Force Research lab	
Gregory	Bowen	Survice Engineering/DSIAC	OH
Chett	Boxley	GlycoSurf, LLC	UT
Wayne	Bradshaw	USTAR	UT
Alexander	Brickner	SimpleSense	NV
Darin	Brush	Davis Technical College	UT
Hansen	Bryce	Salt Lake Small Business Development Center	UT
Scott	Budge	Utah State University	UT
Andrew	Buffmire	University of Utah	UT
Joel	Buttars	Borsight	UT
Rong	Cai		UT
Benjamin	Carpenter	AFRL	
Clinton	Cathey	Optisys, LLC	UT
Celia	Chadburn	J. Willard Marriott Library	UT
Koushik	Chakraborty	Utah State University	UT

Jiyoung	Chang	University of Utah	UT
Yu	Chen	Binghamton University	NY
Rong-Rong	Chen	University of Utah	UT
Natan	Chetrit	ReRouting LLC.	UT
Tierah	Chorba		GA
Jeffrey	Cline	DSIAC/SURVICE Engineering	MD
Gay	Cookson	University of Utah	UT
Erin	Crawley	AFRL	VA
Neal	Crookston	Weber Tech College	UT
Erik	Crosman	University of Utah	UT
Michael	Czabaj	University of Utah	UT
Amber	Dalley	RJ Lee Group, Inc	UT
Sajal	Das	Missouri University of Science and Technology	MO
Kenneth	D'Entremont	University of Utah / Mechanical Engineering	UT
Jeffrey	Derricott	BYU PRISM Lab	UT
Stewart	DeVilbiss	Air Force Research Lab, Sensors Directorate	OH
Zhengming	Ding	Indiana University – Purdue University Indianapolis	MA
William	Doe	University of Colorado Boulder	CO
Greg	Droge	Utah State University	UT
Whitney	Durham	RelChip	
Cayley	Dymond		OH
Eric	Eddings	University of Utah	UT
Jeff	Edwards	Utah Advanced Materials & Manufacturing Initiative	UT
Michael	Eismann	AFRL	OH
CG	Farmer	University of Utah	UT
Kevin	Felix	Blue Path	VA
David	Ferro	Weber State University College of Engineering, Applied Science and Technology	UT
Brian	Frandsen		FL
Cynthia	Furse	University of Utah	UT
Pierre-Emmanuel	Gaillardon		UT
Dean	Gallagher	University of Utah TVC	UT
Javier	Garay	University of California, San Diego (UCSD)	CA
Matteo	Grattieri	University of Utah	UT
William	Gregory	AFRL/RI	NY
Steve	Grizzell	InnoVentures Capital	UT
Osama	Haddadin	L3 Technologies	UT
Mark	Hagmann	NewPass Research LLC	UT
Mark	Hagmann	NewPath Research L.L.C.	UT
Ming	Hammond	University of Utah	UT

George	Hansen	Conductive Composites/Faraday Cases	UT
Nathan	Hansen	Conductive Composites/Faraday Cases	UT
Salim	Hariri		AZ
Andrew	Healy	Boeing	UT
Christoffer	Heckman	University of Colorado Boulder	CO
Thomas	Henderson	University of Utah	UT
Michael	Hill	Univ of California, Davis	CA
Mark	Hoelscher	Georgia Tech Research Institute	TX
Kimberly	Hoffman	Air University - LeMay Center	AL
Andrew	Hollcraft	Hexcel	UT
Holly	Holman	University of Utah	UT
Niel	Holt	Space Dynamics Laboratory	UT
Jeremy	Horton	University of Utah TVC	UT
Stephan	Howe	Boise State University	ID
Larry	Howell	Brigham Young University	UT
Mark	Howell	University of Utah	UT
Shu-Wei	Huang	University of Colorado Boulder	CO
Doug	Hunsaker	Utah State University	UT
Tatsuo	Itoh	UCLA	CA
Brian	Iverson	Brigham Young University	UT
Devon	Jensen	University of Utah	UT
Mingyue	Ji	University of Utah	UT
Chris	Johnson	Scientific Computing and Imaging Institute	UT
Matthew R.	Jones	Brigham Young University	UT
Lexie	Jones	Center for Unmanned Aircraft Systems	UT
Shami	Kanekar	University of Utah	UT
Ron	Kaspi	AFRL	NM
Ashley	Kelly	SURVICE//AFRL	OH
Joshua	Kennedy	AFRL/RXCCM	OH
Lenell	Kern	AFRL	OH
Latifur	Khan	Latifur Khan	TX
Eun	Kim	University of Southern California	CA
Hanseup	Kim		UT
Yong Lin	Kong	University of Utah	UT
Sriram	Krishnamoorthy	Electrical & Computer Engineering, The University of Utah	
Pankaj	Kumar	University of Utah	UT

Molly	Lachance	Air Force Research Laboratory	VA
Douglas (Doug)	Later	Vaporsens, Inc.	UT
Robert	Leighton	DSIAC	MD
Ming	Leu	Missouri University of Science and Technology	MO
Eric	Lindstrom		UT
Hongfu	Liu	Brandeis University	MA
Kenneth	Loh	UC San Diego	CA
Monika	Lohani	University of Utah	UT
Grizelda	Loy-Kraft	USAF	OH
Jessica	Lundberg	CogniTech Corporation	UT
Weijie	Luo		UT
Jules	Magda	University of Utah	UT
Cordian	Majewski	KIHOMAC	UT
Monnica	Manuel	RSG Performance	UT
Jason	Martineau	Department of Physics and Astronomy, University of Utah	UT
Cheryl	Mathis	university of utah	UT
Benjamin	Maxfield	BAE Systems	UT
Derek	Maxwell	RelChip	UT
Lauren	McCarty	AFRL	OH
Bob	McCoy	Geophysical Institute, University of Alaska Fairbanks	AK
John	McCrea	AFNWC/NICE	UT
Brian	McJilton	AFRL	OH
Lani	McKinnon	The University of Utah Department of Chemical Engineering	UT
Nathan	McMullin		UT
Reid	Melville	AFRL	OH
Rajesh	Menon	University of Utah	UT
Jake	Merrell	XOnano	UT
John	Metcalf	Northrop Grumman	UT
Brian	Mickey	University of Utah	UT
Mitch	Miller	AFLCMC/EZ	OH
Mark	Minges	AFRL/RY	OH
Angela	Mitcham	Vaporsens	UT
Ranjeev	Mittu	US NAVAL RESEARCH LABORATORY	DC
Swomitra	Mohanty	University of Utah	UT
Conrad	Monson	Brigham Young University	UT
Kaitlyn	Moretz	DSIAC	MD
Jesse	Morris	University of Utah	UT
Brad	Mortensen	Weber State University	UT
Violet	Mwaffo	University of Colorado at Boulder	CO
Rajesh	Naik	USAF 711th Human Performance Wing	OH

Billy	Neff		UT
James	Nelson	Power Wiper	UT
Pania	Newell		
Scott	Nielson	ENVE Composites	UT
Greg	Nordin	Brigham Young University	UT
Rodrigo	Noriega	University of Utah	UT
Scott	Nowlin	BAE Systems, Inc.	UT
Anthony	Nygren		UT
Devon	O'Connell	Survice Engineering	UT
Gabrielle	O'Neal	SURVICE Engineering	MD
John	Ontiveros	Survice Engineering/DSIAC	SC
Janos	Opra	Optisys	UT
Chris	Ostrander	University of Utah	UT
Jacob	Packer	CogniTech Corporation	UT
Julia	Parakkat		OH
Sid	Pathak	University of Nevada, Reno	NV
Joe	Paustenbaugh	Northrop Grumman Innovation Systems	UT
Eldon	Pe'a	University of Utah	UT
Aivar	Pere	University of Tartu	
Erna	Petrich	AFOSR/PK	VA
Andrew	Petruska	Colorado School of Mines	CO
Robert	Pilarczyk	HIll Engineering, LLC	CA
Anthony	Polito	AFRL	OH
Zoya	Popovic	University of Colorado Boulder	CO
Kody	Powell	University of Utah	UT
Balakrishnan	Prabhakaran	University of Texas at Dallas	TX
Ranch	Pratt	Indigo Industries	
Rachel	Pyle	USAF/AFRL	OH
Zvonimir	Rakamaric	School of Computing, University of Utah	UT
Sameer	Rao	University of Utah	UT
Erin	Ratcliff	University of Arizona	AZ
Linda	Rawson	DynaGrace Enterprises, Inc.	UT
Allan	Reaburn	Immersive Visualization Inc.	UT
Brady	Redfearn	Brigham Young University	UT
Perry	Renshaw	SLC Veterans Administration & Rocky Mountain MIRECC, University of Utah	UT
David	Riddle	Electron Heat	UT
Pratt	Rogers	University of Utah	UT
Yalda	Saffary	University of Utah	UT
Mike	Scarpulla	Universi	UT

Andrew	Scholand	Sandia National Laboratories	NM
Matthew	Sederberg	Coreform	UT
Berardi	Sensale-Rodriguez	The University of Utah	UT
Mikhail	Skliar	University of Utah	UT
BRETT	SMILEY		UT
Cap	Smith	Colorado State University	CO
Jerome	Solller	Cognitech Corporation	UT
Florian	Solzbacher	University of Utah	UT
Walther	Spjeldvik	Weber State University	UT
Jaime	Stearns	Air Force Research Lab	NY
Melanie	Steiner-Sherwood	University of Utah	UT
Jim	Steppan	HiFunda LLC	UT
Esther	Sternberg	University of Arizona Center for Integrative Medicine	AZ
Kyle	Stewart		NY
Charlene	Stokes	MITRE	MA
Brent	Strong	UAMMI	UT
Randal	Sylvester	L3 Technologies - Communication Systems West	UT
Xifan	Tang	University of Utah	UT
Robert	Thomas	Air Force Research Laboratory	TX
David	Tilton	Conductive Composites/Faraday Cases	UT
Weldonna	Toth	CogniTech Corp	WY
Ranji	Vaidyanathan	Oklahoma State University/School of Materials Science and Engineering	OK
Kobus	Van der Merwe	University of Utah	UT
Andreas	Velten	University of Wisconsin-Madison	WI
Neil	Vickers	University of Utah	UT
Charles	Vono	Retired USAF	UT
Spencer	Walker	University of Utah	UT
Jeffrey	Walling	University of Utah	UT
Yunshan	Wang		UT
Joan	Ward	Defense Systems Information Analysis Center (DSIAC)	MD
Tim	Webb	Air Force Research Laboratory	OR
RALPH	WEGE		CA
Paul	Westerhoff	Arizona State University	AZ
Rudy	Wilcox	Rogue Technologies	UT
Kevin	Wille	BAE Systems	UT
Andrew	Williams	AFRL/RV	NM

Christina	Willis	University of Utah	UT
David	Winberg	Space Dynamics Laboratory	UT
Sheng	Xu	University of California, San Diego	CA
Hao	Xu	University of Nevada, Reno	NV
Austin	Yamada	University of Arizona	AZ
Kimberly	Yoder	USAF	OH
Heayoung	Yoon	University of Utah	UT
Andrea	Young		NJ
Michael	Yu	University of Utah	UT
Dana	Zamalloa	Indigo Industries	
Ling	Zang	University of Utah	UT
Yanyan	Zhang	CogniTech Corporation	
Yu	Zhang	UC Santa Cruz	CA
Huanan	Zhang	University of Utah Chemical Engineering	UT
Matthias	Ziegler	Lockheed Martin	VA

15 APPENDIX C: TRAVEL FUNDS

Travel funds were used to bring 10 key out-of-state speakers. The list of travel fund recipients is given below. One travel fund recipient provided a personal experience, see below.

15.1 LIST OF TRAVEL FUND RECIPIENTS

Enhancing the Warfighter (chair)	Sheng Xu, Department of NanoEngineering, University of California, San Diego
Enhancing the Warfighter (co-chair)	Esther M. Sternberg M.D., Dept. of Medicine, UA Center for Integrative Medicine, University of Arizona, Tucson
Human/Machine Teaming (chair)	Cap Smith, Computer Information Systems, Colorado State University
Air / Space (chair)	David Barnhart, USC Information Sciences Institute (ISI)
Sensors (chair)	Tatsuo Itoh, Electrical and Computer Engineering, UCLA
Next-Gen Communication (chair)	Zoya Popovic, Electrical and Computer Engineering, University of Colorado, Boulder
Poster session (chair)	Zhengming Ding, Department of Computer, Information and Technology, Indiana University-Purdue University Indianapolis
Users Perspective on Conference	Hongfu Liu, Department of Computer Science, Brandeis University
Expeditionary Operations (chair)	Robert McCoy, Geophysical Institute, University of Alaska
Materials (chair)	Ranji Vaidyanathan, Oklahoma State University

15.2 EXPERIENCE ON USAF SCIENCE & TECHNOLOGY 2030 VISIONING WORKSHOP

I am Hongfu Liu, an assistant professor at Brandeis University. I am very glad to attend the USAF Science & Technology 2030 Visioning workshop in Utah with travel fund support. The workshop is a two-day event. I regard the reception on the first evening as the industry track, where several local companies from USTAR demonstrate the air force related techniques including chemical sensor, drone-based 3D image reconstruction. The second day begins at 8:00 am, follows the orientation and introduction, 10 different topic sessions and the post demonstration.

This is a total different workshop from my expectation. For the traditional academic workshop, the authors deliver the presentation and follow the QA. Beyond this, every session in this workshop has a chair from Air Force Research Lab, guiding the participants to involve the discussion and form incentive ideas for 2030 vision. I have a poster presentation at this workshop, titled interpretable clustering via semantic recover. Interpretable clustering attempts to explain the uncovered clusters via the selected features. However, these methods lose their power with non-semantic features, such as visual and audio features. Here we consider the challenging problem, Interpretable Clustering via Semantics Recovery, where the missing semantic attributes are recovered to explain the uncovered clusters with only visual features. To achieve this, auxiliary source data containing visual features, semantic attributes and labels are employed to facilitate the target data clustering. Then we propose a novel dual-level transfer learning method to extract the knowledge from the instance-level and partition-level for the target data recovery and clustering.

Generally speaking, this workshop provides an enjoyable experience to me. Everything is well-prepared. There are many participants from different institutions, where I know several professors from the University of Utah, Binghamton University, University of California, Santa Cruz. Moreover, this workshop gives me a chance to meet Air Force Research Lab. It is beneficial for me to submit related proposal to contribute this area. Finally, I thank Prof. Cynthia Furse at University of Utah for the travel fund support.

16 APPENDIX D: IDEATION TEMPLATE

Ideation Outcome Capture

Technical Topic: _____ Room-Session: _____

Information of Presenter/Creator
Name (First Last): _____ Email: _____
US State: _____ Organization Name: _____

Idea Title
Transformative science and technology concept
Future USAF need or challenge addressed
What difference/impact will it make? What are its advantages?
Keywords/topics/tags

Idea Maturity Level (Choose One)

1. **Basic; Significant foundational research is still required; little/no research related to applications has been completed.**
2. **Applied research related to potential applications is in progress or has been completed.**
3. **Applications have been prototyped with significant lessons learned and/or issues identified.**
4. **Applications have been prototyped with generally successful outcome(s).**
5. **The technology has been commercialized for a similar purpose/application as how the USAF would use it.**
6. **The technology has been commercialized for another purpose/application than how the USAF would use it.**

Idea Area(s) of Study (Select 1 to 3)

- **Sensors and Electronics**
- **Materials**
- **Manufacturing**
- **Structures**
- **Autonomy**
- **Artificial Intelligence / Machine Learning**
- **Data Analytics / Data Science**
- **Decision Making**
- **Precision, Navigation and Timing**
- **Information Systems Technology (Computing and Software Systems)**
- **Air Platforms/Systems**
- **Air Defense**
- **Space Platforms / Systems**
- **Space Defense**
- **Cyber Systems**
- **Cyber Defense**
- **Electronic Warfare**
- **Electronic Warfare Defense**
- **Conventional Weapons**
- **Conventional Weapon Defense**
- **Nonlethal Weapons**
- **Nonlethal Weapon Defense**
- **Directed Energy Weapons**
- **Directed Energy Weapon Defense**
- **Nuclear Technology**
- **Nuclear Technology Defense**
- **Chemical/Biological Defense**
- **Human Systems / Human Performance**
- **Human-Machine Interfaces**
- **Aeromedical Technology**
- **Synthetic Biology / Biotechnology**
- **Air Port Modernization including Ground / Terminal Operations**
- **Sustainment Operations**
- **Land and Sea Platforms / Systems**
- **Energy / Power Management**
- **Command, Control and Communications in Air, Space, and Cyber**
- **Munitions**
- **Other**
- **Not Applicable**

Organization Category (Choose One)

- **Higher Education**
- **Small Business**
- **Entrepreneur**
- **Large Industry (Non-DoD Partner)**
- **Large Industry (DoD Prime)**
- **Federally Funded R&D Centers**
- **Government**
- **None**
- **Other**

17 APPENDIX E: ATTENDEE FEEDBACK

Examples of Unsolicited attendee feedback:

Cindy,

It was a pleasure to meet you in the Advanced Custom Manufacturing session at the AF2030 event at the U this week. From start to finish, the activities were well planned and completed. Kudos to all who were involved in the event. I look forward to feedback from the Air Force on the ideas generated.

I learned about AF2030 through Angie Tymofichuk, a SAMPE colleague. I was quite excited to have participated in giving a presentation, meeting and networking with so many people, and learning more about the Air Force and research at the University of UT.

It was very interesting to learn about your research and other research at the U. I would like the opportunity to talk with you in more detail and to explore possible collaboration in the future.

Best regards,

A.D.

Dear Cynthia,

I found that the workshop on July 11 was very interesting. Thank you for organizing the event and for inviting me to be involved. There were many positive aspects. For instance, I met a number of people with different technical background whom I usually do not interact with. This was a merit as well as demerit. I wished that we could interact more with presenters in different breakout sessions. I mean more a matrix type interactions, horizontally as well as vertically. I know it is difficult to make such arrangement. I found several talks of my interest at tracks different from what I belonged to. Another observation which may be incorrect is that the topics on advanced devices/components/hardware beyond the state of the art that may be transformable are rather few. Perhaps, the workshop might be more suitable for two day event.

Overall, I enjoyed the event. Thank you very much.

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Cynthia Furse

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14. ABSTRACT
The University of Utah (UU) hosted the 6th S&T event at the SJ Quinney College of Law on the Salt Lake City campus over July 10-11, 2018. This workshop helped AFRL to engage with industry and academic partners throughout the United States, with an emphasis on the Southwest region. The objective of the workshop was to solicit and explore science and technology ideas that will be used to guide Air Force investments in basic and applied research over the next decade. In a broad sense, these efforts aspire to result in new capabilities for the Air Force in 2030 and beyond. Commensurate with this motivation, the UU proposes to provide a platform to connect Air Force interests with regional leaders in science and technological innovation from academia and industry.

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