IEEE Workforce Development Committee – Annual Report 2016

The IEEE Workforce Development Committee was tasked with looking at identifying future research/workforce directions within the focus areas of various technical societies and committees of the IEEE. In 2015, a series of workshops were given at selected conferences where delegates were given a focus area and then asked to identify relevant challenges within this area and possible solutions. Although the number of workshops was limited, these workshops were very successful. However, due to budgetary constraints, the expansion of the hosting of these workshops was not possible.

Consequently, in 2016, it was decided to investigate, as per each engineering discipline, the future challenges that lay ahead in this discipline and the curriculum changes that were suggested to help address these challenges.

In order to accomplish this goal, this committee contacted each society and requested that they ask their members to fill in an online document where they would give their focus area and possible future directions within it. Due to the varied hierarchical structure of the societies, we further asked the societies to contact the sub-chairs of their various sub-groups and any and any interested person who would be able to participate. The link to the online document is at: https://docs.google.com/spreadsheets/d/1kzCzpIn6LiQQp6TwjiQD8TfQFdGsEPAwXIy2eB8u_I8/edit?usp=sharing. These societies were contacted in May and September.

Although this document has received input, it is hoped that this document will remain a living document where all interested members of IEEE can obtain access and enter their input. Each input is valuable.

The document was based on 20 engineering disciplines. Although there may be other disciplines, it was decided to cap the number of disciplines at twenty for simplicity. This document was structured to allow each contributor to select their chosen discipline and sub-area within it. An example, the engineering discipline of material science has the sub-area of nano-fabrication within it. Once the discipline and possible sub-area was selected, the contributor would enter the future challenge within this focus area and their recommended curriculum change to address this challenge.

The contributions came from various members and from current specific research areas of universities in the engineering field. These contributions are outlined in Table 1, which is sorted first by discipline, then sub-area, and then challenge, and recommended curricula change. As the contributions were so varied in nature, they could not be coded and analysed in a meaningful way but remain as they are.

Eng Discipline	Sub-Area	Future Challenge	Recommended Curricula Change
Aerospace	Space Systems / GN&C	Space systems integration for manned and un-manned missions to Mars and Asteroids	Increase mathematical foundations, promote interdisciplinary colaboration between different departments.
Aerospace	Flight GN&C; Individual PNT	Fully integrated human/system collaboration	Interdisciplinary system design/integration; human factors modelling

Aerospace	Flight GN&C; Individual PNT	Transition from stair-case to continuous traffic monitoring	better methods of real-time monitoring and responses
Aerospace	Flight GN&C; Individual PNT	Congested airspace	se of new techniques, such as swarming, for collision avoidance
Aerospace	big data	ensors and vehicle produce huge amounts of data	techniques to manage big data to gain meaningful patterns and insights
Aerospace	flight dynamics	Make use of deformable flight and control surfaces	create testbeds to investigate flight challenges
Aerospace	orbital debris mitigation	Define optimally effective strategies to minimize impacts	orbital mechanics with a focus on safe disposal
Aerospace	economic usage of space	Refine methods to expand outer space presence with economic incentives	space economics with a focus on return on investment
Aerospace	low cost access to space	Reduce launch costs by at least one order of magnitude	define and test innovative propulsion techniques
Aerospace	spectrum management	Survey electromagnetic spectrum applications and refine uses	radio and other frequency characterization and innovations
Agricultural	water conservation	Water conservation	development of techniques to re-use waste water and reduce evaporation
Agricultural	pollution	Pollution	predict and mitigate non-point pollution from agricultural watersheds
Agricultural	alt energy	Biofuels	development of biofuels from waste products of agriculture
Biomedical	neural tissue regeneration	Perfect neural scaffolding technologies	demonstrate lab-established neural tissue viability
Biomedical	personal medicine	Perfect predictive theory	establish human markers indicative of disease or other genomic level vulnerabilities
Biomedical	pharmaceutical controls	Reduce fraudulent chemical treatments	define automated laboratory protocol management processes enabling government oversight
Biomedical	advanced nutritional analysis	Capture cause and effect mechanisms due to nutrition	characterize nutritional impacts under various sleep, rest, exertion, and other environmental considerations
Biomedical	blunt force trauma repair	Create near-natural solutions to human body damage	create adaptive organ materials that can replace damaged ones

Civil	earthquake	Earthquake	Seismic Hazard Estimation
Civil	earthquake	complex loading scenarios	ability to conduct multi-scale analysis of components
Civil	earthquake	Foundation Engineering	reliable methods to calculate the Seismic Bearing Capacity of Foundations
Computer	arch	large, fast non-volatile memories	optimisation of technologies for optimal operating system design
Computer	arch	engineered DNA molecules	techniques to develop computation inside living cells
Computer	big data	predominance of video surveillance	object recognition techniques
Electrical	Electrical Systems	Data analytics for forecasting power usage, Connected Vehicles, Battery Capacity and management, Cyberphisical systems	More data analysis studies, and communications issues in every curricula.
Electrical	Networking	Disaster-immune communication and localization	New and enhanced techniques for network adaption and redundancy (considering technical, cost, et aspects)
Electrical	Load Sharing	Load sharing technology for renewable resources	development of optimal electrical storage techniques and devices to manage peak production vs peak loads
Electrical	Robotics	Intelligent control of autonomous robotic systems	implementation of machine intelligence
Electrical	Communications for smart systems	Develop reliable and energy efficient comm technology for IoT	merge HW and SW competences
Electrical and Computer Engineering	ICT	Data analytics, Enviromental Sustainability	Involve ICT and energy technologies in various green and sustainability issues
Electrical Engineering	Control	Internet of Things, Distributed & Edge Clouds	Stronger elements distributed systems, communication, and cloud
Electronic	Super absorbers for ultra-high speed photodetectors and ultra-thin-film photon harvesting		technology behind ultra-thin-films (development, optimised uses) and absorption

Electronic	organic electronics	Carbon-based organic electronic	enhanced techniques to develop and utilise organic electronics to take advantage of their advantages (adaptation, self-healing) while mitigating their constraints
Electronic	distributed processing	demonstrate software development languages that may fully utilize multicore processors	computer architecture
Electronic	threshold for miniaturization	project thresholds due to physics-driven constraints	define alternatives to miniaturization for improved processing capabilities
Electronic	artificial intelligence	machine learning	utilize machine learning capabilities to enhance human knowledge development
Electronic	memory storage	Automatic backup and recovery mechanisms	establish secure and trusted methods through computer science investigations
Electronic	heat reduction	Refine thermal control systems	test and implement advanced material and heat transfer concepts
Electronic	diagnostic systems	Establish suitable redundancy and self-diagnosing electronics	electronics design
Electronic	manufacturing and reuse	Resource recovery and manufacturing quality assurance	design for manufacturing and disposal
Electronic	life extension	Modularize and design electonics so that parts may last longer and be rotated out due to aging	refine materials so that aging effects are diminished
Environmental	alt energy	Small hydro	potential with constraints of small hydro
Environmental	pollution	Emergence of nanotechnology	effects of nanotechnology on environment
Environmental	pollution	Pollution	potential solutions such as bioremediation
Industrial	knowledge systems	Development of dynamically-linked knowledge network	various theories of network building and linkages
Industrial	Flight GN&C; Individual PNT	Flight scheduling	scholastic models and prediction of aspects of weather uncertainty
Industrial	dynamic systems	Rapid responses to threats with impacts on system functionality and inadvertent effects on key system properties	enhanced lightweight system assurance methods to assess all impacts of responses
Material Science	Electrochemistry	Battery capacity	Studies in electrochemistry leading to advances in battery storage devices with higher capacities while maintaining adequate safety standards.Laboratory investigations

Material Science	nano-fabrication	Pollution	residue disposal is already an issue, remediate
Material Science	plasmonics	Material characterization and surface exploitation	enable special surface properties
Material Science	xray spectroscopy	Isolate and study elemental properties	better understand the behavior of the elements under various environmental condtions
Mechanical	complex systems	Cost effective transportation	better integrate options, especially for urban living
Mechanical	complex systems	Living buildings	self maintaining green building technologies
Mechanical	autonomous vehicles	Advanced robotics that can safely operate around humans	system of systems that self-diagnose and operate within safety parameters
Mechanical	semi-autonomous vehicles	Enable multi-modes	enable remote control when required
Mechanical	thermal control systems	Assure systems stay within temperature limits	advanced design concepts for managing temperature extremes
Mechanical	deep sea exploration	Harvest deep sea resource and enable human habitation	design devices and processes that exploit sea resources in environmentally responsible ways
Petroleum	oil sources	Enhanced oil recovery (to supplement depleted oil reserves)	methods of thermal recovery, gas injection, and chemical injection
Petroleum	alt energy	Unconventional fuel sources (shale oil)	development of enhanced techniques to utilise sources or improve efficiency of recovery
Petroleum	environment	CO2 sequestration	methods to store CO2 in unconventional places and ways
Systems	human interface	Human factors in system development	complex relationships between human interfacing with machines
Systems	complex systems	Increasingly integrated and complex systems	development of environments that will facilitate agile and adaptable processes to produce processes of value

Systems	reliable systems	Increasing need for reliable simulation of system	development of common modelling standards, based on firm mathematical foundations, that provide highly reliable simulation and real-world representations

Table 1: Contributions by Engineering Discipline and Sub-Area

It is hoped that this table of contributions will remain as a base for further discussions and further investigations into the future challenges and corresponding curricula changes for the different focus groups. In the future, it is hoped that we would expand this knowledge base into pre-university education and for ongoing professional development of career professionals.