SPECIAL COMPETITIVE STUDIES PROJECT

Defense Paper Series

Exploring the Future Operating Environment: 2035-50

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This paper series includes discussion papers written by SCSP advisors to accompany our Defense Panel's 2024 Working Group Meetings. The views and opinions expressed in this newsletter are solely those of the authors and do not necessarily reflect the views or positions of SCSP.

We live in the thousand-year decade.[1] Technological progress has entered a period of sustained exponential growth[2] (Fig. 1).[3] We will see more progress between today and 2035 than in all of human history to date [60%]. Preparation requires anticipation. But anticipation amid such disruption is hard. Best practice for forecasting the future requires the attribution of probability assessments to uncertain future outcomes.[4] In this paper, the author's subjective probability assessments are provided in square brackets after the stated forecast, as at the end of the earlier sentence: "[60%]". We do not limit ourselves to forecasting only things >50%, since plausible events in 35-50% range with significant impact are important to consider in our FOE, in order to mitigate them.

The author's forecasts prompt the reader to calibrate their own. However, the best way of deriving such forecasts is from crowd judgements and those of 'superforecasters'[5] Where possible, these are used, taken from web-based crowd-sourced forecasts on platforms like Metaculus, and hyperlinked, vice footnoted, to distinguish them from more conventional sources.

Today, these forecasts estimate the arrival of weak artificial general intelligence (AGI) in 2027 (at the 75th percentile of human capabilities), Oracle AGI - one that outperforms us in all cognitive tasks – 21 month later, before the end of 2029. Artificial Superintelligence (ASI), one that surpasses us in all tasks including those requiring dexterity, locomotion

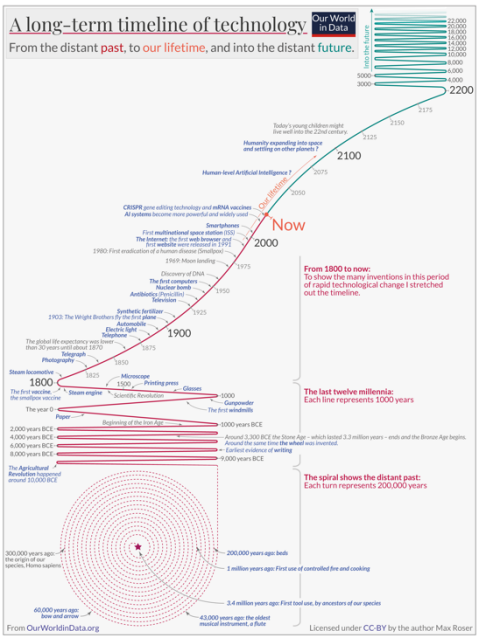

Figure 1. Visualising technological progress.

[1] Phrase taken from: Jason Bradbury, *The Thousand Year Decade.* e.g. https://greatbritishspeakers.co.uk/talents/jason-bradbury/

[2] Although some argue 'that ideas are getting harder to find', this is still compatible with exponential progress providing investment in R&D grows at rates corresponding with this increasing difficulty,
For the argument against see: Bloom, N., Jones, C.I., Van Reenen, J. and Webb, M., 2020. Are ideas getting harder to find?. *American Economic Review*, *110*(4), pp.1104-1144; Park, M., Leahey, E., & Funk, R. J. (2023). Papers and patents are becoming less disruptive over time. *Nature*, *613*(7942), 138-144.
For the reconciliation of the argument with continued growth see:

Crawford, J., 2022. *Ideas Getting Harder to Find Does Not Imply Stagnation*. Progress Forum. Available at: https://progressforum.org/posts/W6cSxas75tN8L47e6/draft-for-comment-ideas-getting-harder-to-find-does-not [Accessed 15 September 2024]; Brynjolfsson, E., Rock, D. and Syverson, C., 2019. *Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics*. In: A. Agrawal, J. Gans, and A. Goldfarb, eds. *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press, pp. 23-57. Available at: http://www.nber.org/chapters/c14007 [Accessed 15 September 2024].

[3] Max Roser (2023) - "Technology over the long run: zoom out to see how dramatically the world can change within a lifetime" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/technology-long-run' [Online Resource]

[4] Friedman, J.A., 2019. *War and chance: Assessing uncertainty in international politics*. Oxford University Press.

[5] Tetlock, P.E. and Gardner, D., 2016. *Superforecasting: The art and science of prediction*. Random House; Mandel, D.R. and Barnes, A., 2018. Geopolitical forecasting skill in strategic intelligence. *Journal of Behavioral Decision Making*, *31*(1), pp.127-137; Friedman, J.A., 2019. *War and chance: Assessing uncertainty in international politics*. Oxford University Press.

and proprioception, is forecast to arrive within 4.3 years of the weak AGI breakthrough, in 2032.

The forecasts for the arrival of all three are trending closer to the present day, not receding into the distant future. Crowd-judgements have been shown to usually outperform those of experts. But in any case, AI-expert forecasts also estimate 'Human Level Machine Intelligence' (aka Weak AGI) in the first five years of the period described in this SCSP assessment of the Future Operating Environment, with the aggregate forecast ascribing a 50% probability of this being achieved by 2040, "down thirteen years from 2060 in the 2022...[survey]".[6]

If it's more likely than not that humanity develops a technology that can outperform us in all tasks, either prior to 2035 or shortly thereafter, the Future Operating Environment 2035-2050 will be radically different from today, characterised by machine-leadership in all decisions, across the full range of policy functions, including those relating to war and warfare.

To envisage this world, we describe the FOE in terms of constants, trends and shifts.[7] Constants: those things that we judge will not change. Trends: those things that will change at a broadly predictable rate and direction. Shifts: non-linearities, grey swans, anticipatable but highly uncertain.

Constants

1. **The Unchanging Nature of War.** In warfare, everything is necessarily focused on psychological effect. For students of warfare this should need no elaboration – Clausewitz told us that war was simply the continuation of politics – getting others to act in your interest – by other means.[8] The US foreign policy expert and game-theoretician Thomas Schelling expressed this idea with even greater clarity writing that '*Violence's only purpose, unless sport or revenge, must be to influence somebody's behaviour, to coerce his decision or choice*'.[9] And indeed, the nuclear domain in which Schelling specialised makes this abundantly clear – even in the case of the use of the most violent and destructive weapons humanity has yet built, the dropping of nuclear bombs on Hiroshima and Nagasaki – the point was not the physical destruction caused, but the psychological effect they had on the Japanese leadership – the aim was to dissuade them from continuing a policy of fighting to the last man and to persuade them to offer an unconditional surrender.[10] Whether you are trying to drive soldiers off a hill, insurgents to the negotiating table, or governments to an unconditional surrender war is about changing behaviours: getting a group or individual

[6] Grace, K., Sandkühler, J.F., Stewart, H., Thomas, S., Weinstein-Raun, B., and Brauner, J., 2023. *2023 Expert Survey on Progress in AI*. AI Impacts Wiki. Available at: https://wiki.aiimpacts.org/ai_timelines/predictions_of_human-level_ai_timelines/ai_timeline_surveys/2023_expert_survey_on_progress_in_ai [Accessed 15 September 2024].

[7] adapted from the framework proposed by Brigadier Ayling (AUS, rtd): Ayling, S. H. (2000). Future warfare concepts: designing the future defence force. Australian Defence Force Journal, (144), 5–11. https://search.informit.org/doi/10.3316/ielapa.200104516

[8] Carl von Clausewitz et al., *On War* (Princeton: Princeton University Press, 1976), 87.

[9] Thomas C. Schelling, *Arms and Influence* (New Haven London: Yale University Press, 1966), p. 3.

[10] Walker, J.S., 2005. Recent literature on Truman's atomic bomb decision: a search for middle ground. *Diplomatic History*, *29*(2), pp.311-334.

to do something different to that which they were doing before (or sustaining a behaviour you want sustained).

What of **war in an age of superintelligent machines?** If only one side has access to such a technology, see 'shifts' for how this changes war. It would not change its nature, but it would likely be decisive, with its holder all but assured of victory.

Assuming both sides have access to such superintelligence, it is unlikely to be decisive on its own. War and warfare remain ultimately about informational inputs to the cognitive domain. Now we are seeking to coerce the decision or choice of a super-intelligent computer, a 'cognitive technology' constantly calculating the probabilities of victory, the path/s to success. As AlphaZero resigned playing Lee Sedol when the probability of victory dipped below 20%,[11] so future States may be setting the point at which they judge the continuation of conflict no longer advantageous. In Imperial Japan, that may have been close to 0% - only when the leadership knew there was no chance, did they surrender. In the Korean War, for both sides, it was clearly someway short of zero. Calculating what your adversary's threshold is will likely be a task for the machines too, reading psychometric data on leaders and populations, from (e.g.) eye, body- and voice- tracking of leaders, to social and streaming-service media, consumer purchasing data, movement patterns, to read the morale of citizens. Manipulating perceptions and behaviours through violent and propagandistic means. Put another way, while the nature of war will indeed endure, its character will be radically different.

This should not surprise. When AlphaZero learned to play Chess, Shogi and Go, it literally changed the game, playing in ways humans hadn't, and wouldn't[12] but now do – improving and out-performing even the Grand Masters in unexpected ways.[13] In war, it will be too risky to take authority away from the superintelligent machine, but assuming [95%] artificial intelligence remains the servant and not the master, the role of humans will be to set the parameters within which the machine prosecutes the war, albeit even those parameters will be set with the advice of the machine weighted heavily.

None of this will make war any more swift, any more certain, or any less bloody. States are sure to pursue decisive advantage, seeking to show they can deliver a 'knock-out blow' with various combinations of technology and approach. But this is almost certain [90%] to remain a chimera, as it has been throughout the history of war.[14] There is an irreducible

[11] Metz, C., 2016. *Go Grandmaster Lee Sedol Grabs Consolation Win Against Google's AI*. Wired. Available at: https://www.wired.com/2016/03/go-grandmaster-lee-sedol-grabs-consolation-win-googles-ai/ [Accessed 15 September 2024].
[12] Silver, D., Hubert, T., Schrittwieser, J., and Hassabis, D., 2018. *AlphaZero: Shedding New Light on Chess, Shogi, and Go*. DeepMind Blog. Available at: https://deepmind.google/discover/blog/alphazero-shedding-new-light-on-chess-shogi-and-go/ [Accessed 15 September 2024].
[13] Nielsen, P.H., 2016. *When Magnus Met AlphaZero. New In Chess Magazine: Issue 8, 2016*. New In Chess. Available at: https://www.newinchess.com/media/wysiwyg/product_pdf/872.pdf [Accessed 15 September 2024].
[14] Freedman, L., 2017. The Future of War: A History. *Hachette Book Group*.

uncertainty in the world that machines may better bound than the human analysts and leaders that preceded them, but which cannot be surmounted.

Similarly, Azar Gat's 'Red Queen effect' – after Lewis Carroll's *Through the Looking Glass* – will still hold. Though both offensive and defensive technologies will constantly vie for advantage, the overall effect will see them running ever faster only to stay in one place.[15] While there may be short-term advantage for attack or defence, distributed geographically or temporally, it will not be sustained. Most wars will be protracted, drawn out affairs. Even when a state is overrun, recourse to insurgency, guided by networked machine and cyborg intelligences - will see the war continue.

Thus war's nature will not change. It will be defined by violence for political purpose, and central to its nature will remain Clausewitz's chance, uncertainty and friction.

2. **Nuclear Deterrence.** The catastrophic effects of nuclear war will not be changed by the development of super-intelligent machines. While such machines could be used as systems of subversion, and might be able to exert considerable influence on people's attitudes and actions, they are unlikely to be persuasive to the point of being hypnotic. People are likely to be able to resist the siren call, no matter how perfectly pitched. Therefore, while you might be constantly outmanouvred poltically and militarily by a superintelligent AI leading the other side in war, you would retain your ability to strike back, even if only out of spite with all hope of victory gone. This being the case, while we don't rule out the possibility of improved methods of interception or interference to neuter a nation's nuclear arsenal, we judge that single biggest deterrent and/or coercive factor in international affairs and war, will remain nuclear weapons.

   Nuclear weapons will encourage restraint in nations going to war, and constraints in war as they seek to keep conflict below the threshold at which the other side might be prepared to risk armageddon by launching a nuclear strike.

   The most likely path to the breaking of the nuclear taboo will remain miscalculation during a conventional 'hot' war, rather than a dichotomous shift from cold or no war to nuclear exchange.

3. **The predominance and proliferation of intra-state over interstate wars.** As Lawrence Freedman notes, intrastate warfare, civil wars drawing indifference or interference, destabilising regions, causing widespread human suffering, have been the dominant form of warfare in the period from the end of the Cold War to 2024.[16] This can be expected to

[15] Gat, A., 2009. So why do people fight? Evolutionary theory and the causes of war. *European Journal of International Relations*, *15*(4), pp.571-599.
[16] Freedman, L., 2024. *Sudan: The Future of War?* Comment is Freed, Substack, 16 September. Available at: https://substack.com/@lawrencefreedman454213/p-148920934 [Accessed 16 September 2024]; Freedman, L., 2017. The Future of War: A History. *Hachette Book Group*.

continue. As ever more advanced technology increases the prosperity and power gap between developed and developing nations, we are likely to see a return of debates around the 'responsibility to protect'. It seems possible that developed nations will be less dependent on developing nations than today [55%], perhaps reducing the value or utility of proxy wars between powerful states. If this is so, intervention or indifference will be a solely moral debate, not one that turns on arguments around interests. The extent to which uncrewed systems, androids, cyborgs, can act as global policeman, as negotiators, as mass and individual manipulators in search of peace, is uncertain. That there will continue to be many intrastrate wars and moral demand for machine intervention, seems sure [90%].

Trends

Character of Conflict. Even with those things that won't change, there are important implications for the environment in which our Armed Forces and National Security Agencies will operate. But for those things where the thin whisps of tomorrow are already evident, change will come dramatically and rapidly.

Economically, even well short of AGI, we are already today at AI's 'jagged frontier' with human performance, where it increasingly outperforms us in a narrow domains, but with human advantage remaining in others. At AGI, none will be left where humans have the advantage. However, Defence will also need to consider that in part because of pervasive tech scepticism, tests of AI capabilities are generally being benchmarked against the peak of human performance. While the military and national security professions boast many truly elite individuals, operating at the frontier of human performance, it also, necessarily, contains a great many that are less than elite, average, and below average. By 2035-2050 it will likely be the case that the norm of authorising machines that significantly outperform most, but not all humans, to complete tasks better than we can, or reduce accidents or causalities, will likely be well established. Such norms will come when leaders in Government, the private sector, defence, lose legal cases where an individual or relative can show that statistically, they would been much less likely to come to harm were machines in control of a system or process, rather than humans. Self-driving cars and trucks, air transport, shipping, all seem likely to be in the vanguard of this process. The future will be uncrewed, and opposition to taking a human out of the loop will seem anachronistic and backward.

Within the period 2035-50, automation, robotics and artificial intelligence will have eliminated nation's dependence on people to create wealth, and scale armed forces to deter or fight [40%]. The iron shackle chaining destiny to demography will be broken. For national power, today so dependent on the vitality of a nation's ability to produce ideas, turn those ideas into products and services, and scale their distribution, this constraint will cease to apply: AI systems will research, invent, create, build, better than we can [70%]. Thus nations with smart strategies and systems will be able to outperform those with numerous citizens, regardless of how innovative those citizens might be [80%].

Transformation of state bureaucracies will be essential to succeed: the deliberate design of cybernetic systems – a system focused on outcomes, via the deliberate design of interconnected systems of components and incentives that self-regulate and adapt through

continuous feedback loops the key to success [60%]. Allende's *Cybersyn* in Chile – a cybernetic approach to state management - is likely to be the model for many experiments globally. This will perhaps prove easier for less democratic states, but not undemocratic states – think Singapore, holding advantage over the chaotic feedback loops of Anglo-Saxon and European democracies, but also over the autocracies where feedback loops cannot be too direct, for fear of Orwellian 'thoughtcrimes'. We are seeing this today with China's censorship, and efforts to protect 'core socialist values' , prevent 'the undermining of national unity' or the 'inciting of the subversion of state power'.[17] Such a system cannot function cybernetically, and will fall behind.

Where does a cybernetic future take the world's militaries? First, it optimises around outcomes. That sounds obvious but it isn't what we do now. Force structures and the systems we purchase are the result of multiple messy compromises. Figuring out how we would fight involves looking at the systems we have, and figuring out how we configure them to maximise our chances of winning. A rational system would optimise around $ cost / $ damage,[18] where damage is not just direct, but scored against how it changes the wider probability of success in conflict. Today such equations can only be used locally, but as simulation and learning systems become more capable, calculations will prove more reliable over a wider breadth and greater recursive depth. War becomes maths.

Nash Engine for Automated R&D. A cybernetic approach would build on the 'intelligence explosion' born of recursive self-improving AI, and scientific runaways enabled by self-driving labs.[19] It would link sensor data from the frontline directly into the self-driving lab, the front end of the loop for automated R&D, such that as battle rages, data is being fed back: version 1.1. of the drone, the rifle sight, the directed energy weapon, the electronic warfare device, will be designed and produced based on the requirements identified from sensor data, flowing back through the system, in real-time.

More than that. A Nash-engine would be constantly seeking to forecast, ahead of what is happening, nanoseconds, seconds, minute, hours, days, weeks, months, maybe years, to calculate the moves and capabilities needed to win wars. It would a be simulation engine, fed by digital twins of the real-world, to design and test capabilities. [20] Yes, it would have to mitigate challenges such as the Base of Sand Problem, where small model errors get aggregated as systems become larger and more complex, and non-monotonicity and chaos

[17] McMorrow, R. and Hu, T., 2024. *China Deploys Censors to Create Socialist AI. Financial Times*, 17 July. Available at: https://www.ft.com/content/10975044-f194-4513-857b-e17491d2a9e9 [Accessed 17 September 2024].
[18] Dear, K. and Brown, A., 2024. *Ready for a Fight: 5 Provocations for Change*. Wavell Room, 28 June. Available at: https://wavellroom.com/2024/06/28/ready-for-a-fight-change-warfare/ [Accessed 17 September 2024].
[19] Schmidt, E., 2023. *Eric Schmidt: AI Will Transform Science*. *MIT Technology Review*, 5 July. Available at: https://www.technologyreview.com/2023/07/05/1075865/eric-schmidt-ai-will-transform-science/ [Accessed 17 September 2024]; Mollick, E., 2024. *Four Singularities for Research: The Rise of AI is Creating Both Crisis and Opportunity*. *One Useful Thing*. Available at: https://www.oneusefulthing.org/p/four-singularities-for-research [Accessed 17 September 2024].
[20] Perolat, J., De Vylder, B., Hennes, D., Tarassov, E., Strub, F., and Tuyls, K., 2022. *Mastering Stratego: The Classic Game of Imperfect Information*. DeepMind Blog, 1 December. Available at: https://deepmind.google/discover/blog/mastering-stratego-the-classic-game-of-imperfect-information/ [Accessed 17 September 2024]; & e.g. Skyral, 2024. *Government Solutions and Capabilities*. Skyral. Available at: https://www.skyral.com/government/[Accessed 17 September 2024].

in combat models, where weird mathematical phenomena seemingly distort simulation outcomes.[21] It would also have to overcome the challenges faced by RAND's GREEN (General Research, Engineering, and Evaluation Network) and SimNet[22], which never quite lived up to their promise despite significant sums spent on them by the DoD through the 1980s in particular.

However, recent and promised breakthroughs point the way. Deepmind's AlphaStar mastering Starcraft II, required the application of game theory, long-term planning, in real time, in vast action space, with partial observability and thus uncertainty. The company's DeepNash mastering Stratego, showed how AI can master uncertainty and successfully balance outcomes to help solve complex problems. Quantum computing, with its promise of unprecedented computational power and fundamentally new forms of simulation will help overcome past challenges. Simulations constantly refined and tested vs observed outcomes in massive digital twins will ensure progress.

The automated R&D pipeline of the future will link:

1. Information requirements from academia, industry, Government, defence, *citizens*, through crowd-source question generation tools, will be linked to sensors in the frontline.
2. Real-time data from sensors at the front line, from intelligence sources, & feedback from the constantly running simulations in the Nash-Engine will recursively update those information requirements and,
3. Feed the front end, hypothesis generation of the self-driving lab.
4. This in turn will feed the scientific experiments needed to produce new materials, designs, approaches, systems, capabilities – remember that in 2023 Materials Science was revolutionised when Deepmind's GNoMe (Graph Networks for Materials Explorations) discovered 2.2 million new forms of crystal, 380,000 years' worth of knowledge?[23] By 2050, this kind of discovery will be constantly applied in manufacturing, and in defence innovation pipelines, faster and more effectively. From this, will flow…

Factory requirements – factories that at first will be fully automated but otherwise much as today, will as we approach 2050, likely have moved from traditional warehouse-like, robotic production line designs, to additive manufacturing centres ever closer to the Star Trek

[21] Davis, P.K. and Blumenthal, D., 1991. *The base of sand problem: A white paper on the state of military combat modeling*. Santa Monica: Rand; Dewar, J.A., Gillogly, J.J. and Juncosa, M.L., 1996. Non-monotonicity, chaos and combat models. *Military Operations Research*, pp.37-49.

[22] Van Creveld, M., 2013. *Wargames: From gladiators to gigabytes*. Cambridge University Press; Davis, P.K., 1984. *RAND's Experience in Applying Artificial Intelligence Techniques to Strategic-Level Military-Political War Gaming*. RAND Corporation. Available at: https://www.rand.org/pubs/papers/P6977.html [Accessed 17 September 2024]; Ben-Horin, Y., Lorell, M.A., Schwabe, W., and Shlapak, D.A., 1986. *The RAND Strategy Assessment System's Green Agent Model of Third-Country Behavior in Superpower Crises and Conflict*. RAND Corporation. Available at: https://www.rand.org/pubs/notes/N2363-1.html [Accessed 17 September 2024].

[23] Materials science is a discipline born in the 1940s. In wartime it was applied interdisciplinary research collaboration for the development of new weapons and military systems. The implications of the GNoMe revolution for defence should be clear.

Before GNoMe, human experimentation had produced 20,000 computationally stable crystals in the history of science to that point, while other attempts to apply computational methods had still only yielded a further 48,000. Deepmind has open sourced the results.

'replicator' able to manufacture anything[24]; digital fabrication labs[25], doubling in number every year and a half in 2023, will turn data into bespoke objects while enabling localised manufacture.[26] The convergence of additive manufacturing, chemputing[27], bioprinting[28], molecular assemblers[29], nanofactories[30], and the further development of science to turn light into matter will transform manufacturing and assembly. Procurement contracts, even for hardware, will be service contracts, everything updated all the time. There is no waste. Everything is recycled into new systems.

At its apogee, automated innovation pipelines create a world where atoms move as fast as bits. Digitally fabricated systems comprised of nanobots, receive the data and information, the requirements, the intelligence, just like the factories and fab labs, and literally reconfigure themselves in flight or during the fight,[31] optimising against the threat picture before them tactically, and configuring into formation and the wider strategic or operational attack/defensive profile according the wider instructions of the Nash Engine.

By 2050. those systems have long-since been fully uncrewed. The battlefield increasingly resembles a dystopian zoo, as biomimetic systems are deployed – biological evolution at first pointing the way to what is possible in machines, and later surpassed. Machines are themselves increasingly hybrid bio-mechanical systems, with the size, weight and power advantages of bioengineered 'wetware' increasingly outperforming the hardware of the early AI revolution in the 2020s. Machines are cyborg, in being combined with biological systems, but not in the sense of being in anyway meaningfully human. So too in command positions. Just as today, human wetware is the limiting factor in, for example, centaur chess – where the machine now beats the human-machine team – so in the period 2035-2050, human intelligence and our

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[24] See recent research breakthroughs e.g. elly, B.E., Bhattacharya, I., Heidari, H., Shusteff, M., Spadaccini, C.M., and Taylor, H.K., 2019. *Volumetric Additive Manufacturing via Tomographic Reconstruction*. *Science*, 363(6431), pp.1075-1079. DOI: 10.1126/science.aau7114; Pagac, M., Hajnys, J., Ma, Q.P., Jancar, L., Jansa, J., Stefek, P. and Mesicek, J., 2021. A review of vat photopolymerization technology: materials, applications, challenges, and future trends of 3D printing. *Polymers*, *13*(4), p.598; Somers, P., Münchinger, A., Maruo, S., Moser, C., Xu, X. and Wegener, M., 2024. The physics of 3D printing with light. *Nature Reviews Physics*, *6*(2), pp.99-113;

[25] A $38Bn market in 2023, 30% CAGR to $238Bn by 2030. Global Digital Fabrication Market Size 2023 : Industry Insights, Emerging Trends, Future Demand And Forecast To 2030 | Stratasys Ltd., 3D Systems Corporation, HP Inc (digitaljournal.com)bur1edl*d*9

[26] See Gershenfeld, N., Gershenfeld, A. and Cutcher-Gershenfeld, J., 2017. *Designing reality: How to survive and thrive in the third digital revolution*. Hachette UK. & Fab City Global Initiative: Join Sustainable Cities Movement

[27] Keats, J. 2021. *Using an Automated Chemistry Lab to Find the Origin of Life*. Discover.

[28] Lee, H., 2023. Engineering In vitro Models: Bioprinting of Organoids with Artificial Intelligence. *Cyborg and Bionic Systems*, *4*, p.0018.

[29] L. R. Liu, J. D. Hood, Y. Yu, J. T. Zhang, N. R. Hutzler, T. Rosenband, and K.-K. Ni, "Building one molecule from a reservoir of two atoms," Science 360, 900 (2018).

[30] '*Stereodivergent synthesis with a programmable molecular machine*' Salma Kassem, Alan T. L. Lee, David A. Leigh, Vanesa Marcos, Leoni I. Palmer and Simone Pisano, *Nature*, **549**, 374-378 (2017). Summarised in Leigh Group, 2017. Building with a Programmable Molecular Robot. University of Manchester.

Engwerda, A.H. and Fletcher, S.P., 2020. A molecular assembler that produces polymers. *Nature Communications*, *11*(1), p.4156.

[31] Gershenfeld, N., Gershenfeld, A. and Cutcher-Gershenfeld, J., 2017. *Designing reality: How to survive and thrive in the third digital revolution*. Hachette UK; Fridman, L., 2021. *Neil Gershenfeld: Physics, Fab Labs, and the Future of Machines*. Lex Fridman Podcast. Available at: https://lexfridman.com/neil-gershenfeld/ [Accessed 17 September 2024].

brains, no matter how intensely bioengineered and fused with machines, will be the limiting factor on machine intelligence. War is a human endeavour only in that the nations and states give the machines their mandate, their parameters, their orders, the objectives they are to optimise against. Machines explain when trade-offs are necessary, and human leaders accept or reject them. But the speed of warfare between machines is such that this is not possible at the tactical level.

This AI-enable R&D cycle makes bioweapons the new WMD, with mutually assured destruction leading to intense global regulation. Humanity delegates authority to track, prevent and counter pandemics to super-intelligent machines, yielding human agency in return for global safety.

After the intelligence explosion, perhaps the most profound change to the operating environment is the way in which we move increasingly beyond the 'Geo' in Geopolitics'[32]:

As demography matters less for a nations relative power in the world – and as we have suggested, perhaps not at all – other profound changes in the operating environment follow.

We live in a smaller world; distance shrunk; more interconnected. Transport is transformed. Transport of goods is automated everywhere. Transport of humans a mix of crewed and uncrewed systems. The world is small because journeys are so much quicker - jets, trains, flying taxis, spacecraft dipping in and out of orbit[33], maybe orbital rings and space-based logistics serving the planet – increasing trade and travel. New forms of fuel and propulsion accelerate net zero without compromising connectivity. For militaries, supply chains can operate faster, more efficiently, more effectively. Theatre entry will be challenged as it always has been, as countries attempt to interdict, disrupt, destroy supply chains, or seek to maintain air, sea, coastal defences that can maintain 'area denial' and keep an enemy away. But when this fails, it will be possible to much more rapidly deploy forces, and to sustain them at scale, anywhere on earth. For nations whose remoteness was once a protection – Australia and US notably – the shrinking of distance with much faster transport will have the more profound effects, increasing mainland vulnerability. Geography will be less protective.

National energy self-sufficiency will be widespread. Breakthroughs in Fusion energy, enabled by self-driving labs[34], dramatically reduce the cost of production and of living. This breakthrough allows nations to become energy independent.[35] In-space solar farming, wireless energy transmission, portable energy storage via super-capacitators transform the energy market, making roads and homes themselves energy storage and distribution

[32] Dear, K. (2022). Beyond the 'Geo' in Geopolitics: The Digital Transformation of Power. *The RUSI Journal*, *166*(6–7), 20–31. https://doi.org/10.1080/03071847.2022.2049167

[33] Sydney Morning Herald, 2019. *Hypersonic Jet Could Slash Flight Time from Sydney to London to Four Hours, Say UK Space Agency*. *Sydney Morning Herald*, 25 September. Available at: https://www.smh.com.au/traveller/travel-news/hypersonic-jet-could-slash-flight-time-from-sydney-to-london-to-four-hours-say-uk-space-agency-20190925-h1icaa.html [Accessed 17 September 2024].

[34] Deepmind. 2022. Accelerating fusion science through learned plasma control.

[35] DTU. 2023. Global Wind Atlas.

facilities.[36] Wireless energy powers the home, and many military facilities.[37] Geography matters far less in a nation's energy policy. Dependence on overseas fuels is a thing of the past.

Nation states will still be the most powerful 'imagined communities' but will face competition for citizens. "The empires of the future are the empires of the mind" as Churchill put it.[38] Just as today our phones are no longer a tool that we use but a place where we live, so our minds will spend more and more time in borderless, geography-less virtual worlds. Such worlds already exist in prototypical form. In some online games, in vast virtual worlds, such as Roblox, players are spending an average of twelve hours a week in online games,[39] or 26 days a year already. They are able to make money, in proto-economies, sometimes exceeding the minimum wage in the countries they live in, increasing their real-world wealth. There's the social aspect – people have been radicalised in these Roblox games. One Iranian Presidential candidate talked about building 'a virtual Iran' to recruit citizens too. Estonia and other nations are pioneering e-citizenship and e-businesses. Increasingly, competition for consumers of all those products and services will be found online. Nations will compete for citizens for their virtual worlds. Some estimates suggest that metaverse – or virtual world – economies will exceed that in the real world long before 2035.[40]

Just as tourism will be able to be done virtually, in augmented reality, so too espionage. People will live in different 'belief circles', living in the same towns, walking in the same streets, but with very different augmented reality layers, seeing different signs, accompanied by different people. The CCP's effort to regulate online games such as Fortnite, and e-sports events, to stop their citizens encountering 'wrongthink' show the risk (and opportunities) such virtual worlds will create.

Military competition in the Metaverse may have already begun. The tank game War Thunder, is so realistic, users in Western militaries have been frustrated when their own nations tanks don't perform as they know they can. One French and one British tank crew member, have each separately uploaded classified information to the games servers, to persuade the game's developers to increase their LeClerc and Challenger tank capabilities in the game. The trouble is, the game is built by a Russian company. Russia and China have used it at trade expos to showcase the apparent superiority of their tanks to encourage sales.[41] Contrastingly, one

[36] MIT News, 2023. *MIT Engineers Create Supercapacitor from Ancient Materials*. MIT News, 31 July. Available at: https://news.mit.edu/2023/mit-engineers-create-supercapacitor-ancient-materials-0731 [Accessed 17 September 2024]; Sky News, 2023. *Quest to Power Homes with Solar Panels in Space Passes a Critical Milestone*. *Sky News*, 31 July. Available at: https://news.sky.com/story/quest-to-power-homes-with-solar-panels-in-space-passes-a-critical-milestone-13107285 [Accessed 17 September 2024].
[37] Hareven, B., 2024. *Wireless Electricity Is Real – So Why Isn't It Everywhere? Forbes*, 9 June. Available at: https://www.forbes.com/sites/bennyhareven/2024/06/09/wireless-electricity-is-real--so-why-isnt-it-everywhere/[Accessed 17 September 2024].
[38] Churchill, W.S., 1943. *The Gift of a Common Tongue*. International Churchill Society. Available at: https://winstonchurchill.org/resources/speeches/1941-1945-war-leader/the-gift-of-a-common-tongue/ [Accessed 16 September 2024].
[39] **Atom Stars**, 2024. *Gen Z Engagement in Games and Virtual Worlds*. Available at: https://atomstars.com/blog/crazy-genz-gaming-demographics-that-cmos-ignore [Accessed 17 September 2024].
[40] Dear, K. (2022). Beyond the 'Geo' in Geopolitics: The Digital Transformation of Power. *The RUSI Journal*, *166*(6–7), 20–31. https://doi.org/10.1080/03071847.2022.2049167
[41] Ibid.

Ukrainian gunner in a US Bradley armoured vehicle, claims to have known how to destroy a T90M from having played War Thunder many times, and known its vulnerabilities.[42] Where does this go by 2050? Deterrence is signalling. Like an ape beating its chest, the size and colour of the lion's mane, the growl of a dog – all these things are to deter. In human groups the beating of shields, war cries and more, were dances to deter. By 2050, massively highly realistic simulations will likely be a key part of deterrence, a location to signal strength. The dances to deter will take place primarily in the metaverse.

With commercial space companies bringing the cost of getting to space down to $10 per KG in the 2020s,[43] energy costs dropping precipitately, and artificial intelligence reaching ASI levels, the most lucrative markets in human history will be found in space. Space mining[44] and the space economy[45] will have changed the balance of power on earth. The pursuit of El Dorado will have launched an age of mercantilist space industries, supported by states, colonising the solar system, perhaps beyond by 2035. The asteroid Psyche-16 alone is sometimes said to hold US$10 quadrillion in minerals, 70,000x global GDP (in 2023). The industry will be dominated by AI-agents and telepresent, telexistent, human interaction, much via neural interfaces connecting humans with machines, and humans with humans. By 2050, nations and corporations commence space colonialism at scale, populating galaxies with AI-agents to create solar farms and energy settlements on planets to extend the reach of their mining enterprises. Big compute is in orbit, where power, cooling and connectivity savings outweigh launch costs. War in space is now not just about what happens on earth, but on seizing valuable territories and industries. Controlling strategically placed planets as once we competed to control strategically placed ports.

Creating wealth in space, reducing reliance on people in discovery, innovation, manufacturing, and services, energy independence, sends production soaring. Access to consumers and markets to buy the almost limitless supply of goods and services is fiercely protected, contested. Trade barriers and blocs strengthen, solidify. In consequence, metaverse economies boom, their consumers unconstrained by geography. First, with in-game economies encompassing everything from real-estate to fashion. Then with augmented accessories architectural and personal, then as a multiverse of parallels worlds at times overlapping and integrated with an authoritative augmented and virtual layer that wraps and duplicates, enhances, blurs the boundaries of the physical. Virtual countries allow e-citizens from all nations to join, reducing migratory pressures, opening markets trade barriers can't interdict.

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[42] Altman, H., 2024. *Video Games Helped Ukrainian Bradley Gunner Win Duel With Russian T-90M Tank*. TWZ. Available at: https://www.twz.com/video-games-helped-ukrainian-bradley-gunner-win-duel-with-russian-t-90m-tank [Accessed 17 September 2024].

[43] Wang, B., 2024. *How Will SpaceX Bring the Cost to Space Down to $10 per Kilogram from Over $1000 per Kilogram?* NextBigFuture, 19 January. Available at: https://www.nextbigfuture.com/2024/01/how-will-spacex-bring-the-cost-to-space-down-to-10-per-kilogram-from-over-1000-per-kilogram.html [Accessed 17 September 2024].

[44] David. L. 2023. Space mining startups see a rich future on asteroids and the moon. Space.com

[45] Remington, T. Talton, E. 2018. *Space Tech Startups Are The Key To Making Life On Mars Possible*. Forbes Magazine.

Distributed edge compute is appearing in wearables and implants. Implanted tech combined with cryptologic signing and differential privacy technology means that information and data ownership are becoming realistic prospects. Cyborgs are both fashion and reality. Technologically enabled people can now broker a satisfactory balance between being a part of the digital whole, and being an individual with agency. Those who are not adopting these technologies are less empowered, less agentic, constantly microtargeted with ever-increasing psychometric accuracy. Law and order becomes more anticipatory, with the boundary for intervention to prevent crime, opening up similar debates on life chances and life choices.

Shifts

The trends of increasing migration, falling birth rates, increasing longevity may create more fundamental shifts. While it is most likely the migration and integration continues as for centuries, stop-start, occasionally violent, often tense, but nevertheless continuous. It is possible it leads to a small number of less populated, wealthy states that wall themselves off from the great mass of the globe, especially once demography no longer matters for productivity and prosperity. Such a situation would require constant policing, enforcement. It would likely see accelerating inequality, not just of wealth but of health, intelligence and many other currently fixed and somewhat randomly distributed features, as humans edit their genetic make-up, fuse with machines, enhance their biology: make inequality deterministic.

Another potential shift is that just Deepmind's once fanciful mission to 'solve intelligence' now seems not so far fetched – indeed more likely than not – so too those working to 'cure death', might make real progress, perhaps even achieve it, by 2050. Such an outcome would change politics forever. Perhaps making humanity more long-term in its outlook, but also less able to recycle wealth, create equality of opportunity.

It is possible that rather than several nations reaching and having access to AGI and ASI, only one does. Should this happen, it is likely no nation would ever catch them, and they could dominate global (and interplanetary) politics and economics such would be their state of advancement, and race of advance. If a nation does achieve such 'innovation escape velocity', it is not clear how much time, if any, would be enough to force them to share, or to destroy what they have built.

Finally, amid this ASI future, there is the small chance that emergence leads to agentic systems that seek to subjugate us, as described by those concerned with existential risk from AI. It is also possible it creates a Deeptopia, where humanity occupies itself with a search for transcendental meaning, in people's roles in community and search for something greater.

But in this FOE it is thought these possibilities unlikely. We will live in a world directed, commanded, by humans, but managed by machines. And we will work, and live with them among us, as guides and aides. We will seek to 'get along' and 'get ahead' as fundamental evolutionary drives. AI, no matter how anthropomorphised, will remain a tool and aide in this pursuit. People will still work, and trade, and struggle, and soar. War will remain a tool too. We will be no more free the scourge of it.

Probability Range	Judgement Terms	Fraction Range
≤ 5%	Remote chance	≤ 1/20
10% – 20%	Highly unlikely	1/10 – 1/5
25% – 35%	Unlikely	1/4 – 1/3
40% – < 50%	Realistic possibility	4/10 – < 1/2
55% – 75%	Likely *or* Probably	4/7 – 3/4
80% – 90%	Highly likely	4/5 – 9/10
≥ 95%	Almost certain	≥ 19/20

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