The Millennium Project
Global Futures Intelligence System
WWW.THEMP.ORG

4421 Garrison Street, N.W.
Washington, D.C. 20016
U.S.A.

Tel./Fax 1.202.686.5179
e-mail info@millennium-project.org
www.stateofthefuture.org

September 29, 2018

Dear MP Planning Committee Members:

You are welcome to share the results of the Science & Technology Real-Time Delphi that assessed 15 long-range actions to address future work-technology dynamics with relevance to the science and technology community with S&T leaders and institutions, in your country.

The top five most effective actions rated by the international panel were:

- Directors of national science labs and other leaders in the S&T community should devote more effort to making current science and future technology understandable to general public.

- Create national policies and standards for the Internet of Things (IoT) that stresses future cyber security systems.

- Forecast synergies among the full range of next technologies (NTs), and their potential impacts (e.g., artificial intelligence, robotics, synthetic biology, nanotechnology, quantum computing, 3D/4D printing and bio-printing, IoT (Internet of Things), drones (and other autonomous vehicles), VR (virtual reality) and AR (augmented reality), cloud analytics, conscious-technology, semantic web, holographic communications, blockchain, and tele-presence).

- National S&T leaders should be part of the national team that creates, regularly updates, and implements their country's national S&T strategy.

- S&T and legal communities should collaborate nationally and internationally to establish legal frameworks and treaties that anticipate future liability requirements that can deter technological hazards and encourage technology.

For each of the 15 suggested actions, the international expert panel was asked:

- If implemented, how effective could this be in improving our long-range work-technology prospects by the year 2050?
- How feasible is it to implement this suggestion (in enough time to have a substantial effect by 2050)?
- Additional comments?

The participants were also asked what other science and technology related strategies would better improve work/technology dynamics by 2050. Their responses were distilled to an additional 25 actions.

This is the fifth and last report in a series of Real-Time Delphi studies to assess actions to address issues raised in future ***Work/Technology 2050 Global Scenarios***.

The ***Future Work/Technology 2050*** study has six phases:

1. Literature and research review to find what questions were not asked or poorly answered as input to our international Real-Time Delphi survey.

2. Over 300 futurists, AI and other technology professionals, economists, and other related experts from over 45 countries shared what should be considered in the construction of alternative future work/tech scenarios.

3. Three Work/Technology 2050 Global Scenarios drafts were written and reviewed by over 450 futurists and others via three Real-Time Delphi questionnaires: *It's Complicated – A Mixed Bag*; *Political/Economic Turmoil – Future Despair*; and *If Humans Were Free – the Self-Actualization Economy*.

4. These three scenarios (each about ten pages) were used as inputs to workshops in 20 countries to identify long-range strategies to address the issues raised in these detailed scenarios.

5. The suggestions were distilled and grouped for relevance to education & learning; government & governance; business & labor; culture & arts; and science & technology and assessed by separate international Real-Time Delphi expert panels.

6. Results were analyzed/synthesized, put into separate reports, shared with relevant government departments in over 50 countries, and integrated in to a draft final report.

Workshop participants suggested over 250 actions via 30 workshops conducted in 20 countries (full text will be available in the final report's annex). The 15 actions suggested below were combined and distilled from the workshops and scenarios for their relevance for the ability of the S&T community to address issues in the future Work/Technology 2050 Global Scenarios. They were then assessed by an international panel of 145 participants from 38 countries using a Real-Time Delphi (an online expert judgment assessment tool).

A distillation of the panel's comments on each action gives a rich insight into what we should do and factors to consider in their implementation. Also enclosed at the end is a distillation of an additional 25 actions suggested by the international panelists, except those actions already covered in the other four Real-Time Delphi studies.

Best regards,

Jerome Glenn
Co-Founder and CEO

The top five most effective actions relevant to science & technology to address issues raised in the *Work/Technology 2050 Global Scenarios* as rated by the international panel are:

- Directors of national science labs and other leaders in the S&T community should devote more effort to making current science and future technology understandable to general public.
- Create national policies and standards for the Internet of Things (IoT) that stresses future cyber security systems.
- Forecast synergies among the full range of next technologies (NTs), and their potential impacts (e.g., artificial intelligence, robotics, synthetic biology, nanotechnology, quantum computing, 3D/4D printing and bio-printing, IoT (Internet of Things), drones (and other autonomous vehicles), VR (virtual reality) and AR (augmented reality), cloud analytics, conscious-technology, semantic web, holographic communications, blockchain, and tele-presence).
- National S&T leaders should be part of the national team that creates, regularly updates, and implements their country's national S&T strategy.
- S&T and legal communities should collaborate nationally and internationally to establish legal frameworks and treaties that anticipate future liability requirements that can deter technological hazards and encourage technology.

The top five most feasible actions relevant to science & technology to address issues raised in the Work/Technology 2050 Global Scenarios as rated by the international panel are:

- National S&T leaders should be part of the national team that creates, regularly updates, and implements their country's national S&T strategy.
- Directors of national science labs and other leaders in the S&T community should devote more effort to making current science and future technology understandable to general public.
- The S&T community should work with their government to create an office or agency for technology assessment to both anticipate potential negative outcomes to avoid repeating past disasters and to anticipate positive outcomes to ensure benefits are achieved and available.
- Create national policies and standards for the Internet of Things (IoT) that stresses future cyber security systems.

- Scientific associations (e.g., International Science Council, national academies of science, etc.) should develop methods and procedures to carry out their responsibilities to establish and communicate scientific facts, as AI could dramatically accelerate the impact of disinformation.

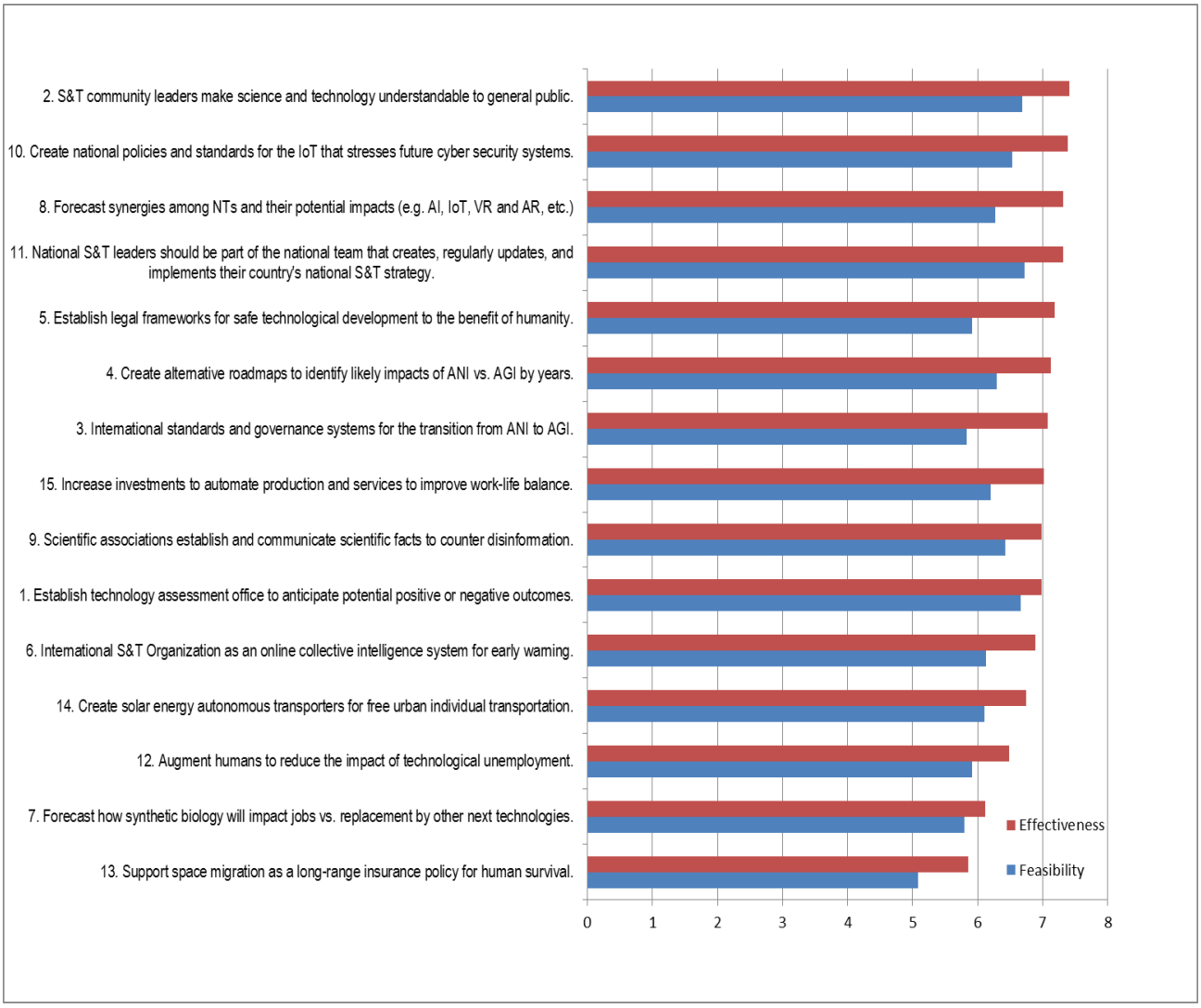
The complete list of 15 actions with the averages of the international panel's ratings as to their effectiveness and feasibility is below followed by a distillation of the international panel's comments on each action.

S&T Related Actions to Address Issues Raised in the *Work/Technology 2050 Global Scenarios*

No.	Actions 10 = High 1 = Low	Effective	Feasible
1	The S&T community should work with their government to create an office or agency for technology assessment to both anticipate potential negative outcomes to avoid repeating past disasters and to anticipate positive outcomes to ensure benefits are achieved and available.	6.98	6.66
2	Directors of national science labs and other leaders in the S&T community should devote more effort to making current science and future technology understandable to general public.	7.41	6.69
3	AI leaders should work with government and international organizations to create international standards and governance systems for the transition from artificial narrow intelligence to artificial general intelligence.	7.08	5.83
4	Create alternative roadmaps to the development of artificial general intelligence and identify likely impacts of artificial narrow intelligence vs. artificial general intelligence by years, and make the results widely known.	7.13	6.3
5	S&T and legal communities should collaborate nationally and internationally to establish legal frameworks and treaties that anticipate future liability requirements that can deter technological hazards and encourage technology.	7.19	5.92
6	Establish International S&T Organization as an online collective intelligence system (not as a new bureaucracy) that shares on a global basis forecasts of technology, their potential impacts, and a range of views updated similarly to Wikipedia -- but with more peer review systems built in. The system should show contradictions, differences put next to each other with links to data and research, and act as an early warning alert system.	6.89	6.13
7	Forecast how synthetic biology will or will not create more jobs than other next technologies (NTs) replace.	6.12	5.8
8	Forecast synergies among the full range of next technologies (NTs), and their potential impacts (e.g., artificial intelligence, robotics, synthetic biology, nanotechnology, quantum computing, 3D/4D printing and bio-printing, IoT (Internet of Things), drones (and other autonomous vehicles), VR (virtual reality) and AR (augmented reality), cloud analytics, conscious-technology, semantic web, holographic communications, blockchain, and tele-presence).	7.32	6.27
9	Scientific associations (e.g., International Science Council, national academies of science, etc.) should develop methods and procedures to carry out their responsibilities to establish and communicate scientific facts as AI could dramatically accelerate the impact of disinformation.	6.98	6.43

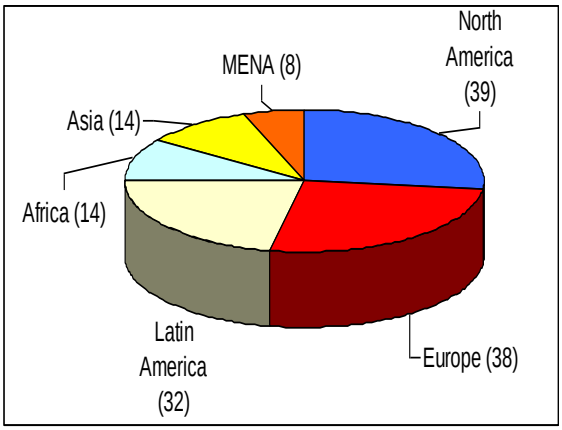
10	Create national policies and standards for the Internet of Things (IoT) that stresses future cyber security systems.	7.39	6.53
11	National S&T leaders should be part of the national team that creates, regularly updates, and implements their country's national S&T strategy.	7.31	6.72
12	Increase R&D in technology to augment humans where possible, to help reduce the impact of technological unemployment.	6.49	5.92
13	Support space migration as a long-range insurance policy for human survival.	5.86	5.08
14	Create solar energy autonomous transporters for free urban individual transportation.	6.75	6.1
15	Increase investments to automate production and services to free human creative development, allow those less technical to participate in advanced technology, and improve work-life balance.	7.02	6.2

Actions ordered by effectiveness:

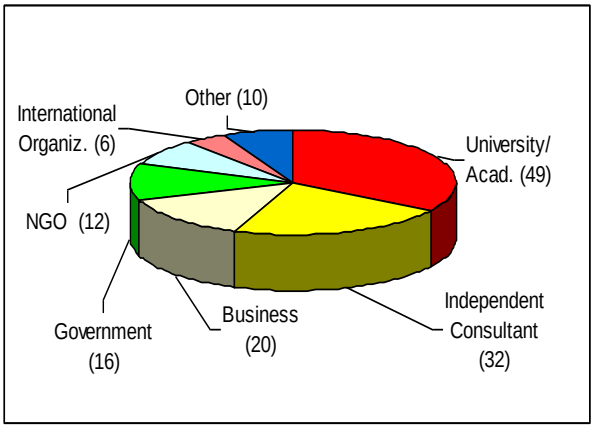


Demographics of the participants:

Regions:



Professions:



Distillation of participants' explanations and comments per each question:

Suggested Action 1: The S&T community should work with their government to create an office or agency for technology assessment to both anticipate potential negative outcomes to avoid repeating past disasters and to anticipate positive outcomes to ensure benefits are achieved and available.

1.1 How effective?

Huge first step, since politicians and their staff are largely uninformed about specifics about the implications of S&T and have no balanced source of information; will have a great impact in my country specially if the S&T community is involved because government S&T actions are inadequate; if adequately staffed it will have a significant impact; the acceleration of tech change increases the need for this every day, and its public outreach should be stressed; will contribute to having a better scenario in 2050; strategic alliances for open collaborative work are a powerful way to go forward; there is a need for a global, leaderless organization to consolidate the activities of cooperating countries around the world; government's decisions must be based on knowledge, open to dialogue, and an office of this type is very important; effectiveness depends on ability to enforce policy, in a free capitalist economy it is doubtful that industries can be regulated by virtue of "possible negative outcomes" except in the most extreme cases (i.e. climate change); while of utmost importance, suggesting that one government agency can cover the extremely broad range of technologies is asking a bit much, besides, we already have the Food and Drug Agency and other monitoring and prior approval agencies, that are challenged enough by the influence of self-interest groups to do the job they were mandated to do, perhaps narrowing down what critical tech, like AI for example, would help make this action more realistic; the idea of Technology Assessment Agencies affecting the rate and direction of technological change has yet to be demonstrated (and it has been tried for more than 30 years); bureaucracy will ruin technology assessment.

1.2 How feasible?

Easier in some countries than others, but lower income countries could draw on the output of richer countries; if each individual government has to be sold on the concept, it will take too long, instead have an international organization, like The Millennium Project, volunteer as many Nodes as possible to lead the effort in each country, that decision will provide each country with a

knowledgeable cadre; this would require action outside of government to make synergy with the S&T community; unless the role(s) of this agency are narrowed down, there is little chance of it having any significant impact, but if it is more focused on AI, for example, then it could have significant impact by 2050; countries where ideological messages are more important than scientific facts or opinions will resist this; the reluctance of ignorant policy-makers to listen to anyone except some lobbyists makes this very difficult; in my country the government keeps changing, so it's feasible only if the government has long-term vision to implement and make it last into future administrations; in Mexico there is already an office with the elements that will allow it to solidify and transform itself into an agency with the required characteristics; the Argentian's crisis might help Latin American governments to understand the urgency and need for analysis of possible future national economies, which are currently based on natural resources instead of knowledge.

1.3 General comments?
Of course, the S&T community should work with their government to create an office or agency for technology assessment; not only the S&T community but also foresight experts; it must have some sort of "teeth," politicians must feel that their future is dependent on the right (and evidence-based) future-oriented decisions; it can be very effective, and should be very feasible to implement since such agencies are already in place in several countries; necessary to allow for independent views so they are not influenced by what others have already said; the assessment of negative outcomes of technologies is in the hands of very few people who may not consider outcomes outside of their field of expertise, so a diversified group of thinkers should weigh in to give a more balance perspective; many politicians are under pressure from various social groups and religious organizations to reject or modulate science in order to fit their beliefs about how the universe works; commissions of parliamentarians that can review the legislation in light of future technologies and make a coordination among agencies has been effective in my country; many S&T companies are global which will complicate the matter of working together with "their government;" how could such government agencies anticipate things and take action fast enough; the S&T community needs less government interference; industrial policy has had a checkered past in picking technology winners and losers, better to assess and adjust the economic incentives in line with the societal goals; there are a plethora of government regulatory agencies dedicated to protecting the population from inappropriate technologies (FDA, AEC, USDA, etc.), and the range of technologies to assess is so broad that no one agency could do it well, narrowing the focus of this new agency to something like AI in all its forms could help to make it more effective; a goal will have to be defined for this organization similar to “how do we put a man on the moon and return him safely by the end of the decade?”, or similar to the MP’s 15 Global Challenges; one problem with the old OTA in the US was that too often it assessed tech that was already in the market, too late to have much impact, ways to prevent politics and lobbying distorting reports has to be created; being too late was not the problem with OTA, it was politics that killed it, we need it back.

Suggested Action 2: Directors of national science labs and other leaders in the S&T community should devote more effort to making current science and future technology understandable to general public.

2.1 How effective:
This action is vital, as too many in societies resist what they don't understand only because they don't understand it; much communication is needed, little is done; such directors should make alliance with traditional media; public also has to be motivated to engage the labs in discussion; an informed citizenry might also put the right pressure on politicians and eventually help with the dialogue with the S&T community; important to avoid the danger of a divided society that does not understand science and the other that values science; a society that appreciates science will

certainly promote a long-term vision and take timely measures in relation to technological development; the accelerating technology will make it easier to present data specific to the cognitive learning styles of individuals.

2.2 How feasible?

Over ten years ago, The Millennium Project did a study on future management of S&T, during the study all directors of national labs interviewed said they had the responsibility to inform the public of their work and would take communication training to improve their impact; science communication skills are usually missing, an effort is required to train both directors and grass root scientists; it might need some efforts from the S&T community to better visualize the data including online interactive models the public can easily use; it would be ideal to create a position specifically for outreach, a "lab spokesperson", however in general national science labs are tight on money and are unlikely to create a position for this job; just takes a directive from the relevant authority to say do it, and add some small funds in their budget to make it happen; relatively easy, since most research centers do have a PR department; most labs already post news releases and even hold public forums regarding their accomplishments, but making science understandable to the public takes a budget and time away from conducting research that is unlikely to get funded; Discovery channel and related TV shows are good, but more is needed, in schools and the mainstream media of all sorts; web videos (like YouTube) should make this task much easier.

2.3 General comments:

Examples of graduate degrees in science writing: http://sciwrite.mit.edu and http://advanced.jhu.edu/academics/graduate-degree-programs/science-writing/, us AAAS's Mass Media Science and Engineering Fellowship program (https://www.aaas.org/news/mass-media-fellows-prepare-summer-science-journalism), Science communicators entice their readers with carefully selected wording, key interviews, visually stunning images, and a compelling angle, see Best American Science and Nature Writing https://www.publishersweekly.com/978-1-328-71551-7 and Science and Entertainment Exchange, a program of the National Academy of Sciences http://scienceandentertainmentexchange.org/about/about-the-program/, the Exchange worked on a number of popular films and television shows with the power to reach the common person and shape their ideas about what science is about and what scientists do. For example, the Big Bang Theory (physics), House (medicine), and Bones (forensic anthropology). "Broadcast in more than 25 countries, The Big Bang Theory has achieved worldwide commercial success. As Steven Paul Leiva opined in the Los Angeles Times in 2009, “The Big Bang Theory” is the finest and best fictional portrayal of scientists in any current media—and a series that is carving out a place for itself in the annals of television comedy.” (Physics Today, https://physicstoday.scitation.org/doi/pdf/10.1063/PT.3.3427); Help people envision possible outcomes when a technological innovation becomes mainstream, show, don't tell, a TV series like “Black Mirror” reaches a wider audience than science channels do; explaining how the technology works is less important than explaining how it will affect people’s lives.

Granted, many top scientists don't want to deal with the public, but you don't need all top scientists, just a few, and those who don't want to deal with the public should support those who do, in part, Carl Sagan was a successful communicator because fellow scientists did not try to put him down, but supported his public leadership; Better S&T communications is definitely needed to counter nationalist and silo thinking, especially in the age of "post truth" and "fake news," people must be educated to be able to distinguish between (real) facts and conspiracy theories, distorted or biased opinions, etc.; this was one of the priorities of the current EU S&T framework program (Horizon2020); NASA and the ESA have great educational outreach efforts, but how many actually partake? The task is particularly challenging in developing countries where large scale illiteracy still

remains a problem; necessary to have a strategic agreement between the S&T agency, the universities and the social media; this question relates to the survey on education, on how to teach people to engage in continuous learning and lifelong education; as Next Technologies (NT) proliferate the knowledge gap between the educated and uneducated will have significant negative impact on the uneducated cohort in each country; people get scared from what they do not understand and can get paranoid; how to get more of the general public to read Science News, Popular Science, Popular Mechanics, and the Christian Science Monitor, as well on line sources?

Suggested action 3: AI leaders should work with government and international organizations to create international standards and governance systems for the transition from artificial narrow intelligence to artificial general intelligence.

3.1 How effective?
Without them we face the disasters that Gates, Hawkins, and Musk have warned about, imagine the world today if we did not have the standards and a governance system (IAEA) for nuclear energy; this is definitely needed, especially as it relates in any way to the application of military weaponry, otherwise there will be serious backlash against the development of artificial general intelligence; international agreement on AI systems standards and application will be very challenging, though it is important that attempts are made to keep up with developments in the AI field globally; I do think that the deployment of AI systems requires different regulatory frameworks, and that this is a very important conversation; given the dangerous military applications of AI, it is imperative to have a governance structure with the same abilities applied to nuclear weapons, including sanctions; international guidelines are essential, even though not everyone will adhere properly, the effort still must be made; in Latin America we must sit down to work more on this issue, we have been simple users of technology, it is an urgent issue to address.

3.2 How feasible?
The framework to do it is already out there, so it should not be too difficult, but probably it will take some time; it will happen; we are already too far behind to be effective on this; complicated, difficult, but necessary; requires a new class of educated political leaders dedicated to the common good; it is feasible like creating the International Atomic Energy Agency, but it will take some time; very challenging to get international agreement on AI standards since so few people in governments have sufficient understanding of it to be able to approve what would be effective standards for systems transitions; it is impossible since no one really knows what the real AGI will look like, feel like, and act like, hence there is a huge risk that this will lead to increased government spending and that is all.

3.3 General comments:
Industry is far ahead already and will set standards on its own if public organizations do not catch up quickly; it is so important that leaders should work with government and international organizations to create international standards and governance systems for the transition from artificial narrow intelligence to artificial general intelligence; tech creators often don't want regulations, but this is different, the potential for acceleration means that if we wait too long, it will be too late—if AGI is created, we have no idea how fast artificial super intelligence (ASI) could emerge; this is very important and it is best left to practitioners and leaders of AI and not to governments, which should limit their role to being facilitators for it; standardization in S&T cuts two ways: makes more hardware able to integrate with others, but can hold back advances; this would be effective but how could we ever agree on something this complex like AI; since the conflict of interest among countries is significant, bilateral and/or regional agreements may be necessary before a global general agreement is possible; while agreement on standards may result in accelerating the implementation

of the technology, there is a danger that AI be used as a major tool for government's to maintain control over its citizens; recommended reading: https://www.theatlantic.com/magazine/archive/2018/10/yuval-noah-harari-technology-tyranny/568330/; a complicated issue for Latin America, since we are only users and consumers; AI should not be hampered by regulations and standards at its beginning stages; this would require addressing a persistent paradox—AI leaders are ignorant about the full spectrum of political and social effects, while politicians are ignorant about AI impacts; this suggestion is based on a nation-state paradigm which does not match the real world of global corporations, are Google and IBM really American; I don't believe international governance systems are currently open to this question; we need a new class of informed and visionary politicians.

We had a similar discussion about nanotechnology in the early '90s and very little happened, as 'nano' diffused into materials, energy, and medical research and basic safety standards took over, perhaps the same will happen with AI, perhaps the role of an international standards body is to inform local or industry-specific standards bodies to adjust their standards to deal with AI as it appears; the issue is the integrated control overall system for the Internet of Things (IOT), which is far more inevitable than human-level AI, standards are needed FIRST for theorem-based security of operating systems, communications, and chips (in that order, because OS's are easier), and overselling of fake AI is also a major problem, replacing humans at times with systems which do not actually work as well; maybe when AI or AGI will get to replace policy-makers, it will develop some codes of conduct—for better or worse.

Suggested Action 4: Create alternative roadmaps to the development of artificial general intelligence and identify likely impacts of artificial narrow intelligence vs. artificial general intelligence by years, and make the results widely known.

4.1 How effective?
This is an important undertaking capable of fighting the ongoing hype about AI and the useful reframing of AI and AGI; the current international conversation on AI continually confuses narrow, general, and super AI making policy and public discussions very misleading; would help expand understanding of AGI, how it works, and how it is self-evolving and the sorts of controls needed to prevent humans from being subjugated to it rather than enhanced by it; alternative roadmaps would be necessary to deal with exponential contexts of development; seems an impossible task to identify impacts for a technology so alien to anything we have experienced so far, nevertheless it is a useful exercise.

4.2 How feasible?
Some exist, but not well-packaged and communicated for public consumption; there will be lots of these at the international, government, and individual corporate planning levels; it is vital but complex in that it will have to combine different interests (sometimes opposed); we definitely need to appropriately identify who will/should develop these scenarios if it is to have the sort of positive impact wanted, because if left to the developers of it, they will not anticipate well enough some of the consequences; who will have the knowledge, motivation, and incentives to do this; could make a difference if it is widely distributed.

4.3 General comments:
This is the best approach at the current stage of AI; it is so important to create alternative road-maps to the development of artificial general intelligence; assume governments are investigating the consequences of being behind on these technologies, especially in military applications; organizations like Partnership on AI, Future of Life Institute should take this on along with Google

and IBM. The Human Genome Project has little backlash, probably because public communications was built into the budget from the beginning. it might be most effective if each industry develops its own AI roadmap, few industry roadmaps are as effective as the one for the Semiconductor Industry Association which has been predicting outcomes, because nearly everyone in the supply chain takes part in it and it has driven research and capital investments; who will be burdened with this non-productive task (in relation to individual efforts by S&T entities); the sector is focused on gaining the greatest profits, which alternative roadmaps may put at risk; can be conducted as global study, but global co-operation will be difficult at government levels; the MP can start it right now; needs to be done by independent persons/entities to avoid self-perpetuating biases of implementers being built into them, then media campaigns through a wide variety of channels and sponsors including government, academia, private foundations, and the private sector as well; most seem to begin with the applications, products and services one prefers to see, rather than with the probable science and technology breakthroughs that will be necessary; without regulation and enforcement, the focus will remain on short-term gains with long-term dangers; it is vital that governments, especially in the US and China, get more involved in steering this journey away from quick wins and financial gratifications; it might be too future forward and abstract for many of us to feel the urge to act now on it; nevertheless, alternative roadmap may be valuable, but to give a timeframe is pure guessing.

Suggested Action 5: S&T and legal communities should collaborate nationally and internationally to establish legal frameworks and treaties that anticipate future liability requirements that can deter technological hazards and encourage technology benefiting humanity.

5.1 How effective?

This is really complex, so the sooner we get working on it the better; this is much needed and could even pave the way for better competition and hopefully useful results and technology; without a doubt, I am totally in favor of this implementation as collaboration between the academic and scientific community is the only thing that can bring improvements to society; future legal arguments will need new rulings to establish who or what is a legal entity and what are the legal responsibilities of such entities in a world that includes AI; this is a noble goal, however it may be difficult in the absence of real-world issues since often it is pain that motivates policies, when issues arise and lawsuits result, policies will follow; yes, it is a noble goal, and one that specialized government regulatory agencies such as the FDA, USDA, EPA and others should address, but with existing technologies let alone the new ones with AI enhancements make this difficult; reaching a consensus is not easy sometimes but could be managed as recommended by William Ury (founded the International Negotiation Network).

5.2 How feasible?

Complicated yet necessary; legal conferences and international meetings can include panels of legal experts to debate the specifics of AI in legal terms and definitions; self-interest groups have shown to be effective at infiltrating regulatory agencies such as the FDA and corrupting their determinations at the expense of the public, so, while this is definitely needed, for it to have the desired effect, will require cleaning up existing regulatory structures and preventing their political dismantling by feckless individuals in power; S&T communities may not be that interested in such arrangements; the chance of reaching a consensus looks remote due to cultural differences related to risk-taking. for example, the European emphasis on proof of avoidance of any harm can inhibit innovation while the U.S. utilitarian risk/reward approach can lead to unforeseen disastrous consequences for those who had no say in the decisions; I expect that legislation will follow—not precede—harmful results.

5.3 General comments:

Pay attention to the warnings of Steven Hawkins and others, it is urgent that the scientific community get an agreement and push the governments, academy, companies, and international organizations to establish a general framework; rather than wait for legal complexities to occur, it seems better to get ahead of the curve and demand that legal professionals worldwide begin to debate it and for courts to issue preliminary opinions; this has worked with nuclear, chemical, genetic technologies; legal frameworks that define future liability are useful to expedite S&T development, the exploration and understanding of technological hazards is already a requirement of engineering best practices; creating international legal frameworks—while necessary—takes time to build consensus across countries, and then more time for implementation, yet, it is an essential exercise; alternatively it is easier to insist on creating national legal frameworks first, and then move gradually to create an international consensus; legal frameworks and treaties can renew a focus on developing technologies that benefit humanity, numerous scholars have provided both critique of unsustainable systems, and ideas for innovation; these critical discussions need to move out of the academy and into the S&T development community; who decides when something is a liability or a hazard and when something is beneficial; finding common ground could be extremely difficult, especially when it comes to military applications (secrecy and one-upmanship); when the rule of law is barely functional in as many places in the world as it is at present, the implementation of any international agreements will be inconsistent; must be interpellation among all relevant actors; not only S&T and legal communities, but also social and human science (very important foresight and bioethics experts) and civil organizations; governments are slow to react to change—communities need to petition them to keep up with tech change.

Suggested Action 6: Establish International S&T Organization as an online collective intelligence system (not as a new bureaucracy) that shares on a global basis forecasts of technology, their potential impacts, and a range of views updated similarly to Wikipedia—but with more peer review systems built in. The system should show contradictions, differences put next to each other with links to data and research, and act as an early warning alert system.

6.1 How effective?

Peer-reviewed, self-correcting well-monitored information sources like Wikipedia are a good idea; why compete with Wikipedia, it can be used to manipulate people, with the proper peer review systems this could be extremely valuable, accurate data is a good thing; this should be the central focus or baseline information utility from which the world learns from and contributes to, this could make other systems, laws, regularization, etc. more effective and intelligent; given the problems with online collective experience, particularly around fraud, misinformation, disinformation, cybercrime, corruption, and worse—this seems too vulnerable, too idealistic and too voluntary, access and implementation would be very difficult to manage; this can be implemented under the umbrella of UN; getting into agreements when things are not yet stable and inequalities are common is not an easy job; we already used such Livejournal in Russia although DDOSed and spammed for political reasons, Occam's razor should be used instead of creating new entities.

6.2 How feasible?

If this is an extra-governmental organization, that includes inputs from government, and with effective media campaigns to raise public and government and academia awareness of its existence, then it could have significant impact by 2050; it´s a kind of movement that requires a good critical and well-prepared mass to implement; it must be possible; it is not difficult, just a matter of willingness and some dedicated organization that would continually monitor it and make sure updates are happening on a continual basis; it comes down to distribution and ease of use; although

relatively easy to set up, they are more difficult to sustain, and eventually they become abused by self-interested parties canceling each other out inside the wiki and overwhelmed by unreliable and fake news spread more widely outside the wiki; the lack of present day political action to seriously mitigate climate change shows that though the body politic has been given 'early warning' alerts of extremely dangerous and damaging conditions, leadership has opted to value the profit margins of their funders over safety, this is a precedent that cannot be ignored.

6.3 General comments:
In this age of real-time communication across the world, it is inevitable that there will be a free flow of exchange and information between international S&T organizations as an online collective, by 2050, one would imagine many more technological breakthroughs happening that would radically transform the nature of connectivity across regions and nations; of course this is essential, but what kind of organization, how to get it right, needs a rich network of two-way, n-way information flows that any real intelligent system would have; The Millennium Project and the other similar think tanks at global and regional or national levels, have to create a joint system of AI, working together and meeting at least once a year, similar to what the WEF does in Davos, in a Summit of World Collective Intelligence System; agree that the system should show contradictions, differences put next to each other with links to data and research, and act as an early warning alert system; the International S&T Organization has to be an international self-regulator to work; depends on finding someone with enough gravitas to get this going; this may have to be an extra-governmental entity, if it is to not get bogged down in petty politics and bureaucracy such as evidenced in the UN and other international systems; it is definitely needed and will need effective peer review systems built in without fossilizing the results in the process; this is quite feasible but seems mostly focused on sharing information, not necessarily on doing something with the information, how do we apply the info; we joke that a lie can run around the world twice before the truth has time to put its shoes on; if citizens are not trained to question what they read and trained to investigate questionable information, establishing yet another source of information, no matter how reliable, will be ineffective.

Suggested Action 7: Forecast how synthetic biology will or will not create more jobs than other next technologies (NTs) replace.

7.1 How effective?

As a generalization, the world is ignorant about synthetic biology and its potential future; synthetic biology is opening a wide variety of possibilities particularly when following biomimicry, learning with nature; there are so many wild assertions as to how synthetic biology will create jobs in the future, without any real analysis, that any legitimate and detailed forecast would be better than what we are doing now; it can only be completed if accurate forecasts of all NT job replacements are available; two different exercises for this study: how many jobs does synthetic biology create and how many are destroyed in other technologies, the "long-term" discussion will be in terms of "hours of employment" and not "number of jobs;" a great tool for terrorists, so it could create lots of jobs tracking them down; this should be both on jobs and ethics of synthetic biology to be of real long-term relevance for society; it might create more work after synthetic biology causes some eco systems disasters.

7.2 How feasible:
As we move appropriately in this direction there would be many possibilities that may benefit global well-being; doesn't the ILO provide any of this analysis of trends in jobs globally already, maybe what is needed is a better futures department in that organization with some help from such groups as The Millennium Project network; past efforts to do such a thing with, for instance, robots, have

provided a number of existing robots for jobs, but unreliable forecasts; it will depend on "geographic" and "time" terms: lag in times between the jobs that are destroyed and those that are created and in what territories are they created and destroyed.

7.3 General comments:
A challenge, but a good one; it is not clear how synthetic biology will affect jobs, that's the reason why the MP research projects are so important, because they create possible scenarios; synthetic biology is in its infancy and it is too early to make any reliable forecast about future employment creation; why focus only on synthetic biology?

Suggested Actin 8: Forecast synergies among the full range of next technologies (NTs), and their potential impacts (e.g., artificial intelligence, robotics, synthetic biology, nanotechnology, quantum computing, 3D/4D printing and bio-printing, IoT (Internet of Things), drones (and other autonomous vehicles), VR (virtual reality) and AR (augmented reality), cloud analytics, conscious-technology, semantic web, holographic communications, blockchain, and tele-presence).

8.1 How effective?
It could be very effective for supporting the work of the education and learning actions, as well as cultural transformation actions because realizing the technological links between sectors and making that known could help more people relate with and prepare for those changes; it is certainly very important for the business world to know where to invest, hence very effective for NT development but not clear how effective for improving work/tech relations; life works with synergies and this extends S&T; such road maps need to show the complex relationships to be effective; the only way this synergy will arise is by setting a master plan or one goal to restore the planet to the sustainable level so humans can survive, otherwise we will have to emerge into the matrix by destroying the other species while cooling the planet; it is a good exercise, but would likely not be a substantial industry driver; hybridization of technologies is what is really going to give potential to each technology.

8.2 How feasible?
Easy, just fund several research institutes to do the study and compare the results; a few industry-level technology road maps do occasionally work well in guiding investments in many interconnected technologies at once; some in the private sector are doing this as they develop their new products, but sharing proprietary information is not likely; to forecast the impact of hypothetical advances in any one technology is difficult but a reliable forecast of real world synergies of all of them seems beyond our current capability.

8.3 General comments:
Another good challenge—extremely necessary; will help identify the unintended consequences of the integration and interaction of NT technologies to prevent bad scenarios from developing; this would have to be done on an international level to achieve the full potential impacts from it on the future of work and technology, it could make a difference if this analysis is accessible very broadly across the world, in both government, private, academia, media and other sectors; the wide spectrum of NTs promises a quantum leap in generating synergies the actual range of which we may not be able to grasp at this stage, something that one may easily be able to predict is that these would vastly improve the work-technology prospects for 2050, this is still uncharted territory that would be very effective and feasible; in general, the more complex the supply chain, the longer it will take for all the complex relationships to solve themselves, but where something like the Semiconductor Industry Association roadmap has worked, competitors for solutions to each link in

the chain in the long term (6 to 12 years or longer) can anticipate when and where an investment might pay off in the 3 to 5-year time frame, get funding from venture capitalists or others, and move the industry forward in a reliable way, as for the long-term 'human side' of the equation (beyond 12 years), perhaps it is best to leave this to science fiction writers, who can explore scenarios in dialog and relationships between people in a way that technology forecasts usually cannot.

Suggested Challenge 9: Scientific associations (e.g., International Science Council, national academies of science, etc.) should develop methods and procedures to carry out their responsibilities to establish and communicate scientific facts as AI could dramatically accelerate the impact of disinformation.

9.1 How effective?
Certainly an important part of the equation; would help avoid disinformation; since they are the source/focus for scientific knowledge, who else could be more effective, naturally depends on how seriously they take this responsibility, their relation with or use of social media would be very important; very important, the regulation that creates these institutions should impose this obligation urgently; it would be essential in order to foster more inclusive and collaborative work worldwide through the web; this should complement the actions of Q#1-8 and as such will be very useful, to the extent that they can get beyond stifling inbred peer review processes that could stymie dissemination of the most useful information and policy recommendations; it is important work to be sure, however some of the issues we face is that these institutions are not trusted so putting out more facts does not always have the desired impact, some people would rather believe conspiracy theories than facts.

9.2 How feasible?
If these could be linked into a collective intelligence network with very broad inclusion and access, it might create the greatest impact, one challenge will be protecting the information from hacking and falsifying; most of these organizations would be managed by more conscious and well-prepared teams that would do the work; requires strong leadership, which is not yet visible; we also need politicians and congresses linked and related to prospective capacity.

9.3 General comments:
There is a risk that AI could dramatically accelerate the impact of disinformation, which will be hard to avoid; important that these scientific associations learn to better communicate with the general population rather than trying to reinforce a kind of elitism, these organizations and their networks definitely need to be part of the process of keeping the world informed about science and technology including AI; good suggestion, broadly speaking, but one should be on guard against the science councils and academies degenerating into scientific bureaucracies, some countries, especially among the less developed countries, have witnessed that happening in the past; I agree that the scientific associations should develop methods and procedures to carry out their responsibilities to establish and communicate scientific facts as AI could dramatically accelerate the impact of disinformation; associations and academies already have some forums to communicate to the public who often are unable to access such information, improving this may require going out into communities, at the street level, on public transportation, though local public services, including health care, public libraries, and government service offices to reach people and to get feedback; I find this an interesting topic, because I often feel scientists are communicating in a way that almost seems to be aimed at having a small number of people understanding what they are working on, what will happen if communication would be more effective and transparent.

Suggested Action 10: Create national policies and standards for the Internet of Things (IoT) that stresses future cyber security systems.

10.1 How effective?
The more things are connected, the more targets for crime, manipulation, and information warfare. See: https://youtu.be/hqKafI7Amd8; national policies and standards are good, but more far-reaching and relevant would be international standards; national groups needs international coordination; use well-protected blockchains; a wonderful measure to preserve and promote jobs in the cybersecurity field; important, but only as part of an overall solution to taking advantage of technology to facilitate productive and rewarding individual and societal lives.

10.2 How feasible?
Complicated and challenging to develop and get agreement amongst countries, but worth the effort if the policies go beyond stressing future cybersecurity; it is possible to come up with ways to measure aspects of IoT and to help citizens “visualize” its presence around them, what kinds of signals are the IoT units producing and communicating to the network; if adopted, standards and policies can have a large impact; how well will national policies and standards work in a global world; consensus may take some time; not easy, the subject is very complex for consensus.

10.3 General comments:
Only a handful of big nations are powerful enough to establish and install national IoT policies and standards; organized crime can buy the best software talent money can buy, honorable geniuses are needed; this is most urgent important thing where action is needed immediately, it was understandable when Stuxnet type technology encouraged NSA to restrict and even suppress the kind of technology needed to create unbreakable OS's (which existed already in the 1960's!), but after all the leaks, all high-electricity high-internet nations are at risk of losing half their generators within ten years, unless we all move firmly to open transparent machine-verified OS standards, AI simply cannot fix this by itself, to survive, organisms need brains—AND immune systems;

Many, if not most nations tend to start with national standards and then migrate to international meetings to try to agree on international standards. Early in tech development, startups don't like standards that limit creativity, but eventually they each want to be the standard and they need standards to scale up to large networks. The question here is how governments will attempt to ensure security from invasion of privacy and theft from payment systems when many more IoT devices per person will be present in the home and the infrastructure. Standards-setting institutes may need to anticipate and invent new technologies to measure each 'unit of security' or 'unit of safety' or 'unit of well-being' that sellers and consumers alike can use reliably.

Suggested Action 11: National S&T leaders should be part of the national team that creates, regularly updates, and implements their country's national S&T strategy.

11.1 How effective?
Although few read any national strategy documents about anything, the process that creates them can have an impact; S&T leaders should also participate in national and international strategies for education and learning, business and labor, and cultural evolution, too often science has kept too much to itself, at the expense of society; establish "open" procedures to avoid an “enlightened” despotism.

11.2 How feasible?
Seems to me they are already involved, if anyone is listening; should be done based on ethical principles and with good purposes as the WEF does; this is already being done, but the challenge is building the bridges to other disciplines that will facilitate the translation and evolution into future jobs and technologies being easily accepted and taken advantage of by the general population of the world, not just within specific nation states.

11.3 General comments:
This is obviously a practical proposal; depends on the importance and the influence that the political institutions give to the S&T leaders; the national S&T strategies should also integrate foresight or futures approaches; we need to bridge between the real experts, whose technical language is difficult to understand, and the futurists and politicians that make forecasts of exponential change; the "broader benefits" criterion in deciding what to fund, but top down control and—even worse—top-down specification of science or engineering paradigms, has been a disaster, left brain verbal folks who do not appreciate unique right-brain bottom-up engineers and technical people are another growing problem, multi-way communications are essential; national strategies could be developed in concert with international strategies as technologies operate across many borders, it is time to start operating from a more global perspective as what might be considered good in one country might be considered very negative in another, and unless there is sharing across borders of S&T strategies, those national strategies will become the source of international conflict; even smaller low-income countries should do this, granted they can draw on research by others, but each needs to struggle with these issues in their own context.

Suggested Action 12: Increase R&D in technology to augment humans where possible, to help reduce the impact of technological unemployment.

12.1 How effective?
"If you can't beat them, join them," AI and robotics can be created to augment rather than replace labor, not in all situations, but the more we focus on augmentation rather than replacement the less tech unemployment will occur; this is inevitable and necessary, even if some societies attempt to suppress the technology; this may lead to improve some and leave others behind; it is a great idea, but are we expecting private industry to do this; I think it would be wrong to keep a job that will inevitably be less and less human; redefine employment as the main way of economic survival.

12.2 How feasible?
Many people will do this, in order to stay competitive; what would be the incentive for R&D investments in augmentation technology rather than labor replacement technology; not many countries have sufficient scientists and engineers able to create such augmented workers; unfortunately, some will look at this as a "solution" for the technologically disadvantaged, but it avoids addressing the fundamental problem of unequal access to basic human rights.

12.3 General comments:
R&D in technology is bound to open up newer avenues for technological advancement, changing the concept of employment itself; it is so important to increase R&D in technology to augment humans where possible, to help reduce the impact of technological unemployment; some forms of augmentation will happen, how much will become a biological human-machine interface is not clear, but where some societies will refuse to conduct such R&D, others will do it, in order to gain competitiveness; anyone who believes in technological augmentation of humans should really study the full scope of work by Miguel Nicolelis and be aware of the positive and negative applications of brain computer interface; the effectiveness would depend on the cost of the augmentation of humans

versus the cost of automation of the function; in the not-so-near future, this is also connected to synthetic biology; could this be a cop out on confronting the truth of unequal access to what are internationally agreed upon basic human rights; this is the core of the entire issue: human activities will be disrupted by the AI, robotics, biotech, and quantum revolution, the enhancement of nanotechnology and the 3d/4d printing and what you can't succeed to imagine; the priority to afford a lean passage to this evolutionary jump should concentrate all the energy of the institutional body (private and public) to pursue a shared vision of the future where the advantages will be fully available to everyone not only to the elites or establishment and economical groups, do we have the courage to talk of an unusual form of open source of the benefits that recalls to the most ancient shape of communism, like Universal Basic Income or Universal Basic Property; R&D will always replace or eliminate jobs, companies will try to eliminate jobs replacing functions by machines or robots based on productivity, easy management, and low costs reasons, hence we will need dramatic changes in education to prepare for new jobs, self-employment, services, and implement policies to reduce the time-gap of the process, and to have social policies for the unemployed such as universal income systems, re-training programs, etc.

Suggested Action 13: Support space migration as a long-range insurance policy for human survival.

13.1 How effective?
While the principle purpose of the original space race was political, the benefits from that exploration were enormous in the development and emergence of many of the technologies that we currently take for granted; so, while having it as a long term insurance policy for our human survival, it will also serve to further technological development of all sorts from health to mining, to portable technologies, miniaturizing, transport, etc.; so, full speed ahead! support space migration – yes, but long-range insurance policy is only one reason for this.

13.2 How feasible?
Much of this will have to come from the private sector if it is to happen sooner rather than later, which is what is actually happening at present; it will come by necessity; certainly easy to support space migration, but to have a serious impact by 2050, probably more difficult.

13.3 General comments:
To settle space ENOUGH to maintain human survival even after we lose earth would require a whole lot of effective strategic thinking and prerequisites which seem in short supply; the most important prerequisite would be economic sustainability, a natural economic takeoff, which would require more and better export markets from humans in space to earth, energy from space could get us there (a key prerequisite); Mankin's book The Case for Space Solar Power (2014) gives a credible new path to 9 cents/kwh electricity available ANYWHERE on earth, dispatchable and switchable, but requires low cost launch, $500/kg-LEO or less, the US has such technology, but false PR prevents us even maintaining it let along deploying it, technically it is solvable, but world technology is going backwards and the human/political risk is daunting, ironically, fake optimism about things which don’t actually work is a major tool of those who don't want it to; yes, for no other reason than accelerating technological development in order to make it feasible let alone the other long-range objective of human survival; space exploration and settlement is essential to future wellbeing of humankind—it is feasible and will be highly beneficial (by gaining access to unlimited energy and material resources of space); space migration is too long range a project to have any impact by 2050; a different long-range strategy: a virtual-double of each and every individual as described in a recent Scientific American article on AI—seems to be locked into our futures, but this doesn't fit neatly into this category.

Suggested Action 14: Create solar energy autonomous transporters for free urban individual transportation.

14.1 How effective?
Energy and mobility are the two elements that "pull" most science/technology forward having great social impact; it will certainly improve urban life, but not that much impact on future work-tech dynamics; who pays for these, government, or is there a different business model needed for the development of an ongoing financing of this system, and aren't we already on the way to having these, except without the "free" feature?

14.2 How feasible?
Sounds enticing, but how would it be paid for, and how many government and private sector jobs would be eliminated (taxi and Uber drivers, bus drivers, etc.); this could easily be transformative—in Santa Monica the Bird and Lyme scooters took over the city within weeks of being introduced; remember great population growth will mostly be in cities.

14.3 General comments:
One can visualise the creation of alternate (renewable) sources of energy for running autonomous transportation systems well before 2050, and that it may add to the autonomy of the individual but the extent of work impact is not clear; the technology itself seems very desirable in many communities, improving the environment, reducing noise, increasing traffic safety, and perhaps even reducing traffic volume; not just from individual transport, which just reinforces the over-individualized society we currently live in, but also mini-buses with fixed routes and other mass transit as well or we'll just end up with autonomous transport gridlock instead of driver gridlock; free urban transportation can be a good social policy; important to create solar energy autonomous transporters for free urban individual transportation; existing infrastructure issues, getting consumers on board with AI cars by 2050 is feasible, but other than mega-cities some longer transport options are still needed.

Suggested Action15: Increase investments to automate production and services to free human creative development, allow those less technical to participate in advanced technology, and improve work-life balance.

15.1 How effective?
It would be the ideal world but this may require a more conscious capitalism that may not be so hard to reach at this digital era; a wonderful idea to free human creativity to go back to offering services (paid or for free) if people so desire; this is the best approach, but can we do it, who will do it; this is likely to happen anyway, but how it addresses the issues of future work/tech in the scenarios depends on if or when some form of universal income system is implemented; some automation will actually expand the number of nontechnical people who can contribute to high-tech product and service development in ways that makes it more human and useful; provided there is an adequate discussion of the trade-offs among productivity, innovation, and social equity, I agree that technological development promoted as "social democracy" would allow a better articulation of the human-technology relationship, both in terms of work and social life.

15.2 How feasible?
This would foster more humane development; it could work; there is no consensus yet to create this future, the consensus needs to be built; it will be effective in many situations; there are two different

issues here: automation—this is happening and will accelerate; social benefit—this depends on changing the socio-economic system.

15.3 General comments:
It is the rational way to go about it and it is inevitable, but countries with large populations and relatively higher population growth rates, it would be politically unwise to push for automation without reservations, effectiveness or feasibility per se is not the core issue for such countries, their demographic transition has to be addressed before this 2050 picture can work; it depends absolutely on a new education system; how to finance this; will only work if some form of universal basic income is provided to population, taxed from automation systems; this suggestion ignores the economic issues of how to support leisure and only a small percent of people will use more leisure to develop truly creative economically valuable activities and things; already being done, transparent open personnel systems strengthen empowerment of humans, inalienable rights, and people not being property of their employers or clients; include creative economy labs; we have already seen that when we ask people to contribute according to their abilities and to receive according to their needs, the incentive to contribute grows very small and the system collapses, provided automation eliminates demeaning jobs and increases the ability of many more people to participate in the workforce, and there is sufficient compensation to incentivize them to participate, this philosophy of automation will be useful, otherwise, we will end up with societies that, at best, will be bored and non-participatory or, at worst, revolutionary; more tech has not been, nor will it be, a solution to human ills; a virtual-double of each and every individual, personalized to seek on-line information/contacts that build out the real-you person's strengths (or caters to their weaknesses, biases, preferences, etc.) to climb learning and doing curves quickly and thoroughly - as described in a recent Scientific American article on AI—seems to be locked into our futures.

16 Additional Suggestions from the Panel: What other long-range S&T strategies would better improve work/technology dynamics by 2050? [Some suggestions were not included that were comments not actions, and other suggested actions covered in one the four other Real-Time Delphi studies that will go into the final report.]

- Integrate S&T policy issues for far more attention into the discussion of education and culture worldwide.

- Research how to transition from the global political economy seeking infinite growth through accumulation to an economy for creating a more decent life for all within planetary boundaries.

- Conduct research to create an algorithm that would encourage continued use of humans in industry and business by cutting their cost of employment by two means: 1) find the most efficient way to move the social safety net/welfare costs, such as social security, medical insurance, maternity leave, disability (unless directly safety related) and care, and so forth, from the employer to the government; and 2) find a method that does not decrease efficiency to tax the output of automation/robotics to cover the increased government costs of the social welfare.

- Increase research and attention to pursue the full scope of natural human potential and collaboration.

- Explore options for creating a fintech driven universal basic income engine that self-funds based on automatic taxation of online commerce.

- Identify better mechanisms than the profit motive and government support to allocate resources to technology development and creation of problem-solving systems. For example, improve channelling of philanthropy to develop constructive capabilities, as Bezos, Musk, Allen, et al. are demonstrating.

- Apply S&T and social engineering to replacement of jobs with more fulfilling work.

- Make smart phones a right of citizenship complete with a full-service provider and energy system such as a heat-battery that uses solar and waste-heat for storage.

- Create a cryptocurrency/blockchain-based new economic global system with incentives for improving the life versus maximising corporate profits; this would progress slowly at first but could be synergistic with many good initiatives.

- Invest in R&D that lets anyone create their virtual-double to seek on-line information/contacts for personal development as described in a recent Scientific American article on AI.

- Require government statutes, regulations, and ordinances to meet the same high standards of research, design, cost-risk analyses, and follow-up evaluation that are now routine for some physical products like pharmaceuticals, aircraft, nuclear reactors, etc.; the objective would be to create and maintain bodies of laws that optimally serve the best interests and wellbeing of the people (e.g., as measured by human rights, living standards, quality of life).

- Tax robots.

- Extend ISOs in the power sector as an antidote to the many private and public top-down 1-player control systems.

- Create different work/tech scenarios: one each for low income, middle income, and higher income countries, and the correspondences between these.

- Initiate a worldwide bottom-up basic income movement and system that is not handled by nation states but individuals. This could be funded both by wealthy individuals and crowdfunded by individuals. An option would be to try this out in small communities, then slowly role it out. The idea is partly inspired by the German example of "Mein Grundeinkommen" (My basic income), where basic incomes are crowdfunded and then distributed via lottery. It was founded by an individual who felt lucky that he had time and income on his hands due to having sold his company shares after co-founding a successful start-up. See here: www.meingrundeinkommen.de.

- Improve S&T collective intelligence systems and foresight/futures related processes.

- Merge mystic attitudes with technocratic management.

- Increase R&D in genetic research, life extension, and space travel.

- Explore how to transmit part of the savings due to new technologies to people that are working in more traditional care-taking work that have a major impact on human wellbeing.

- Promote dialogue strategies between government, society, and companies for free access to technological developments that improve the quality of life of citizens.

- Counter-balance the industrial negative ecological developments by international alliances of public bodies, decision-makers, and academia.

- Apply S&T to learn faster: 1) "quick learn" techniques that could be applied to all sorts of complex domains, speeding up climbing the learning curve; 2) the application of "quick learn" to game making (not game playing), increasing the retention rate and levelling the playing field across the various student populations; 3) the introduction of dense reading material at 11 or another early age (e.g., "Conquering the Physics GRE" a GRE Preparatory Book, "Cracking the GRE Chemistry Test", etc.); 4) the diversity of symbolisms associated with a wide range of advanced Math (e.g., "Divs, Grads & Curls" to go with Maxwell's Equations, Einstein & Riemann notations to go with Special Relativity and Gravity, general symmetry equations to go with Weak Fields relationships, etc.) should be introduced far earlier in each of the various learning programs; 5) the teaching of Physics (including the Physics' Math) first, Chemistry second, and Biology last is the appropriate order including the relevant math to each; and 6) the teaching of origami as a sufficient precursor pathway for a career in Synthetic Biology.

- Explore how gross expenditures on R&D could be more democratic.

- Insure that S&T R&D integrates the principles of responsible research and innovation even in the early stages and encourage scientists and engineers to cooperate with experts in social sciences and humanities to anticipate future impacts of the developments.

- Assess the broad impacts of an expanded space program.

Parting comment from a participant: Thanks so much for the ideas presented in this document, hoping all the best for the future.