

BUILDING CAPACITY

STEM, Global Development and the United Nations Sustainable Development Goals

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Outline of Remarks

SET and Engineering Defined Engineer of 2020 **SET for Grand Challenges** Foresight and Global Trends 2030 **Key Megatrends** MDGs and SDGs – Year 2015 in a Nutshell Mapping Engineering Grand Challenges and SDGs Engineer of 2020 Second Machine Age, Knowledge Circulation and WSIS "Black Swans" and "Renaissance Scientists and Engineers" **Final Observations**

Science, Engineering and Technology (SET) Defined

Science is the study of the natural world and has two parts:

(1) a body of knowledge that has been accumulated over time
(2) a process—scientific inquiry— that generates knowledge about the natural world.

Engineering, too, consists of a body of knowledge—in this case knowledge of the design and creation of human-made products—and a process for solving problems. It is an oversimplification, but in many ways engineering is the practical application of scientific knowledge.

Technology is a product of engineering and science.

"A scientist studies what is, an engineer creates what never was."

Theodore Von Karman

SET for Grand Challenges

- Science, engineering and technology (SET) can have disruptive (good and bad) impacts on social, cultural, ethical, civil, economic, political and military affairs
- Emerging, disruptive technologies affect societies, cultures, institutions, governments, international relations, national security
- The New Normal Private/Public Partnerships for economic growth and development powered by global knowledge circulation through ICTs, Internet, cloud, apps, Big Data and AI
- Nations, urban centers and Special Economic Zones are shaped by, and compete for, SET assets, R&D, STEM education to create an innovation ecology

Global Grand Challenges are increasing – S&T, engineering assets and vocational skills are seminal to meet them, foster good governance_and international stability and prosperity

Strategic Foresight

Technology foresight" or "future-oriented technology analysis" Well-developed discipline practiced by governments, corporations, universities, think tanks worldwide

Survey of 1,000 recent foresight exercises indicates modalities such as expert panels, scenarios, trend extrapolation, workshops, Delphi, questionnaires and surveys, opportunities and threat analyses

Qualitative approach is most favored, some quantitative Foresight modalities often mixed, e.g., brainstorming as input to Delphi, scenarios combined with technology trends

Information and communications technologies used : on-line surveys, Big Data analyses, web-based horizon scanning and creativity platforms

"There are no facts about the future." Lincoln Moses, EIA Administrator

"In preparing for battle, I have always found that plans are useless, but planning is indispensable". Dwight D. Eisenhower

Strategic Foresight Recent Examples for 2030

"Global Trends 2030: Alternative Worlds", National Intelligence Council, December 2012

"Why and How Latin America Should Think About the Future: Global Trends and the Future of Latin America", Inter-American Dialogue, December 2013

"Envisioning 2030: US Strategy for the Coming Technology Revolution", Atlantic Council, December 2013

"Global Trends 2030: Can the EU Meet the Challenges Ahead", European Strategy and Policy Analysis System, 2015

> "No Ordinary Disruption: The Four Global Forces Breaking All the Trends" Dobbs, Manyika, Woetzel, 2015





Global Trends 2030: Alternative Worlds

16 Disruptive Technologies Analyzed Across Four Scenarios:

> "Stalled Engines" "Fusion" "Gini-Out of the Bottle" "Non-state World"

> > December 2012

NATIONAL INTELLIGENCE COUNCIL





Agricultural Water Efficiency Precision Agriculture Plant Biotechnologies Synthetic Biology

Multifunctional Graphene

Affordable Solar Energy Cost-Competitive Advanced Bio-Based Energy

> Human Augmentation Human Social Prediction Social Impacts of Social Networks

> Robotics Remote and Autonomous Vehicles

> > Data Solutions Diagnostics Cyberweapons Urban Technologies



Megatrends – An Unprecedented Number of Tectonic Shifts

- Growth of the Global Middle Class
- Individual Empowerment ICTs and Internet
- Youth Bulges, Millennials and Digital Natives
- Unprecedented and Widespread Aging
- Urbanization and Peri-Urban, Rural Continuum
- Food, Water and Energy Nexus, Pressures
- Wider Access to Lethal and Disruptive Technologies
- Definitive Shift of Economic Power to the East and South

NIC Global Trends 2030; Mathew J. Burrows, Director, Strategic Foresight Initiative, Scowcroft Center, US Atlantic Council, 2014; SET for Development

Millennium Development Goals Progress Made But Goals Not Achieved

Goal 1: Eradicate extreme poverty and hunger **Goal 2: Achieve universal primary education** Goal 3: Promote gender equality, empower women **Goal 4: Reduce child mortality Goal 5: Improve maternal health** Goal 6: Combat HIV/AIDS, malaria, other diseases **Goal 7: Ensure environmental sustainability Goal 8: Develop global partnership for development**

http://www.un.org/millenniumgoals/2014%20MDG%20report/MDG%202014%20English%20web.pdf

Selected Rio + 20 Outcomes "The Future We Want"

- Reaffirm Millennium Development Goals for 2015 (paragraph 5)
- Determination to address green economy in context of sustainable development and poverty eradication (12)
- Strengthen existing, foster new public-private partnerships (71)
- Recognize critical role of technology and innovation (72)
- Reaffirm ECOSOC lead for policy review, dialogue and making recommendations for UN-wide coordination of MDGs, Agenda 21 and related activities (82)
- Framework for Follow Up and Action in areas of:

Poverty eradication; food security, nutrition and sustainable agriculture; water and sanitation; energy; sustainable tourism; sustainable transport; health and population; productive employment; oceans and seas (104-133; 138-177)

Bridge digital divide through broadband networks, services (42) Sustainable Cities and Human Settlements (134-137)

SDGs and 2030 Development Agenda: Year 2015 in a Nutshell

Financing for Development Conference – Addis – July 2015

UN Summit on SDGs, 2030 Agenda – NYC – September 2015

WSIS+10 High-Level Meeting – NYC – December 2015 COP 21 on Climate Change – Paris – December 2015

Important Themes and Context SET & ICTs are seminal assets for all SDGs

ICTs are enablers for SET and innovation

Means of Implementation Post-2015 include: Finance; Technology; Infrastructure; STEM Education, vocational training and other Capacity-Building

UN Sustainable Development Goals

Accessed at <u>https://sustainabledevelopment.un.org/?menu=1300</u>, January 26, 2016



Sustainable Development Goals - 2030 Development Agenda

"Transforming Our World: the 2030 Agenda for Sustainable Development" A/RES/70/1- 21 October 2015

Social Sustainability

No Poverty (1) Gender Equality (5) Reduced Inequalities (10) Peace, Justice and Strong Institutions (16)

Economic Sustainability

Quality Education (4) Decent Work and Economic Growth (8) Industry, Innovation and Infrastructure (9) Partnerships for the Goals (17)

Sustainable Cities and Communities (11)

Environmental Sustainability

Zero Hunger (2) Good Health and Well-Being (3) Affordable and Clean Energy (7) Clean Water and Sanitation (6) Responsible Consumption and Production (12) Climate Action (13) Life Below Water (14) Life on Land (15)

SET for Development, 2015

'Engineering Grand Challenges – 2020'' U.S. National Academy of Engineering (2008)

'In each of these broad realms of human concern — sustainability, health, vulnerability, and joy of living — specific grand challenges await engineering solutions. The world's cadre of engineers will seek ways to put knowledge into practice to meet these grand challenges. Applying the rules of reason, the findings of science, the aesthetics of art, and the spark of creative imagination, engineers will continue the tradition of forging a better future."

> Make solar energy economical (SDG 7, 11, 12) **Provide energy from fusion (7) Develop carbon sequestration methods (9, 11, 12, 13)** Manage the nitrogen cycle (2, 7, 12, 13) **Provide access to clean water (6, 12, 13, 14, 15)** Advance health informatics (2, 3, 5, 6) Engineer better medicines (3, 5) **Reverse-engineer the brain (3) Prevent nuclear terror (16, 17)** Enhance virtual reality (2-15, 17) Engineer the tools of scientific discovery (1-15, 17) Advance personalized learning (4, 5, 10, 17) Secure cyberspace (8, 9, 11, 12, 16, 17) **Restore and improve urban infrastructure (3, 6-9, 11-15, 17)**

"The Engineer of 2020 -Visions of Engineering in the New Century"

U.S. National Academy of Engineering (2004)

Two major features: Systems Orientation and Design Under Constraint

Systems Orientation

"Engineering is about systems. The frontiers of engineering today are in tiny systems on one hand and macro systems on the other."

Professional context for future engineers requires "the systems perspective and systemsbased approaches", valuing interdisciplinary study in non-engineering disciplines such as social science and business. Charles Vest, NAE President (2008-2013)

Design Under Constraint

"In designing systems, engineers are mindful of and constrained by nature, cost, concerns of safety, reliability, environmental impact, manufacturability, and many other 'ilities'". William Wulf, AT&T Professor of Computer Science, University of Virginia, former NAE President (1997-2007)

The Second Machine Age and Third Industrial Revolution

- Convergence of Big Sciences, Technologies Nano, Bio, IT
- Generic Purpose Technologies steam, electricity, now ICTs, Internet
- "Recombinant Innovation" to invent anew from existing knowledge
- Advanced Manufacturing, 3-D, AI, New Materials and Robotics
- Transforming the Way Goods Are Made
- Destroying but also creating Jobs
- Need for multi-disciplinary STEM education, new skills and vocational training for modern workforce, especially in the developing world
- Infrastructure Built Environment requires engineering first

Sources: Brynjjolfsson, McAfee, "The Second Machine Age"; Arthur, "The Nature of Technology"; Burrows, "The Future Declassified"; Rifkin, "The Third Industrial Revolution"; McKinsey Global Institute – various; SET for Development

Global Knowledge Circulation: Life Blood for S&T, Engineering and Innovation

"Clouds, Big Data and Smart Assets: Ten Tech-Enabled Trends"

Distributed Co-creation – Open Source software the key Making the Network the Organization – "in-reach" to build teams Collaboration at Scale – "organizational capital" for knowledge extraction The "Internet of Things" – embedded sensors, actuators, "smart" assets Experimentation and Big Data – data doubles every 18 months Wiring for a Sustainable World – smart grids, efficiency reduce GHGs Imagining Anything as a Service – innovate by integrating the end user Age of the Multisided Business Model – shift from 1/1 to multiple players Innovating from the Bottom of the Pyramid – "Alibaba" B2B exchange Producing Public Good on the Grid – e-gov infrastructure and services

McKinsey Global Institute, August 2010

World Summit on the Information Society **WSIS+10**

- WSIS +10 culminated a decade of activities following Tunis Summit and Agenda in 2005 with associated "Action Lines" to foster greater access for developing countries to information and communications technologies (ICTs) and Internet
- Leads for 11 WSIS Action Lines were assigned to, inter alia, UNESCO, ITU, UNCTAD, WHO, FAO, WTO, WHO, ILO, UN-Habitat and US Regional Commissions to address: •
 - role of governments and all stakeholders in promoting ICTs for development;
 building infrastructure, capacity-building, and enabling environments;
 access to information and knowledge;

 - applications in e- government, e-business, e-learning, e-health, e-employment, e-environment, e-agriculture and e-science;
 - cultural diversity and identity;
 media;

 - ethical dimensions of the information society, and;
 international and regional cooperation

The WSIS +10 provided inputs to UNGA deliberations in December 2015 transition from MDGs to Sustainable Development Goals and 2030 Development Agenda •

Black Swan Events

Black Swans (according to Nassim Nicholas Taleb)

Three Attributes:

- 1) Outlier i.e., an Event Outside the Realm of Regular Expectations
- 2) Extreme Impact
- 3) Human Nature Concocts "Plausible" Explanations After the Fact

Moreover, "Black Swan logic makes what you don't know far more relevant than what you do know."

Linear Domains - Engineering, architecture, astronomy, most physics and physical, biological sciences

Complex Domains – social, behavioural, economic sciences, epidemics

Black Swans, Scientists and Engineers

Implications for the Future – Taleb's Bottom Line

- Our world is dominated by the extreme, unknown, improbable
- We focus on "small talk," the known and repeated based on current knowledge
- In spite of our progress and growth in knowledge (or perhaps because of it), the future will be increasingly less predictable;
- Human nature and social "science" seem to conspire to hide the idea from us.
- (1) The Black Swan event should also be considered as a starting point, not an exception

(2) Educate more "Renaissance Scientists and Engineers" who can think holistically, team play, and innovate

Final Observations

SDGs and 2030 Development Agenda An Aspirational Roadmap Diffuse (17 SDGs, 169 Targets) and Lacking Metrics **Urbanization and other Megatrends are Inevitable New Private/Public Partnerships must feature:** Private sector, Universities, NGOs, Governments, IDBs, IOs **Private Capital and Investment Will Dominate** University Research, Curriculum Collaboration Critical for Success **Bottom Line – STEM, scientists, engineers and technologists for** development – a growth industry for viable careers Vocations, technical skills training, certification programs also vital

Final Observations

Strategies for Multidisciplinary, Intercultural Competence

ICT, Internet facilitate networks of faculty and students

Universities with Engineering Education - ASU, Cincinnati, Clemson, OSU, Purdue, Texas/El Paso, Tufts, Utah St, VaTech, Aalborg, UTM

Universities with Holistic, Multidisciplinary Curricula – MIT, GaTech, Duke, UVa, Madison, VaTech, Colorado, Purdue, Notre Dame, USC

Cambridge Handbook of Engineering Education

Journal of Engineering Education

Community Service, Engineers w/o Borders, Intern/Fellowships

Recent NAS/NAE Reports – Ethics; Educate to Innovate; Engineering Education: Designing an Adaptive System; A Look Forward

International Collaborative Research in Social and Behavioral Sciences – GUIRR