People + Technology

(restore/augment/enhance physical capabilities, robotics, etc.)

Contributors:

Berenice Mettler, Heidi Korhonen, Veronica Martinez, Ron Swenson, Rama Akkiraju, Nassin Naaseh, Stephen Kwan, Wolfgang Fink

What we know now?

- **Human Factors**
  - Most 20th century machines were built with the human in mind, c.f. Wright Brothers aircraft.
  - Human factors were much more central to research and industry
  - Design requirements were conceived by people who were invested in augmenting/supporting the operator/worker
  - Today's engineers take human factors for granted: technology has relegated usability to an afterthought

- **Examples:**
  - New electrical steering systems in cars decouple the driver from the driving experience.
  - Dynamic response characteristics
  - Human response time (~100-200 ms) many technologies go way beyond that and still expect things to work safely

- **Automation/Autonomy**
  - Automation successful in areas with structure (e.g., factory): Risk of promoting autonomy at expense of flexibility.
  - Autonomy has so far primarily developed in computer science departments, emphasizing computational perspective.

- **Manufacturing**
  - Purpose-driven Development/Manufacturing
  - Manufacturing for the masses as opposed to for the individual; system-oriented vs. human-centric (customizable); does not necessarily improve quality of life but requires person to adapt to what the technology offers ("one shoe fits all")
  - Economic and societal needs drive technology development (mass production) and oppose customization (considered too expensive); however, personalized medicine would yield significant health care cost reduction, improve personal health outcomes, and reduce hospital remission rates

What is possible/needed/hoped for/critical success factors in the future?

- **Climate change in research environments**
  - Companies like Neuralink may develop new/next generation technologies behind closed doors: need to ensure public dissemination of information in line with NSF's charter
  - While traditional research facilities and tools are available, we need to also tap more into crowdsourcing, i.e., experimental trial and error approaches, which are inherently different from those traditionally pursued by funding agencies
  - Need new approach towards innovation that is more collaborative, experimental, and open
  - Changes in the social structure within companies and society

- **Human-centric Technologies in unstructured/uncertain environments**
  - Need to consider all 4 dimensions for future augmenting and assisting human-centric technologies (space and time, including time/reaction time of humans)
  - Robotics need to enter and work successfully and safely in uncertain, non-structured environments

- **Scalability of Technology for Services**
  - Design with human-centric principles, when scaled (multi-agents), will result in macroscopic structures, infrastructures that carry through organic properties at a larger scale while preserving and enhancing the human-centric properties
  - Build capabilities as properties of systems rather than programming them into the system (emerging properties such as robustness, adaptability)

- **Value of Entrepreneurship in Academia**
  - Emphasizing the importance of entrepreneurial activities (IP, patents, start-up companies) as part of the P&T (promotion & tenure) process (otherwise faculty are forced to leave academia, academia and federal funding agencies lose out), i.e., overcoming traditional, rigid structures still prevailing in academia (i.e., universities)

What is the gap?

- Funding issue: “Valley of Death” (TRL 4-6)
- Perception of social sciences research, forces and dimension not considered *serious* research, i.e., soft science (ironic since a lot of technology development is driven by social interaction)
- Lots of work done (by academia) in understanding people; however, in real-world situations/ environments accuracy/veracity/validity do matter, not just paper benchmarks
- Scaling up of ideas (often does not hold up); this is in part caused by the increasing hardship of securing funding in academia
- Sophistication vs. robustness (e.g., Russian vs. US toilet on ISS); often academic solutions work well in well-controlled environments (e.g., lab) but fail in realistic outdoor/real-world environments which are the focus of industry
- Lack of enabling ecological interactions with the natural environment (it should work in natural environments and not constrain)
- Human-centric factors ignored or lost, especially at larger scale
- Academia is encouraged to be entrepreneurial, the moment faculty/researchers are entrepreneurial/inventors they “get dinged” with FCOI issues at universities and government research labs (with and without federal funding)
- Time Conflicts of Interest: faculty/researchers may want to engage in entrepreneurial activities but may not be allowed to because of teaching and service obligations
- Lack of consortia that would facilitate the handshake between academic low TRL and industrial high TRL (to bridge the Valley of Death)

How to fill the gap?

- **Academic Education**
  - Create degrees in new fields (human factors) similar to field of Biomedicine at the time
  - Modern fields in this area not immediately tangible, but more abstract: need to formalize behavior, cognition, perception

- **Academia & Industry Calibration**
  - Academia and industry have to work more closely to bring in “realism”, “practicality”, and “veracity” to research, to bridge gap between invention and innovation
  - Proper adjustment and introduction of realistic benchmarks in research (otherwise unrealistic)

- **Academe/Industry Collaboratories**
  - Explore/expand/revisit I/UCRC, ERC, STC strategies and look also at some European models (e.g., Steinbeis-Centers as a role model for US-based academic commercial research)

- **Entrepreneurship and P&T Process in Academia**
  - Emphasizing the importance of entrepreneurial activities (IP, patents, startup companies) as part of the P&T (promotion & tenure) process (otherwise faculty are forced to leave academia, academia and federal funding agencies lose out), i.e., overcoming traditional, rigid structures still prevailing in academia (i.e., universities)

Opportunities for academe/industry research partnership

- **Academia & Industry Calibration**
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Challenges, risks and mitigation

- **Challenging the Big Questions**
  - Re-definition of the “Valley of Death”: no one is willing to invest in answering the bigger questions e.g., quality of life. The need to change or issue incentives to industry.

- **Engineering/Scientific Principles, Policies and Market**
  - How can we emphasize certain scientific/engineering design principles to create core values, which in turn will change policies, which in turn will generate economical incentives, which in turn will influence market forces and corporate strategies (e.g., scientific principles in human factors: human-centered designs, ergonomics, biology of humans, quality of life, health).

- **Fundamental, Applied and Industrial Validity**
  - Dichotomy between fundamental research, applied research, and industrially “valid” research.

- **Challenges/Risks**
  - Health implications (long term effect of augmentation on health)
  - Ethical questions of using augmentation (unfair advantages)

What is the possible roles of the NSF in this?

- **Create Awareness**
  - Create cross-cutting awareness in academia around *systems engineering* and *systems-of-systems research*, *data sciences* (statistics, machine learning, etc.), *material sciences*, *human factors*, etc.
  - Encourage future curriculum development: NSF PMs can influence academic institutions to teach students in these areas since they fund research in these areas
  - Focus on/reemphasize more the human-centric aspect: do not design in the absence of the human requirements

- **Novel Research Themes**
  - Develop research themes around mobility, personal transportation, human factors, aspects of health that are influenced by behavioral and human factors, human-compatible prosthetics/robotics, and bi-directional brain-computer interfaces (e.g., along the lines of "Neuralink")
  - Pick up on general market forces (e.g., need for public transportation to relieve cities)
  - Systems not designed top-down, therefore need to focus more on experimental approaches, building the ecosystem, combining/merging bottom-up and top-down engineering