WHERE IS IT ALL GOING?

Prospects for the Human Future

By Dennis M. Bushnell

ABSTRACT: Society now faces many major, even existential, issues that threaten our future. At the same time that accelerating changes are converging to create enormous potential problems, prospective synergistic solution spaces are emerging that offer strategies—and hope—for the human future.

AAI FORESIGHT®

WHERE IS IT ALL GOING?

By Dennis M. Bushnell

Introduction

THE SITUATION HUMANS FIND THEMSELVES IN AND the associated future trends and probable solution spaces are becoming clearer, as—per Ray Kurzweil's projections[1]—technological developments accelerate and interact, rapidly shifting society to a very different future state. Many of the basic trends are a repeat of the consistent historical patterns Ronald Wright examined.[2]

Since the beginning of the Agricultural Age, various civilizations have exploited and outgrown or polluted their local resources, forcing them to move on and exploit other territories and resources. A classic example is the Sumerians, whose agricultural fields became salinated—a phenomenon being repeated now as the aquifers we are pumping become increasingly saline. We are repeating the cycle of overusing or altering the resources we live on, but now we are overusing or polluting nearly the entire planet's ecosystem with no obvious new lands to move to.

However, there are yet planetary resources that could stave off Malthus[3] for a while longer. This may be sufficient to enable humans to accelerate their own evolution at a pace many

Foresight Report
Summer-Fall 2016

• • •

About the Author

Dennis M. Bushnell is chief scientist at NASA Langley Research Center, where he is responsible for technical oversight and advanced program formulation. His previous Foresight Report, "IT Revolution, Aerospace, and Society," is available at http://www.aaiforesight.com/content/it-revolution-aerospace-and-society. He may be reached at dennis.m.bushnell@nasa.gov.

• • •

Foresight Reports are published periodically by AAI Foresight Inc.
1619 Main Street #1172
Freeland, WA 98249
www.aaiforesight.com

Editor: Cynthia G. Wagner
CynthiaGWagner@gmail.com

orders of magnitude faster than natural evolution.

At the same time, major social changes can be expected as a result of the impacts of numerous converging technological developments. We are well on our way to significantly altering our physiology and then, perhaps in the farther future, eschewing our physiology completely.

"Renewable energy now is a wonderful and sorely needed success story. After decades of research to reduce cost and increase efficiency, many renewables are now achieving parity with fossil fuels."

First, the givens: We inhabit a finite planet with finite resources and ecosystems. Until recently (and largely still), the human enterprise was one of broad-scale slash and burn—trash here and then move on to trash elsewhere. Much of human econometrics is based upon growth, and we have reached the point where, in terms of population size and demands upon the ecosystem, we have driven that system into deficit. As populations continue to grow, so will their demands, as the future billions strive to improve their standards of living. The shortfall of resources to meet those accelerating demands may be the equivalent of three planets, some have estimated. Therefore, the growth mantra will, at some point, have to switch to a sustainability mantra, with major impacts on geopolitics and national security as well as econometrics.

The other major given is the innate cleverness of the human animal to subvert or delay Malthus and to invent and deploy technology to enable the continued growth humans seem to seek.

What Is Happening?

We are in the midst of multiple technological revolutions, accelerating and converging: information technology, biologics, nanotechnology, quantum technology, and energetics.

The synthetic, genomic, and even more advanced aspects of the biological revolution will alter nearly all aspects of society, including materials, human physiology, and food and nutrition, as well as enable enormous life extension and ecosystem remediation. These alterations will occur at rates perhaps millions of times faster than "natural" evolution, obviating most of the usual evolutionary cul-de-sacs.

The IT revolution, responsible for computers, the Internet, cell phones, and so on, is continuing apace, producing ever improving machine intelligence, additive (3-D) manufacturing, five-senses virtual reality and immersive presence, and "tele-everything." Through deep learning, big data, neural nets, and so on, the speed and power of computing is now enabling a brute force approach to machine intelligence that provides human-level machine capabilities in an ever increasing number of niche areas. The search is on for the "master algorithm" that could accelerate this approach to artificial general intelligence. Before then, in the medium term, neuroscience and brain-mapping projects that nano-section the human brain to replicate it in silicon could, by this brain emulation, produce a facsimile of human-level artificial intelligence. The wild card in machine intelligence is the way humans apparently acquired their intelligence—emergence. Make something complex enough, and it "wakes up."

Rapidly developing nanotech capabilities are producing revolutions in materials and metamaterials in many areas, as well as major improvements in energy generation and storage. Quantum technology is in the initial stages of providing revolutions in sensors, materials, computing, and much else. Quantum computing, if fully realized, would enable simulations to replace much physical development and experimentation at far less cost and time, given detailed knowledge of the initial and boundary conditions.

Renewable energy now is a wonderful and sorely needed success story. After decades of research to reduce cost and increase efficiency, many renewables are now achieving parity with fossil fuels; consequently, renewable sources represent approximately 60 percent of new energy generation. Many renewables are dispatchable base load, and storage for wind and solar is developing rapidly along a broad front. Their efficiencies are still improving and their costs are still dropping, while fossil fuel costs are rising. The capacity of renewable energy is massive. We have not yet even tapped many sources, such as floating heat exchangers in the Gulf Stream, high-altitude wind, the biomass of halophytes (salt-loving plants), and osmotic power. Beyond this is the wonderment of low-energy nuclear reactions, with over 25 years of experiments indicating there is something there, though the physics are still not understood.

Major Societal Issues Now Developing

As a result of population growth and development—too many humans asking too much of the ecosystem—combined with unsustainable practices and technological innovations advancing at an accelerating rate, we are now beset by a combination of serious societal issues with existential implications.

- **Machines are taking jobs.** As machine intelligence develops, it is rapidly moving from automation to autonomy—and for excellent economic reasons. We have never before invented a second intelligent species, but we are now literally inventing ourselves out of a job. During more than a million years of human evolution, we have had to work to feed ourselves. Work became a major tenant of human existence, and this is now changing rapidly. As a result, an increasing number of countries have recently begun to seriously investigate a guaranteed annual income—a near-term approach to the problem of machines taking away jobs, along with paying people to do stuff or otherwise trying to muddle through.
- **Shortages of clean drinking water, agricultural water, and food are increasing.** Aquifers and arable land are becoming saline, and climate change is altering precipitation patterns. A sizable portion of the population lacks access to quality drinking water. About one-sixth of the world's population rely on the major Eurasian rivers arising from Himalayan glaciers, which are melting away.
- **Income disparities are growing.** The newer industrial sectors now developing are largely a result of digital technologies, including information and communications technologies, big data, and, increasingly, artificial intelligence. Much of the profits from these endeavors are accruing to a relatively few, resulting in the much discussed "1 percent and 99 percent" problem. In *The Lessons of History*,[4] Will and Ariel Durant discuss the historically common cycle of wealth concentration and dispersal, sometimes via revolutions. This current manifestation is purportedly more extreme than in recent history and is not ameliorating.
- **The overburdened finite ecosystem is crashing.** We're short of necessary resources by about half a planet now. As burgeoning populations in the developing world, particularly in Asia, strive to attain Western living standards, that deficit will grow to an estimated three planets' worth of resources. And those resources are increasingly compromised: As recent research by the National Academy of Sciences[5] shows, one out of eight

deaths globally is due to air pollution. This dilemma requires an immediate shift to significant sustainability measures across the board; such measures could radically alter our current growth-based econometrics.

- **The human population continues to increase, placing ever more stress upon ecosystems.** Societal changes such as the education of girls and women have apparently reduced the rate of population growth, with below-replacement birthrates in some nations. But these reductions will be counteracted by increased longevity brought about by various biological and biotech revolutions. Human life spans are already lengthening by about a quarter of a year per year, and this rate of increase could approach one year per year through advanced genomics, synthetic biology, organ printing and replacement, artificial organs, cancer obviation, and DNA alteration with such techniques as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeat). With such developments, humanity may be forced to revisit progeny production.
- **Humans are becoming cyborgs.** Beyond the cochlear implants and artificial retinas, hearts, and limbs that humans have already added to their bodies will be, interestingly, brain chips to fix problems. Efforts are under way to provide brain augmentation. This arena has long been studied by the transhumanist movement and is developing rapidly thanks to biotechnologies and nanotechnologies.
- **Super-intelligent (beyond human) machines and machine intelligence are becoming possible.** While some regard this as a far-future possibility, others regard super-intelligent machines as an issue we had best start to address now before it becomes too late. Along with many issues cited herein, this is a hard problem since we do not yet know whether there is even a successful path to human-level machine intelligence. But, as discussed herein, several approaches are showing some promise.
- **There is bad news and improving news about climate change and energy.** Projections by the Intergovernmental Panel on Climate Change are proving conservative because it has not yet fully included various positive feedbacks due to a lack of scientific data. In reality, changes are generally occurring faster than projected. However, renewable energy sources are winning out over fossil fuels, now constituting some 60 percent of new generation. That percentage is growing. This success of renewables is apparently a result of decades of research yielding increased efficiency and reduced costs. At this point, the costs of renewables for electricity generation are falling to parity with fossil fuels. Fossil consumption across land, sea, and air transport is being replaced by

electric vehicles, thanks to improvements in electrical storage via advanced batteries, chemical storage, and many other approaches. A major ongoing shift in energy is toward distributed generation, which will enable more and more off-grid homes and ultimately alter the business models of central utilities.

Adding to these complex and interconnected societal issues are threats that yet lack solution spaces, such as "terrorism writ large"—the increasing capabilities of individuals to wreak mayhem using the various advancing technologies described herein. Another society-altering environmental threat comes from solar storms similar to the 1859 Carrington Event, which would potentially take down the electricity grids on which society is now wholly dependent.

Our strategies in the near to middle term will likely be influenced by various interests and agendas, and their effects over the longer term are to be determined. Consideration of many of these issues requires a highly knowledgeable electorate with keen interest in and knowledge of advancing future technologies, issues, and possibilities.

Historically, humans tend to do what we have been doing until we face the smoking guns and flaming datum indicating immediate threats we cannot easily avoid. Events associated with the issues of climate and ecosystem degradation, machines taking away jobs, income disparity, and the raw rapidity of technology-induced changes that are destabilizing the population are rapidly approaching that stage. It would be much better, perhaps, if we exercised foresight, strategic analysis, planning, and research to mitigate these various problems, again in a synergistic, multi-issue manner.

Lacking such concerted effort, a likely outcome could include societal disruptions and unrest.

Emerging Synergies in Farther-Future Solution Spaces

"Do-it-yourself" on steroids

In this "back to the future, back to the land" approach, a family could live in an electronic cottage on an acre or less of land, with distributed energy generation, on-site food production courtesy of the bio revolutions, on-site 3-D printing manufacture, and tele-everything (including telemedicine and tele-education). All systems are off the grids: energy, food, water, sewage, and so on.

Before the Industrial Age, very few had jobs per se—few worked for others for wages. Most of the population lived on the land and produced what they needed. Jobs are an artifact of the Industrial Revolution. We are now well beyond the Industrial Revolution and heading now into the Virtual Age, in which, with this approach, we would not need jobs. We could be living green and sustainably; with little income requirements per se, there would be no income disparities. This approach essentially solves the major issues except for the super-intelligent machines.

Halophytes and aquaculture provide energy and food

There are some 10,000 natural halophytes—plants that are tolerant to saline agricultural land. Many will grow reasonably well using direct seawater (no desalinization needed), even before we introduce advanced genomics. These plants could produce nearly all that glycophytes (freshwater plants) now produce.

The immense advantages of switching to halophytes include:

- Saline-tolerant plant biomass uses what we have a surfeit of (and what could be our last major play regarding the ecosystem): wastelands, deserts (44 percent of the land area), and seawater (97 percent of the planet's water resources).
- Seawater contains about 80 percent of the nutrients needed to grow plants, and researchers are developing new techniques to extract nitrogen from the air, thus requiring little fertilizer.
- Advanced technology is not required and cultivation uses inexpensive land and water, so the economics are reasonable. The shift to halophytes could be accomplished in relatively short order.
- Halophyte cultivation for food would free up the 70 percent or more of the freshwater we use for conventional glycophyte agriculture, and which we are now running out of for direct human use, thus solving both water and food problems.
- Cultivation of halophyte biomass would similarly obviate the use of arable land and freshwater for biofuels and provide petrochemical feedstocks for plastics and other industrial products. It is literally "green energy" and chemicals.
- Halophytes sequester up to 18 percent of their carbon dioxide uptake in their roots, removing CO_2 from the atmosphere.

- Seawater contains trace elements essential to healthy human physiology, which we have largely depleted from arable land due to overuse.

Cyanobacteria, seaweed, and algae represent another class of halophytes with potential for aquacultural development. Several of these produce excellent oils and protein and are far more productive than land-based plants. Through genetic engineering, aquacultural halophytes may have enormous productivity. The continent-sized nutrient stream that is the Mississippi River outflow into the Gulf of Mexico, which is now causing overly rich anoxic conditions, could possibly be used to foster aquaculture, thus reducing pumping costs, land taxes, and other costs. The worldwide capacity for aquaculture to replace freshwater use in producing food and biofuels—and provide sustenance to a much larger future human population—is massive.

Overall, halophyte cultivation and development could address our interrelated land, water, food, energy, and climate problems. This approach does not solve income disparity, the machines taking the jobs, or the intelligent machines problems. However, it would provide society some breathing room and push Malthus downstream by perhaps a century or more, thus alleviating many societal issues in a synergistic fashion.

The development of "mind children"

Though it is the longest term of our solution spaces, the human-machine convergence suggested by Hans Moravec[6] and others is increasingly possible, and perhaps probable.

Humans already are increasingly becoming cyborgs. The biological and biotechnology revolutions will provide greatly enhanced human health and augmentation, but such physiological augmentation will not provide what the inorganic, technological advancements can. Increasingly, we could become—in structure and functionality—more machine than wet electrochemistry, especially with regard to brain augmentation.

With advanced brain chips, heightened senses, greater spectral capabilities, and high-bandwidth communication directly into our augmented brains, we would limit the competition with machines and perhaps delay the robots taking all our jobs. As these technologies develop, humans will probably decide, individually, that the residual wet electrochemistry is simply not worth the maintenance and capability shortfalls and, as Moravec suggested, upload themselves into the machines. Hence humans would go forth to explore the universe as their "mind children."

Conclusion

In the usual way things unfold, these three approaches, along with others, will probably develop concomitantly; indeed, they are doing so already at a nascent stage. A fourth, nearer-term solution space under active discussion—guaranteed incomes—only solves the issue of machines taking away human jobs.

Ultimately, the many and serious concomitant societal issues are going to require change, which is hardly ever pleasant. We will be challenged to traverse these changes with our planetary "nest" and societal consilience intact. We are just now beginning to clearly define these problems and issues and to develop the synergistic strategies for the mid- to farther-term solution spaces. Our journey into the future will be "interesting." We shall live and we shall see.

References

1. Ray Kurzweil, *The Singularity Is Near,* Viking Press, 2005.
2. Ronald Wright, *A Short History of Progress,* Da Capo Press, 2004.
3. Thomas Robert Malthus, "An Essay on the Principle of Population," printed for J. Johnson in St. Paul's Churchyard, 1798.
4. Will and Ariel Durant, *The Lessons of History*, Simon and Schuster, 1968.
5. National Academy of Sciences, "The Future of Atmospheric Chemistry Research," The National Academies Press, 2016.
6. Hans Moravec, *Mind Children,* Harvard University Press, 1988.

| AAI |

AAI Foresight Inc. provides issues identification and tracking, strategic planning, organizational development, messaging, marketing, technological assessment, and strategic services for a broad range of clients.

1619 Main Street #1172
Freeland, WA 98249
www.aaiforesight.com

Contact: **Timothy C. Mack,** managing principal, tcmack333@gmail.com

Author photograph: Sean Smith / NASA