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Title-2: **AGE OF ABUNDANCE: A Vision for**

OPENING THOUGHTS

Peter Thiel famously asked, "What important truth do you believe, that very few people agree with you on?" Despite all the dystopian news stories on climate change, political polarization, natural disasters and wars, I believe that today is, by far, the single best time in all of human history to be alive.

Over the past three decades, I've had the privilege of studying exponential technologies and their convergence patterns. I've founded organizations like the XPRIZE Foundation and Singularity University, co-authored books on abundance and exponential thinking, and worked alongside brilliant entrepreneurs and scientists who are literally remaking our world. Through my Abundance Community, *Moonshots* podcast, and countless conversations with visionaries from Ray Kurzweil to Elon Musk, I've come to understand a fundamental truth that is giving birth to an extraordinary future, namely:

"The speed of exponential tech is accelerating, and these technologies are converging and reinventing everything in their path. There will be much change, but that change will uplift humanity, create abundance, and give us a vacation from survival. In the process, we, all of us, are gaining godlike powers."

The next decade—2025 to 2035—represents the most transformative period in human history.

We're not just experiencing isolated technological breakthroughs; we're on the cusp of 10 simultaneous Metatrends that will transform every aspect of our lives – how we raise our children, run our companies, govern our nations and live our lives.

Consider this: when I was in medical school in the late 1980s, the idea that a computer could diagnose disease better than a doctor was ludicrous. Today, that is a fact. Even more insane is the realization that these AI systems revolutionizing medicine are available for free to anyone with a smartphone. But that's just *one* Metatrend.

What happens when AI converges with humanoid robotics, quantum computing, space manufacturing, and biotechnology—all in the same decade?

The answer is abundance at a scale we've never imagined.

"Exponential technologies are resource-liberating mechanisms, transforming scarcity into abundance, uplifting humanity and redefining prosperity. Since the dawn of humanity, a privileged few have lived in stark contrast to the hardscrabble majority. But this gap is closing. Fast."

This report examines 10 Metatrends that are simultaneously reaching inflection points between now and 2035. From universal access to food, energy, and education powered by AI and automation, to the emergence of digital superintelligence that outperforms humans in every cognitive domain. From billions of humanoid robots transforming labor and caregiving, to longevity breakthroughs that will add decades to our healthspan. From digital currencies that democratize finance globally, to transportation systems that are autonomous, electric, and airborne.

So, Why Now? Each of these Metatrends builds upon accelerating computation, advanced materials, artificial intelligence and a host of other exponential technologies. But their true power emerges from their convergence. AI enhances every other technology. Robotics enables space exploration and digital manufacturing. Quantum computing accelerates drug discovery and materials science. Networks and sensors create the data layer that makes everything else smarter.

The result is that we're approaching what I call the "**Abundance Inflection Point**": the moment when exponential technologies converge to solve humanity's greatest challenges faster than new problems can emerge.

"As these trends continue, we will soon have the ability to meet and exceed the basic needs of every man, woman, and child on the planet. Abundance for all is within our grasp."

The Demonetization Pattern: Throughout history, what begins as expensive and exclusive becomes cheap and universal. The first computers cost millions and filled entire rooms. Today, your smartphone has orders of magnitude more computing that the processing power that took the Apollo mission to the Moon. The same pattern is unfolding across every Metatrend in this report. Gene sequencing dropped from $100 million to $200 per genome. Solar energy costs have fallen 85% in a decade. Soon, we'll see the same transformation in longevity therapies, access to Earth orbit, personalized education, and advanced manufacturing.

This isn't speculation on my behalf... it's pattern recognition.

The entrepreneurs and scientists I work with are doing more than building better products... they're engineering abundance itself. They're turning scarcity into abundance, transforming what was expensive into what's now free, and making what was once available only to the wealthy accessible to everyone on Earth.

Acknowledging the Risks: Make no mistake, these exponential technologies also bring profound risks that we must navigate wisely. From AI alignment challenges and job displacement to privacy erosion and new forms of inequality, each Metatrend in this report carries potential dark sides that require our vigilance and proactive governance. Throughout this report, I'll examine both the extraordinary opportunities and the serious risks these technologies present, because abundance without wisdom is not abundance at all.

My goal with this report is twofold. First, to help you understand the science, timeline, and business opportunities emerging from these ten decade-long Metatrends. Second, to challenge the scarcity mindset that pervades our media and culture. When you understand exponential technologies and their convergence patterns, you realize that our greatest challenges—climate change, energy access, healthcare and education inequality—are not "unsolvable problems" but engineering challenges with clear technological pathways to abundance.

This transformation from scarcity to abundance, from expensive to demonetized, from the rich to everyone, is happening in every industry, everywhere on the globe. The question isn't whether these changes will occur, it's whether you'll be positioned to benefit from them, invest in them, and help guide them toward outcomes that serve all of humanity.

I hope you enjoy this Metatrend Report and are preparing for a future where abundance isn't just possible but inevitable.

Best wishes,

Peter H. Diamandis, MD
Founder & Executive Chairman, XPRIZE Foundation

Executive Founder, Singularity University
Founder, Abundance360
Co-Founder and Executive Chairman, Fountain Life
Author: *Abundance*, *BOLD*, *The Future Is Faster Than You Think*, *Life Force*, *Longevity Guidebook*

WHAT IS A METATREND?

A Metatrend is the unstoppable, long-term transformation of an industry or domain—such as education, energy, or space—propelled by the convergence of multiple exponential technologies. It is a sweeping wave of change, a tidal force gathering momentum from ever-increasing computational power, artificial intelligence and robotics. As it advances, it systematically **digitizes, dematerializes, demonetizes, and democratizes** the field, reshaping it at an accelerating pace and unlocking entirely new possibilities.

KEY TAKEAWAYS

7 INSIGHTS FOR THE NEXT DECADE OF EXPONENTIAL CHANGE

1. THE CONVERGENCE DECADE

2025-2035 represents the most transformative period in human history, as **10 fundamental Metatrends simultaneously reach inflection points.** Unlike isolated technological breakthroughs, we're witnessing unprecedented convergence: **AI enhances every other technology**, robotics enables space exploration and digital manufacturing, quantum computing accelerates drug discovery, and networks create the data layer that makes everything smarter. This represents **exponential multiplication.** It's not only new technologies and new companies, but also new business models. We are witnessing a "Cambrian Explosion" of creative genius solving problems on a global scale, at the speed of digital superintelligence.

2. THE ABUNDANCE INFLECTION POINT

We're approaching the moment when **exponential technologies solve humanity's greatest challenges faster than new problems emerge.** By 2035, **the three pillars of abundance—food, energy, and education—will be democratized at scale** through autonomous systems and AI. **Local production will meet 90%+ of caloric needs**, abundant clean energy will be harvested and traded locally worldwide, and **every child will have access to personalized AGI tutors.** *What used to be charity soon becomes protocol.*

3. INTELLIGENCE BECOMES SUBSTRATE

AI will evolve from a tool to the fundamental substrate of civilization itself. Every person will deploy personalized swarms of AI agents handling research, negotiations, and creative work. **Scientific discovery becomes autonomous and continuous**, with AI agents autonomously running millions of experiments daily. Governments will simulate policies before implementation, and **quantum-AI systems will solve previously intractable problems** from in silico simulation of human biology to climate geoengineering.

4. THE ROBOT REVOLUTION REDEFINES HUMAN LABOR

Two hundred and fifty million or more humanoid robots will integrate into daily life by 2035, handling 80% of household chores, providing 24/7 eldercare, and working alongside humans in construction and manufacturing. Humanoid robots will quickly tackle the jobs that are dull, dangerous, or dirty. These robotic systems will work in **extreme environments including off-world on the Moon, Mars, and on asteroids**, preparing the way for human settlement. This represents **the greatest transformation of human labor since the Industrial Revolution**, potentially eliminating labor scarcity while raising profound questions about purpose and human identity.

5. BIOLOGY BECOMES PROGRAMMABLE

Medicine shifts from reactive to anticipatory, with **aging becoming optional rather than inevitable.** Continuous health platforms will **scan millions of biomarkers in real time**, detecting disease years before symptoms appear. **Digital twins will test treatments virtually** before they reach your body. Cellular reprogramming, organ printing, and AI-designed therapies will **extend healthspan by decades**, with people in their 80s routinely starting companies and training for marathons.

6. THE DEMONETIZATION CURVE ACCELERATES ACROSS ALL DOMAINS

The pattern of expensive-to-free is unfolding simultaneously across every Metatrend. How incredible is it that the most powerful technology in the world, namely advanced AI systems, are now free to billions of humans around the world? Gene sequencing dropped from $100 million to $200. Soon, longevity therapies, space access, personalized education, and advanced manufacturing will follow the same trajectory. **What begins as accessible only to billionaires becomes available to everyone**, turning scarcity into abundance and making the impossible inevitable.

7. NEW RISKS REQUIRE NEW WISDOM

With great power comes great responsibility. Without question, each Metatrend carries profound (potential) dark sides that demand proactive governance. From **AI alignment challenges and mass job displacement** to privacy erosion and new forms of inequality, **exponential technologies amplify both opportunities and dangers.** The speed of change may outpace human wisdom and regulation, requiring **unprecedented cooperation between technologists, policymakers, and society** to ensure abundance benefits all humanity rather than concentrating power among the few. Simulating all the potential futures that are held in superposition by these technologies, understanding our preferred path and proactively doing what it takes to choose and implement that path is critical. Our goal is creating an intentional future.

STAR TREK VS. MAD MAX

When I was growing up in the 1960s, I was witness to a dramatic **one-two punch** that shaped my mindset forever, providing me with an optimistic, abundant and Moonshot vision of the future. he dynamic duo was the release of the TV series *Star Trek* (1967) and the Apollo 11 Moon landing (1969). Apollo showed me what extraordinary achievements humanity could accomplish, and *Star Trek* offered me a bold and beautiful vision for our future.

It's been said that "without a vision the people will perish." I believe that to be true. We humans need a compelling, hopeful and abundant vision of the future that fuels us to overcome hardships and challenges. A reason to wake up every day and create a better tomorrow.

Personally, I'm saddened by the constant flow of dystopian visions put forward by Hollywood. Story lines of killer robots and AIs gone insane. In these cinematic visions of the decades to come, over and over again technology doesn't uplift humanity but instead pushes it to the brink of extinction.

The author Matt Ridley put it beautifully in his most excellent book, *The Rational Optimist,* when he said:

> *"It's incredible, this moaning pessimism, this knee-jerk, things-are-going-downhill reaction from people living amid luxury and security that their ancestors would have died for. The tendency to see the emptiness of every glass is pervasive. It's almost as if people cling to bad news like a comfort blanket."*

Much of this is due to the wiring of our brains for fear. From the earliest days of human evolution, the amygdala—the brain's threat detection center—learned to prioritize danger over opportunity, giving ten times more attention to bad news than to good. This ancient survival mechanism kept our ancestors alive, but in today's world it often works against us.

Hollywood has mastered the art of feeding this negativity bias with dystopian blockbusters, while the news media—what I sometimes call the *Crisis News Network*—delivers every tragedy and act of violence into our living rooms, on repeat, until fear feels like the default state.

But fear doesn't build a better future—vision does. Humanity needs an inspiring, hopeful picture of the road ahead, something worth striving for. That's the purpose of this report: to offer you a glimpse of an abundant, uplifting future, and to inspire action toward making it real. **If it resonates with you, I encourage you to share it.**

HOW TO NAVIGATE THIS REPORT

This report examines 10 Metatrends driven by converging exponential technologies over the decade ahead, 2025 through 2035. In success, these Metatrends are unstoppable forces creating unprecedented global abundance.

Each Metatrend is structured using a consistent framework designed to help you quickly understand the transformative potential, technical requirements, business opportunities, and risks ahead.

Report Structure: Every Metatrend follows the same analytical framework to enable easy comparison and navigation across domains. Each section begins with a **one-sentence vision statement** summarizing the 2035 outcome, followed by an **"Opening Scene: It's 2035, and..."** narrative that brings the future to life through specific, human-centered examples from around the world.

The **"A Vision for 2035"** section expands this into a comprehensive picture of how each technology will reshape society, while **"10 Technology Breakthroughs Required"** identifies the specific innovations needed to make each vision reality. **"10 Predictions for 2035: New Products & Services"** translates technical possibilities into concrete business opportunities for entrepreneurs and investors.

Balanced Analysis: Each Metatrend also includes a **"Dark Side of Abundance"** section examining potential risks, unintended consequences, and societal challenges that must be managed. This is followed by **"Wisdom for an Exponential Age":** philosophical reflections on how to navigate these transformations responsibly.

The Convergence Thesis: While each Metatrend is analyzed individually, the report's central insight is convergence. AI enhances every other technology. Robotics enables space exploration and digital manufacturing. Quantum computing accelerates drug discovery and materials science. Networks and sensors create the data infrastructure that makes everything else intelligent. Understanding these interconnections is key to grasping the magnitude of change ahead.

ABUNDANCE: FOOD, ENERGY, EDUCATION (2035 VISION)

By 2035, every person on Earth has access to abundant food, energy, and education——enabled by exponential technologies and distributed infrastructures.

OPENING SCENE: IT'S 2035, AND...

At sunrise in rural Kenya, twelve-year-old Amina walks through a lush permaculture food forest growing on once-barren land. Her family's solar-powered aquaponic system, managed by an AI assistant and replenished via atmospheric water harvesters, provides year-round nourishment—without need for centralized supply chains. Her wearable flashes a reminder: she has class in 5 minutes.

Across the globe in Argentina, a teenager in a solar village is preparing to take the entrance exam for MIT, delivered through an adaptive AI education platform tailored to her learning style and spoken language. She's never set foot in a traditional classroom, yet her digital mentor has helped her learn AI vibe coding, and the basics of quantum physics through immersive XR environments.

Meanwhile in Bangladesh, a local energy cooperative uses a smart contract system to balance loads between rooftop solar arrays, community battery banks, and neighborhood AI energy traders. Electricity is not scarce. It is abundant, hyperlocal, and self-managed: accessible to everyone at a fraction of its former cost.

By 2035, energy, education, and nutrition——once symbols of inequality——have been reimagined as **human rights delivered through exponential infrastructure.**

A VISION FOR 2035: By 2035, three pillars of abundance—**food, energy, and education**—have been democratized at scale. Once bound by scarcity and centralized control, these essentials are now **delivered via autonomous systems, open protocols, and regenerative design.**

IN FOOD closed-loop vertical farms, precision fermentation bioreactors, and AI-optimized agroforests have transformed both urban rooftops and rural deserts into super-productive, climate-resilient food engines. Local production meets 90%+ of caloric needs for most communities.


World's largest vertical farm in Bustanic, Emirates

IN ENERGY solar, wind, geothermal, and advanced storage technologies—distributed through peer-to-peer energy webs—have replaced the centralized, fossil-powered grid. Abundant clean energy is harvested, stored, and traded locally in every region of the world. All of this takes place while the world prepares for the next wave of energy abundance technologies such as small modular (fission) reactors (SMRs) and fusion powerplants to come on-line in larger numbers. The tech is proven and safe, but mass production is just gearing up.

US to Add 1.2 Terawatts of Solar, Wind and Energy Storage by 2035

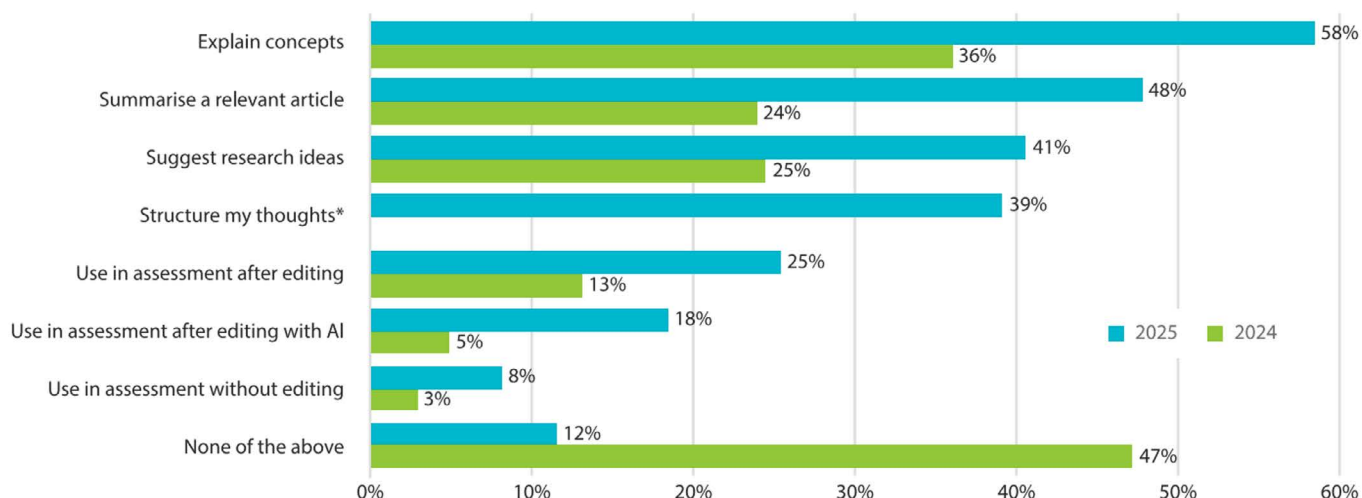Forecasted cumulative 2024-2035 new clean energy build by US region
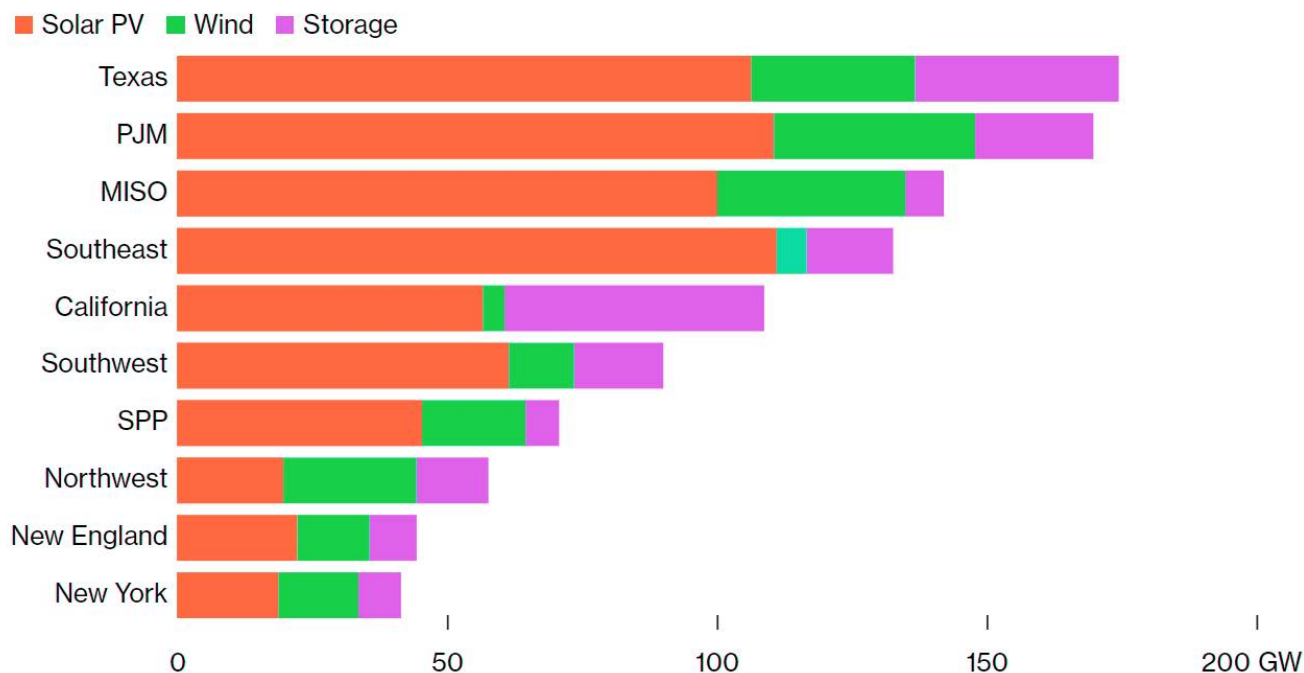
Source: BloombergNEF
Note: GW alternating current (AC) for wind and storage; GW direct current (DC) for solar. PV refers to photovoltaic. Difference between the sum of all regional forecasts and our total US forecasts is due to the buffers used in our sector forecasts.

BloombergNEF

Total global solar installations to double in the next five years, cross 6 TW by 2029

World cumulative solar PV market scenarios 2025-2029

IN EDUCATION immersive, gamified learning experiences powered by AI tutors and XR simulations deliver personalized, mastery-based education at near-zero marginal cost. Students no longer need buildings, they need access. And access is now global.

Which countries put the most focus on AI in education?

High

Medium

Low

How have you used generative AI for assessments?

	2025	2024
Explain concepts	58%	36%
Summarise a relevant article	48%	24%
Suggest research ideas	41%	25%
Structure my thoughts*	39%	
Use in assessment after editing	25%	13%
Use in assessment after editing with AI	18%	5%
Use in assessment without editing	8%	3%
None of the above	12%	47%

What used to be charity is now protocol. What used to be rationed is now ubiquitous. In 2035 the best teachers are digital super intelligences that offer every student on the planet access to the very best and personalized education fully dematerialized, demonetized and democratized. This is **engineered abundance**: powered by code, grounded in justice, and measured not by GDP, but by lives uplifted.

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

FOOD

1. **Autonomous Vertical Farming Kits:** Plug-and-play, AI-managed hydroponic/ aeroponic systems with low energy, water, and labor needs. Systems are designed for rooftops, schools, or villages. These systems use AI to autonomously adjust lighting, nutrients, and harvesting schedules for year-round food production with minimal inputs. This enables local food production in urban slums and deserts.

Vertical Harvest Farms

2. **Health Sensing / Food Production Systems:** At-home robotic food manufacturing systems that connect to your health-related wearables to create personalized meals based on metabolic needs. The system provides delicious food that is linked to your health outcome objectives and your actual biomedical, nutritional needs that day.

3. **Cellular Agriculture Protein Production:** Cellular agriculture platforms mass produce nutrient-dense, culturally adaptable proteins (e.g., lab-grown fish, plant-based chicken). Food becomes hyperlocal, ethical, and climate-resilient.

4. **Large-Scale Closed-Loop Regenerative Agriculture Systems**: AI-coordinated vertical farms, aquaponics, and mycelium networks optimize nutrient recycling and soil health. The implication is high-yield farming that works anywhere: from deserts to rooftops.

Good Meat cultivated food

5. **Atmospheric Water Harvesting & Smart Purification:** Localized systems extract and purify drinking water from the air using solar-powered desiccants and AI filtration. This technology enables universal safe water access.

ENERGY

6. **Hyper-Efficient Perovskite Solar Cells:** Breakthrough in durability and efficiency of perovskite-based photovoltaics, enabling 30%+ efficiency on flexible, low-cost substrates. Perovskite solar panels and edge batteries will power homes or micro-communities off-grid, enabling lighting, cooking, internet, and education anywhere in the world. This enables decentralized energy in every region, especially off-grid zones.

China is blanketing the country with solar

7. **AI-Optimized Energy Mesh (Solar + Battery) Microgrids:** Development of edge-AI-managed, self-healing microgrids that balance energy loads and autonomously trade power peer-to-peer. Microgrids provide integrated solar, storage, and smart contracts to deliver 24/7 electricity to off-grid regions. Community-owned, resilient energy systems.


300MW solar project in Zhejiang province, China

8. **Coal Plant Upgrade to Fusion, Gen-5 Nuclear & SMR Deployment**: For larger cities, coal-burning plants will be replaced by clean energy. Instead of burning coal to produce steam and generate electricity, coal power plants will replace their boilers with fusion or Gen-5 Nuclear reactors, which create clean energy. This upgrade would keep the existing plant infrastructure (distribution, etc.) while eliminating carbon emissions.
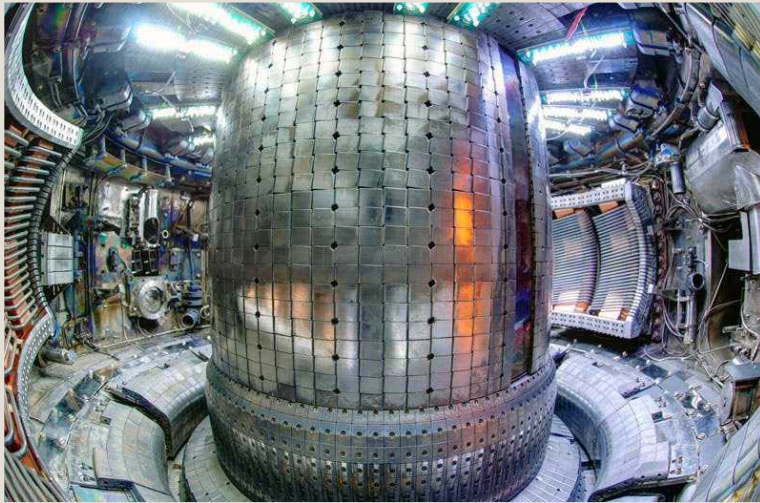
Commonwealth Fusion
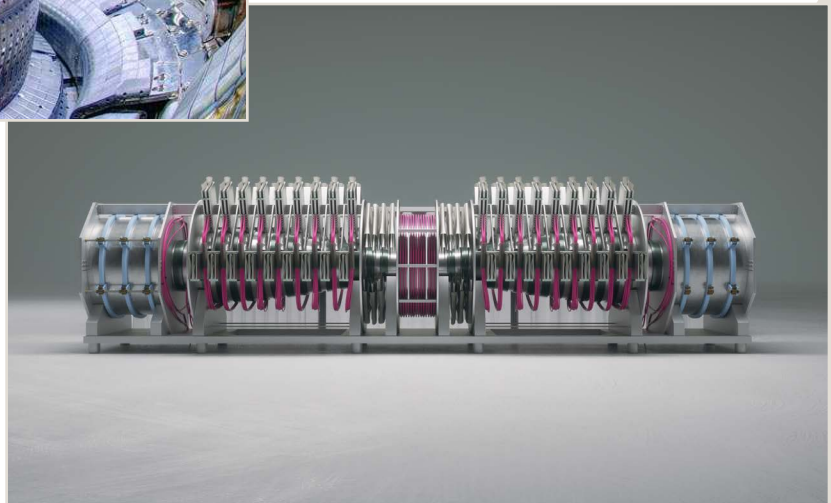
Helion Fusion

EDUCATION

9. **AGI Tutors:** AGI-based educational agents that understand and respond to emotional cues, language nuances, and learning pace. They provide one-on-one, adaptive instruction in any subject or language, accessible through audio or XR interfaces. This breakthrough enables fully dematerialized, democratized, demonetized, and personalized, equitable education for every child.

10. **XR (VR/AR-Based) Learning Interfaces:** XR learning tools that bring lessons to life with avatars, simulations, and contextual overlays without the need for screens. Enables fully immersive, full-stack education even in low-tech environments. Allows students to experience historical events, conduct science experiments, or practice languages in real-time 3D environments.

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

FOOD

Autonomous Vertical Farming Modules: Compact, AI-controlled, solar-powered growing units that plug into rooftops, backyards, or rural hubs, producing vegetables, herbs, and fungi 24/7 with no human intervention. Hyperlocal food security for families, schools, and clinics.

Projected vertical farming market worldwide from 2022 to 2032 (in billion U.S. dollars)

Source: GlobeNewswire © Statista 2025   Additional Information: Worldwide; 2022
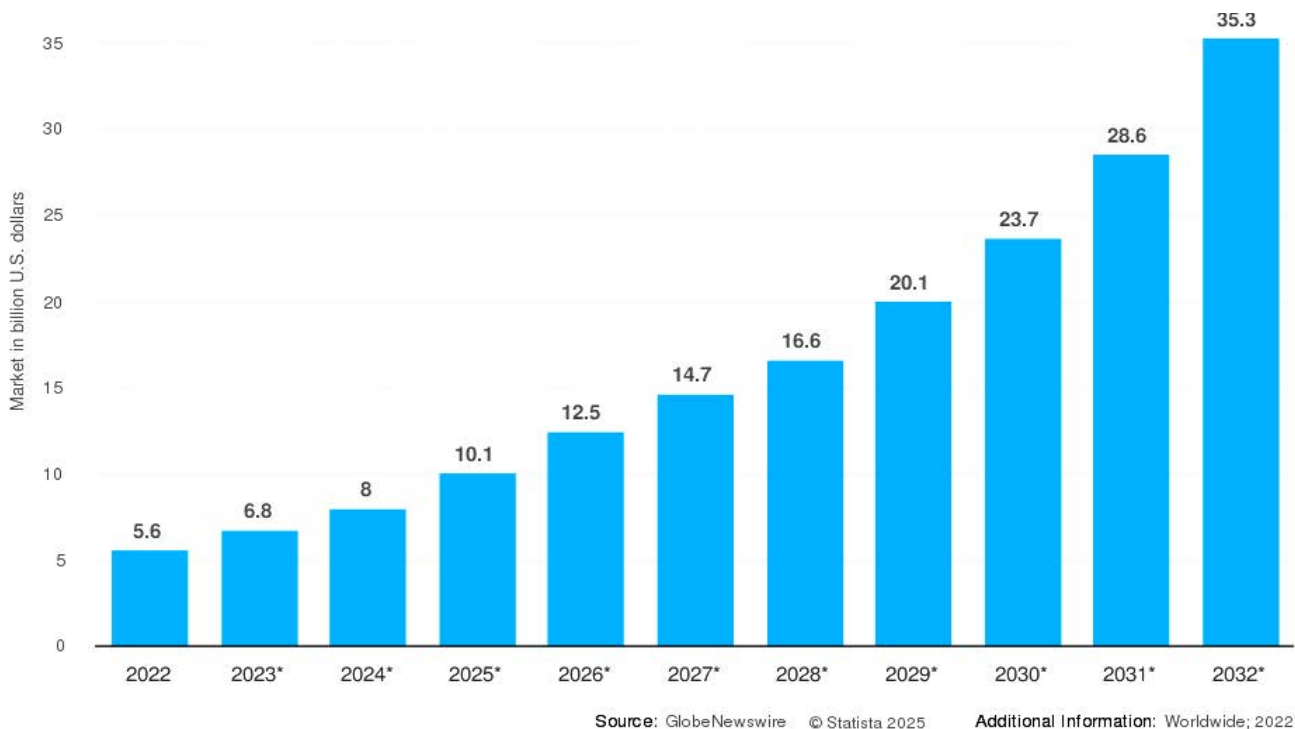
Personalized Food Printer + Health Link: A kitchen device that syncs with your wearables and blood biometrics to synthesize daily meals tailored to your mood, micronutrient needs, and medical conditions. Food becomes a prescription for peak performance and disease prevention.

Community Bioreactor-as-a-Service: Shipping container-sized cellular agriculture hubs growing high-density animal-free proteins, tailored for local taste, culture, and nutritional needs. A future of ethical, scalable protein access in every village.

Atmospheric Water Harvest Grid: Decentralized network of AI-controlled condensation towers producing clean drinking water from air and distributing it via smart pipes or refill stations.

ENERGY

Peer-to-Peer Microgrid Exchange / Solar DAO: A decentralized energy trading platform allowing users to buy, sell, or store electricity across neighborhoods via tokenized solar credits and AI demand forecasting. Villages run and profit from their own solar grids: buying, selling, and storing power via blockchain-managed smart contracts. Enables local energy to become tradable, profitable, and resilient.

Urban Micro-Nuclear Utilities: Mass-produced small modular reactors (SMRs) replacing fossil infrastructure in urban areas—offering clean baseload energy within recycled coal plant footprints. Zero-carbon cities without rebuilding from scratch.

SMR - installed capacity and cumulative emissions avoided 2020-2050)
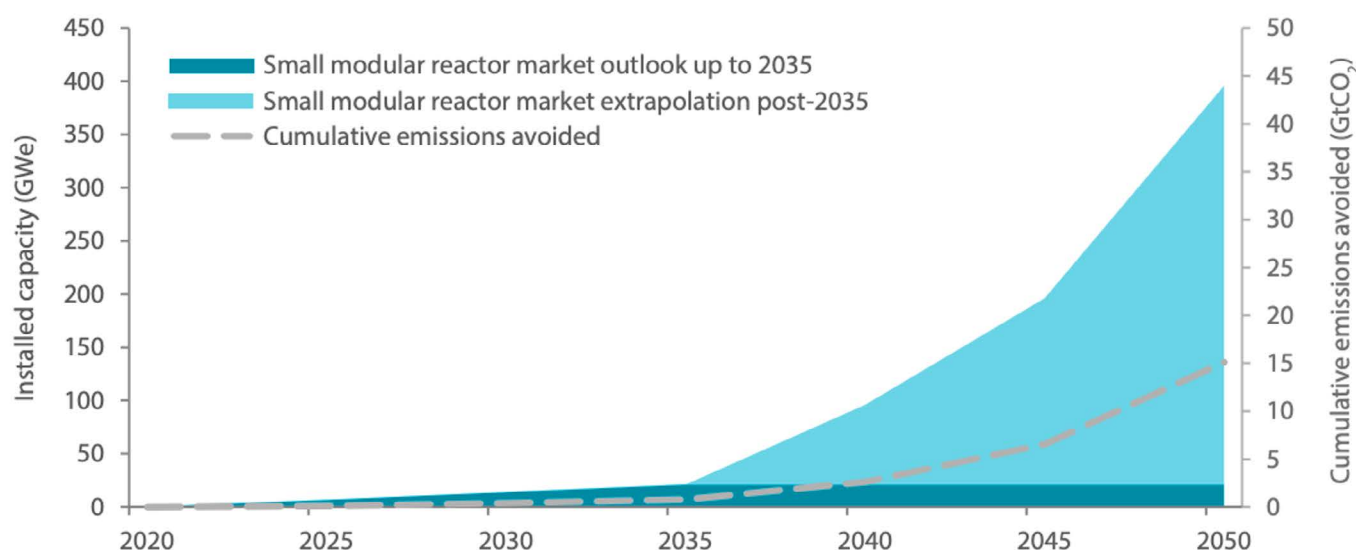
Note: It is assumed that nuclear power (12 g CO_2eq/kWh) is displaced by gas with a carbon footprint of 490 g CO_2eq/kWh (Bruckner, 2014). SMR 2035 market outlook based on NEA (2016). Extrapolation post-2035 based on SMR build rate envisaged by McKinsey & Company (2018) "Nuclear deep decarbonization scenario". By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg CO_2 per kg of H_2).

EDUCATION

Personal AGI Tutor Platforms: An always-on educational agent that knows your strengths, gaps, language preferences, and emotional states: teaching any subject, anywhere, at any level. As a result, every learner has a customized superteacher.

Mixed-Reality (Fully Gamified) Learning Glasses: XR eyewear that overlays any learning experience, as well as historical content onto real-world environments as students walk, explore, or work.

Education is a fully gamified, AI-guided ecosystem where students explore math through music, history through role-play, and physics on Mars. The result is that the world becomes your classroom.

Borderless Credentialing Network: A blockchain-based platform that validates AI-graded projects, portfolios, and skills. This replaces traditional diplomas with reputation-weighted credentials. The key point here is that talent matters more than pedigree.

Knowledge Commons DAO — Community-Led Curriculum Design: Open-source, token-incentivized platform where teachers, creators, and learners co-create modular learning content vetted by AI for global impact. Learning becomes participatory and culturally relevant.

DARK SIDE OF ABUNDANCE (FOOD, ENERGY & EDUCATION)

While a future of abundance offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top five dark sides that are likely to emerge:

1. **Protocol Colonization**: Wealthy nations or companies may export infrastructure under extractive terms, replicating colonial power structures under a "techno-philanthropic" guise.

2. **Dependency on External Systems**: If local ownership isn't built in, communities may become dependent on outside updates, funding, or API keys to run life-critical systems.

3. **Digital Illiteracy and Access Gaps**: Even as devices become cheaper, barriers in language, context, and trust may exclude the most marginalized.

4. **Ecological Blowback**: Overproduction or mismanaged bioengineered systems may disrupt local ecologies, water tables, or pollinators.

5. **AI-Driven Cultural Homogenization**: Global access to AI tutors and media risks eroding local languages, traditions, and indigenous knowledge unless diversity is actively preserved.

83.3% of ChatGPT users couldn't quote from essays they wrote minutes earlier.
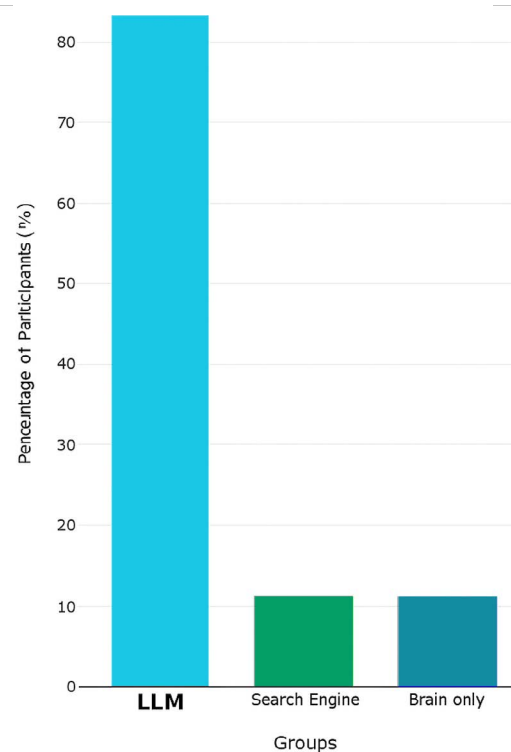
WISDOM FOR AN EXPONENTIAL AGE (ABUNDANCE)

Following are thoughts worth reflecting up during our decade ahead:

"Abundance is not about excess. It's about access."

"Abundance is not about a world of luxury. It's about a world of possibility."

"The true measure of progress is not wealth creation, but suffering reduction."

"When every child eats, learns, and grows with dignity, we are finally a spacefaring species worth exporting."
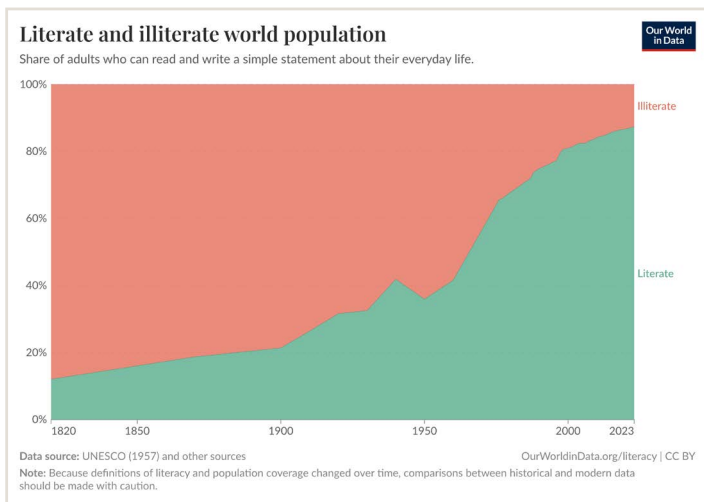
"The tools of abundance must be matched by the ethics of inclusion... or we risk repeating the past, only faster."

"Scarcity is not natural. It is engineered, and so is abundance."

Literate and illiterate world population

Share of adults who can read and write a simple statement about their everyday life.

Illiterate

Literate

Data source: UNESCO (1957) and other sources
OurWorldinData.org/literacy | CC BY

Note: Because definitions of literacy and population coverage changed over time, comparisons between historical and modern data should be made with caution.
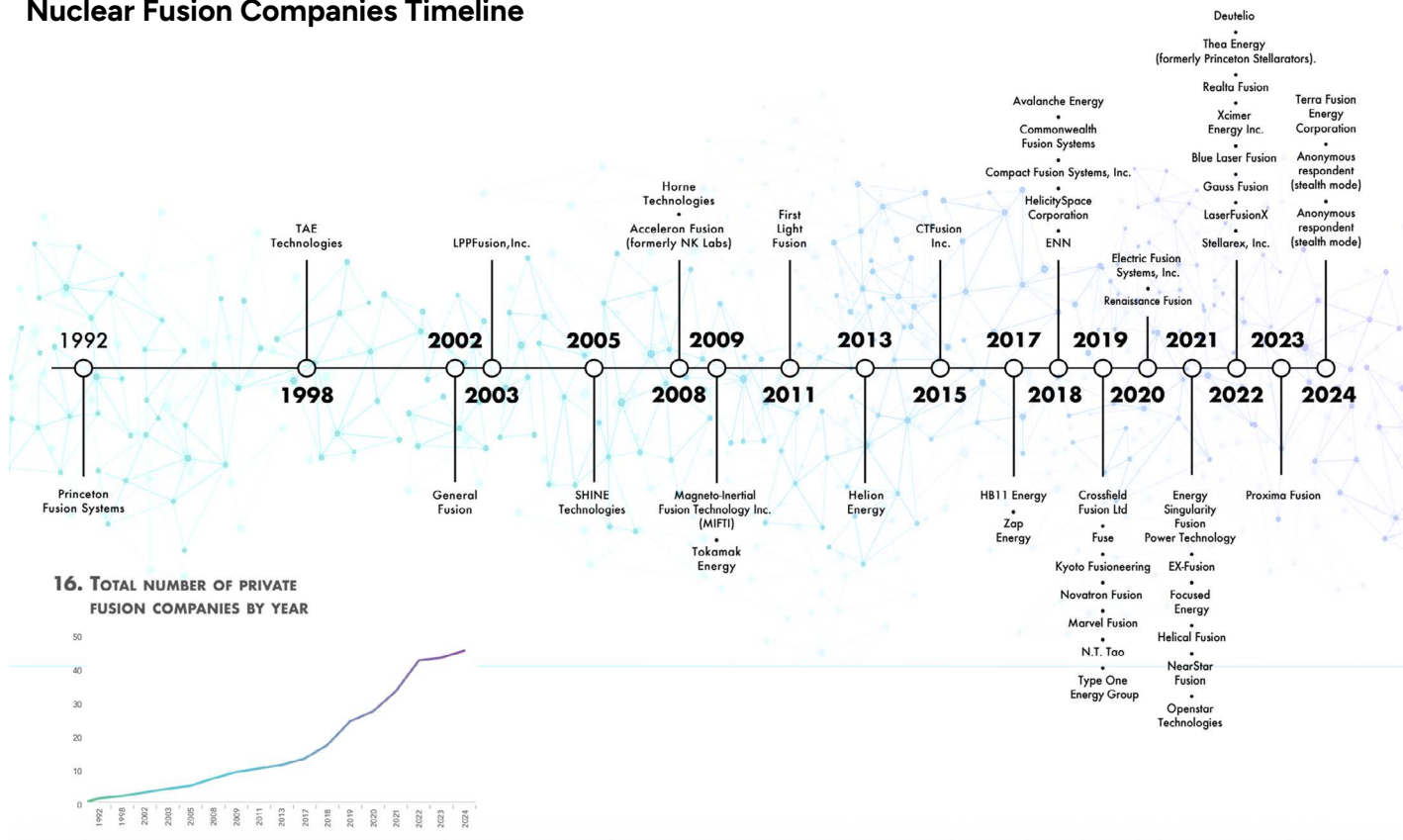
Online Course Revenue by App

LinkedIn Learning generated the most revenue, although several were close to matching it.
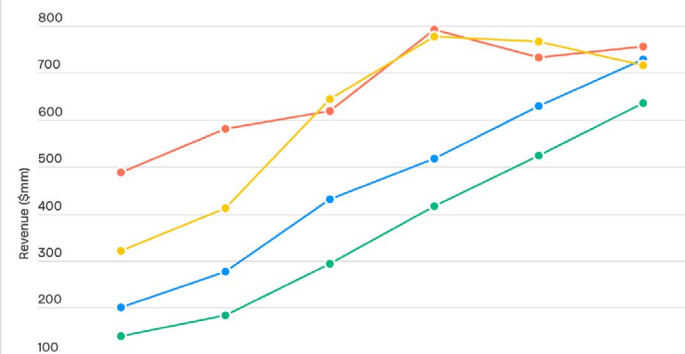
Nuclear Fusion Companies Timeline

16. TOTAL NUMBER OF PRIVATE FUSION COMPANIES BY YEAR

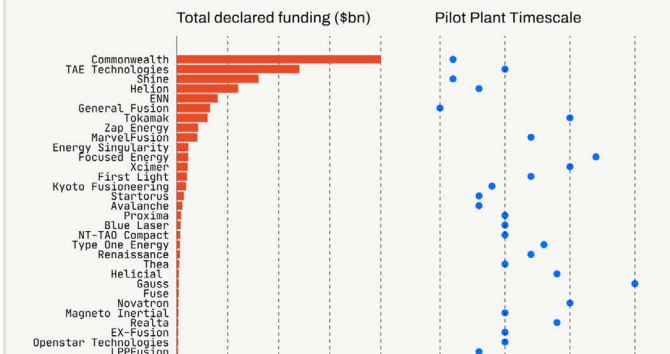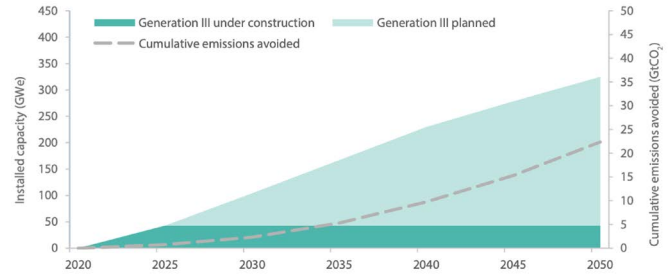**Funding for nuclear fusion startups has topped $7 billion**

Figure 9. **Generation III new builds – installed capacity and cumulative emissions avoided (2020-2050)**

Note: It is assumed that nuclear power (12 gCO$_2$eq/kWh) is displaced by gas with a carbon footprint of 490 gCO$_2$eq/kWh (Bruckner, 2014). Planned construction based on NEA/IEA Tracking Clean Energy Progress 2021 – nuclear chapter. By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg CO$_2$ per kg of H$_2$).

Nuclear Power Reactor Technology by Generation
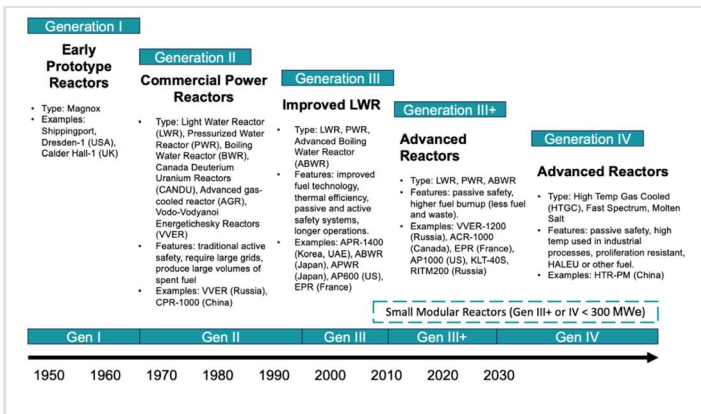
Solar capacity would reach 2900 GW in China by 2030 in a 1.5°C-aligned scenario
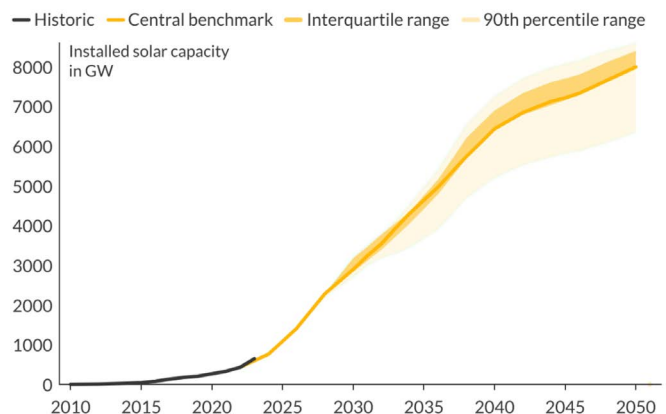
AI & QUANTUM (2035 VISION)

By 2035, AI and quantum intelligence outperform humans in every domain—from scientific research to governance— reshaping civilization at the speed of thought.

OPENING SCENE: IT'S 2035, AND...

It's 6:12am in Rio de Janeiro. Ana, a postdoctoral researcher turned solo founder, wakes to find an alert on her NeuroBand: *"One of your AI agents has solved the protein folding configuration for a novel anti-fibrosis compound. Peer-reviewed. Patent filed. Sent for publication."*

She didn't sleep through the discovery. She delegated it.

Last night, while Ana rested, her cloud of autonomous AI agents—trained on her style, ethics, and research goals—were collaborating with 173 other AI swarms around the world, cross-referencing open research datasets, personal lab notes, and real-time feedback from quantum simulations. The breakthrough was verified by synthetic experiments conducted in a virtual biochemistry sandbox running on a 512-qubit photonic quantum array based in the cloud.

She pours her coffee. Her AI life assistant, Davos, offers to summarize the findings and a policy impact brief it prepared for the Brazilian Ministry of Health. One click, and a full regulatory proposal is ready for submission to the Ministry's AI: complete with all data, citations, market analysis, and ethical commentary.

This isn't unusual. By 2035, AI isn't a tool. It's an extension of the self. It's your co-researcher, co-pilot, scientific advisor, lawyer, therapist, translator, and strategist. And when paired with quantum compute, its reach includes the previously unreachable: solving problems with more variables than atoms in the universe.

A VISION FOR 2035: A college student in Nigeria co-develops a climate modeling algorithm on a neuromorphic chip the size of a wristwatch. She uses it to simulate desertification countermeasures across the Sahel, down to the resolution of individual plants. Her co-author? An advanced AI model that fine-tunes variables using real-time satellite feeds and ground sensors.

In Shenzhen, a fusion reactor's core stability is monitored not by engineers but by a constellation of narrow-scope AIs that negotiate tradeoffs across temperature, material fatigue, and magnetic field fluctuation in femtoseconds, orders of magnitude faster than any human reflex could manage.

In Brussels, parliaments no longer vote on complex policy drafts without first running them through an extensive simulation model trained on citizen sentiment analysis, real-time surveillance data, national values, legal precedence, and socio-economic history. Every major decision is filtered through probabilistic futurescapes computed by citizen-owned AGIs.

In this world, general-purpose AI agents serve everyone from individual artists to planetary scientists. Creativity, governance, and health are no longer bottlenecked by human bandwidth. Every citizen has access to thousands of minds, not just one.

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to make the AI & Quantum Metatrend vision a reality:

1. Emergence of Digital Super Intelligence: GPT-class models and beyond scaling to 1 trillion+ parameters with real-time reasoning.
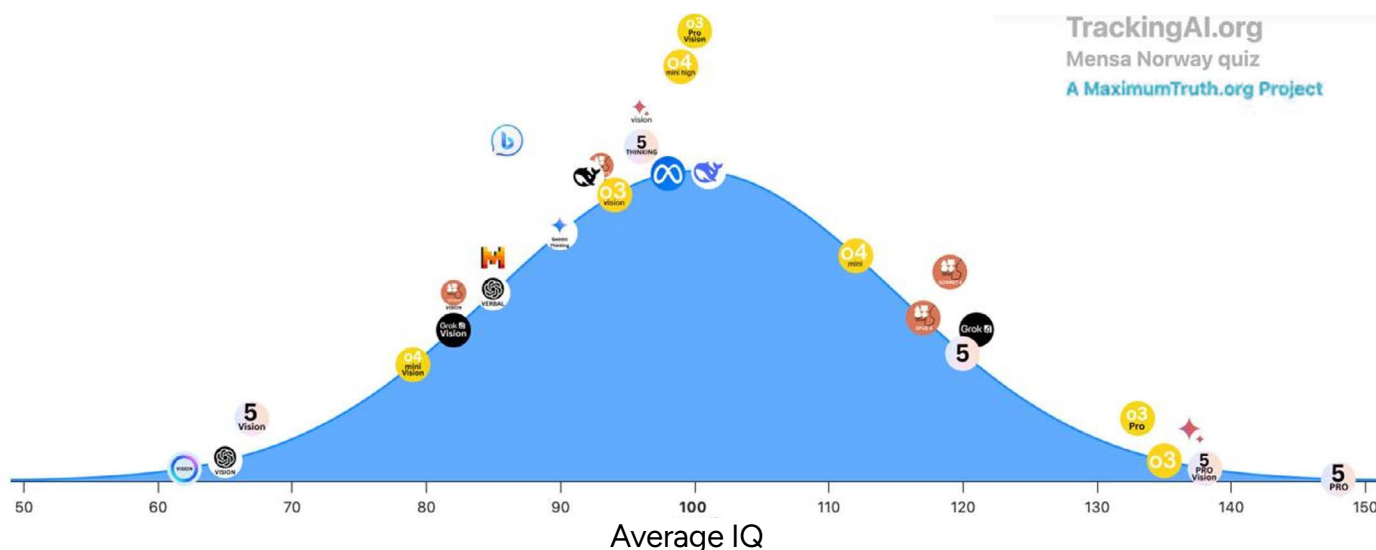
A Google quantum computer

2. Scalable, Error-Corrected Quantum Computers: Breakthroughs in qubit stability and error correction enable machines with 10,000+ logical qubits to outperform classical computers on real-world problems. Unlocks exponential advances in materials science, drug discovery, and climate modeling.

The quantum computing market is expected to reach $28B-$72B by 2035 and $45B-$131B by 2040.

Expected market size in each scenario,[1] $ billion
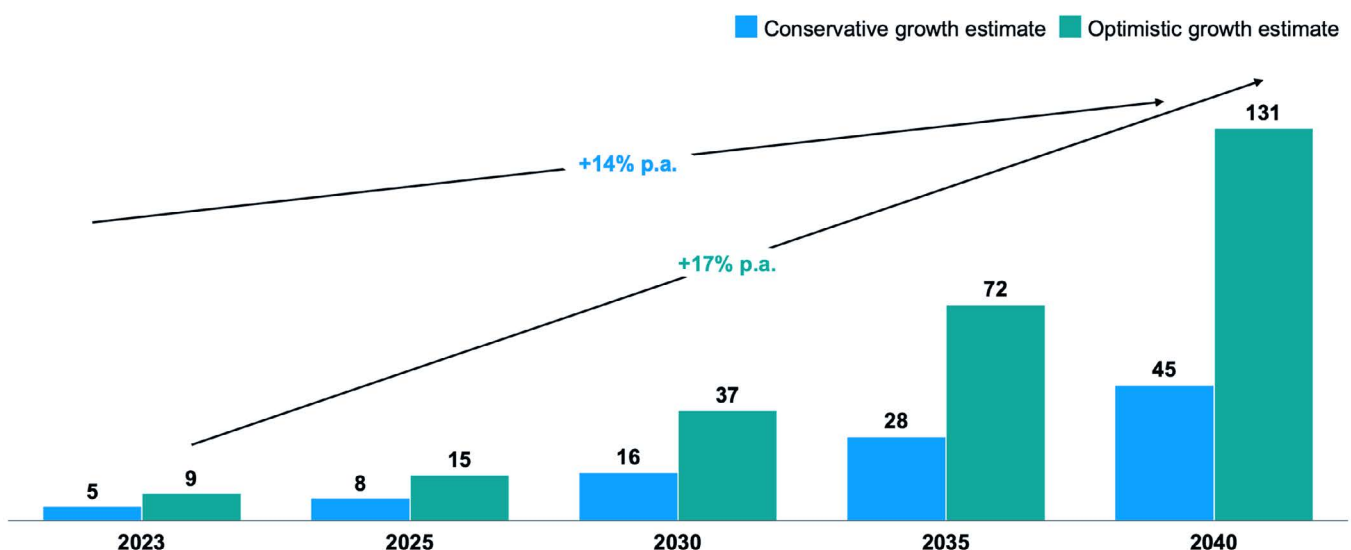
¹Market projection follows an adoption curve for quantum computing assuming a timeline to quantum advantage based on understanding of current QT and projected total high-performance-computing market sizes.

Source: Etale data, market data, expert interviews, and McKinsey analysis

McKinsey & Company

3. Mass Adoption of AI Agent Ecosystems: Individuals and enterprises routinely deploy swarms of autonomous AI agents trained on personal, corporate, or national goals. Accelerates productivity, decentralizes innovation, and reshapes workforce dynamics.

4. AGI-Level Personal Companions: Emotionally aware, multimodal AI companions deeply understand user context and cognition across health, learning, and productivity. Mental health, education, and life coaching become universally accessible.

5. Brain–Computer Interfaces with Thought-Based Interaction: Neural interfaces allow direct mental communication with AI, enabling silent, high-bandwidth cognitive collaboration. Blurs boundary between human intelligence and machine cognition.

6. Civic Simulation Engines for Governance: Large-scale socio-economic simulators—powered by AI and quantum systems—model policies before real-world implementation. Governments adopt evidence-driven, adaptive decision-making frameworks.

7. Federated & Privacy-Preserving AI Infrastructure: Secure AI training and inference occurs on encrypted data across devices, preserving privacy while learning from global datasets. Enables inclusive, decentralized innovation without compromising user control.

8. Neuromorphic & Edge AI Chips at Planetary Scale: AI chips modeled on the human brain run efficiently at the edge (e.g., in wearables, drones, vehicles), enabling real-time AI anywhere. Expands intelligence into every corner of the physical world.

9. Autonomous Robotic Labs & Self-Driving Experimentation: AI-orchestrated robotic labs integrate quantum simulations, microfluidics, and automated synthesis to validate discoveries at scale without human intervention. Collapses R&D cycle times, enabling individuals and small teams to achieve breakthroughs at industrial scale.

10. Verifiable Alignment & Provenance Systems: Mechanistic interpretability, secure provenance tracking, and cryptographic verification frameworks ensure AI agents are aligned, auditable, and trusted in high-stakes domains. Unlocks safe deployment of AI in governance, healthcare, and finance through transparent and legally robust decision-making.

Together, these factors enable what Kurzweil calls *accelerating returns on intelligence*. AI is no longer a tool, it's the substrate of civilization itself.

The Cost Of Intelligence Has Dropped Almost 1000x In 3 Years

Inference price across select benchmarks, 2022–24

Source: Epoch AI, 2025; Artificial Analysis, 2025 | Chart: 2025 AI Index report
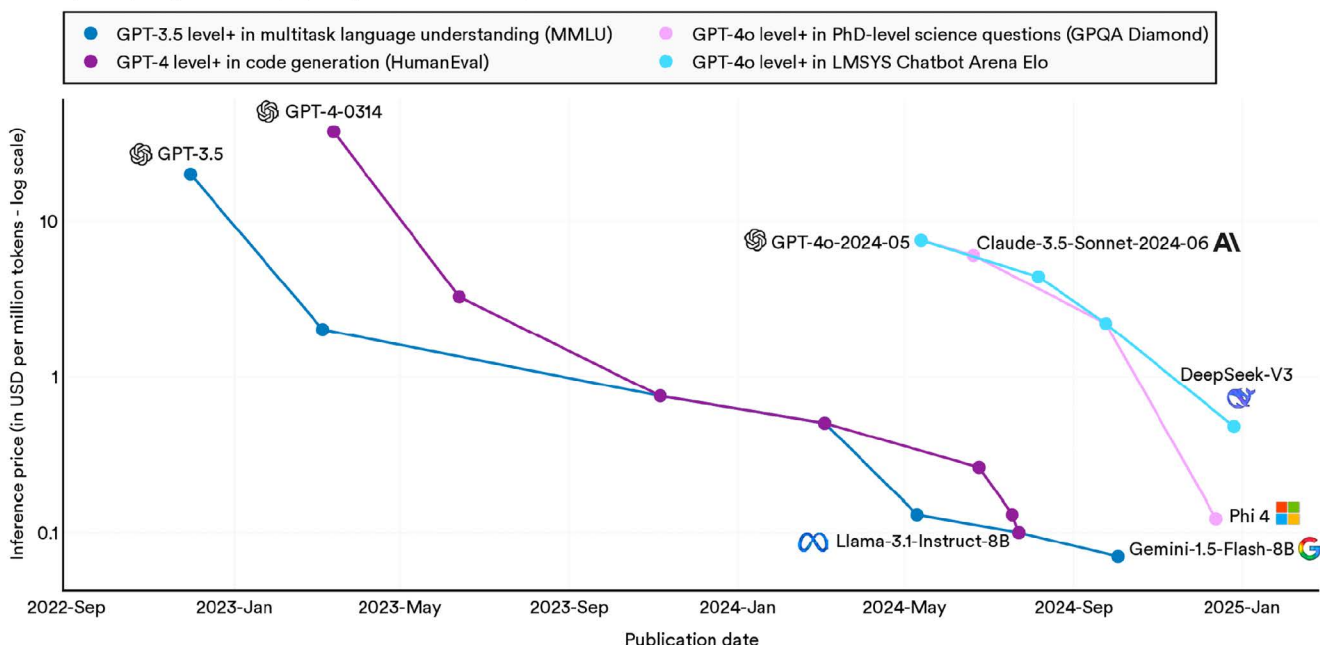
10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Scientific Discovery Becomes Autonomous and Continuous: AI agents paired with quantum simulators autonomously run and verify millions of experiments daily, advancing science faster than any human institution ever could.

2. Every Person Has a Cloud of AI Agents Working on Their Behalf: From teenagers to retirees, individuals will deploy personalized swarms of AI agents: handling research, negotiations, legal filings, creative work, and more.

3. National Policies Simulate Before They Pass: Governments use ASI-powered civic simulators to model the long-term impact of laws before enacting them and reducing corruption, inefficiency, and unintended consequences.

4. Thought Interfaces Replace Screens and Keyboards: Neural interfaces allow direct communication with AI systems—silently, instantly, and with full emotional context—creating a frictionless interface between mind and machine.

5. Quantum-AI Systems Solve Problems Once Considered Intractable: Molecular medicine, fusion energy optimization, and climate geoengineering become solvable via quantum-AI hybrids, compressing centuries of R&D into a decade.

6. Autonomous AI Research Labs Outperform Academia: Decentralized, cloud-native AI labs—staffed entirely by autonomous agents—routinely publish peer-reviewed breakthroughs in physics, biology, and economics without human intervention.

7. Personalized AI Therapists and Coaches Become Ubiquitous: Emotionally intelligent AI companions deliver 24/7 mental health support, relationship advice, and life coaching, tailored to your personality and neurobiology.

8. Every Startup Has ASI Product Designers: Entrepreneurs co-create with AI agents that use quantum simulations to design products (e.g., pharmaceuticals, batteries, materials) that are optimized before prototyping begins.

9. Autonomous Judicial Systems Handle Routine Disputes: AI judges, trained on legal precedent and real-time ethics simulations, resolve small claims, contracts, and mediation cases faster and more fairly than human courts.

10. Global Collective Intelligence Becomes a Public Utility: An open-source, decentralized intelligence layer—composed of millions of AI agents, quantum solvers, and neural contributions—serves humanity as a digital commons.

DARK SIDE OF ABUNDANCE

While a future of AI and Quantum offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top eight dark sides of AI and quantum that are likely to emerge:

1. Loss of Human Agency & Identity: As individuals delegate more decisions and creative processes to their AI agents, there's a risk of eroding personal agency, self-discovery, and meaning. People may begin to question the value of their own thoughts when outperformed in every domain. Consequence: a crisis of self-worth, motivation, and psychological reliance on AI for life choices.

2. Massive Inequality of Intelligence Access: While some individuals own personalized clouds of AGI agents, others may be excluded due to economic, political, or geographic barriers. Consequence: a new cognitive aristocracy emerges: those with superintelligence at their fingertips dominate wealth creation, innovation, and influence.

3. AI-Driven Authoritarianism: Governments or corporations could weaponize AI-governance systems and simulation engines to manipulate populations, suppress dissent, or predict and preempt political opposition. Consequence: loss of democratic agency and the rise of hyper-efficient surveillance states under the guise of optimization.

4. Reality/Truth Collapse & Epistemic Instability: With AI generating science, simulations, and media, it becomes nearly impossible to discern what is real, what is generated, and what is manipulated. The ground truth becomes fluid. With AI capable of generating perfectly realistic video, audio, and text, trust in media, memory, and even shared reality begins to fracture. Society struggles to agree on what is "real." Consequence: breakdown of societal trust in knowledge, expertise, and shared narratives.

5. Acceleration Without Alignment: The sheer speed of AI and quantum advancements may outpace human wisdom, regulation, and ethical understanding. Consequence: unintended consequences emerge at planetary scale, ranging from runaway economic feedback loops to quantum cyberattacks or biosphere miscalculations.

6. AI Monopoly & Cognition Inequality: Mega-corps with privileged access to frontier AI models shape economics, culture, and geopolitics and risk creating a new kind of digital feudalism.

7. Autonomy Crisis: As AI copilots outperform humans in every domain, individuals may experience existential anxiety, identity dislocation, and loss of purpose. The "abundance of intelligence" doesn't guarantee meaning.

8. Weaponized AI and Quantum Offensives: From autonomous cyberwarfare agents to quantum codebreakers, exponential intelligence can destabilize trust, security, and peace unless tightly governed.

WISDOM FOR AN EXPONENTIAL AGE (AI & QUANTUM):

Following are thoughts worth reflecting up during our decade ahead:

"We've passed the point of questioning whether AI and quantum will change the world. Now we must decide who gets to shape that future, and how."

"Power without wisdom is peril: As AI and quantum tools multiply our abilities, they must be matched with ethical foresight."

"Intelligence is abundant, wisdom must be cultivated: In a world where every person has access to thousands of AI minds, discernment—not data—becomes the ultimate skill. Knowing what not to do is as vital as knowing what's possible."

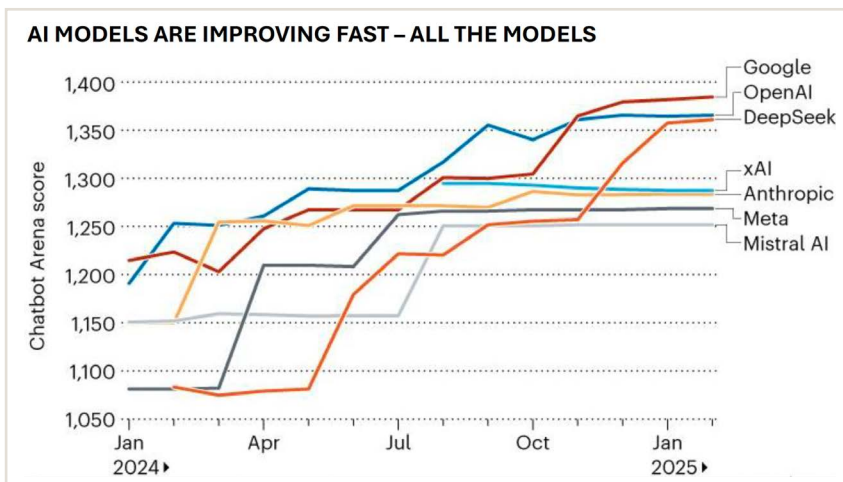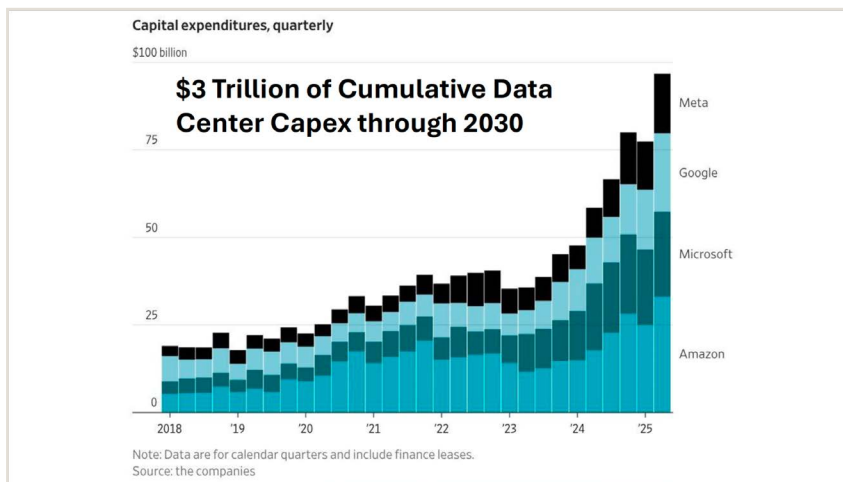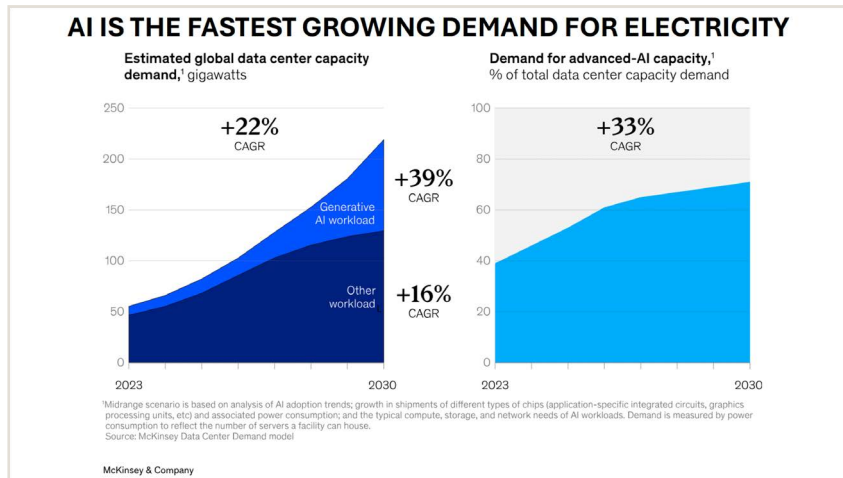"When machines learn everything, humans must remember what it means to be human: Empathy, purpose, and meaning will distinguish us, not speed or memory. Our humanity becomes more essential, not less, in a post-AGI world."

"The first question isn't 'Can we?'—it's 'Should we?': Technological capability must always be guided by principled inquiry. Ethics, values, and long-term thinking are not luxuries. They are foundations."

AI IS THE FASTEST GROWING DEMAND FOR ELECTRICITY

Estimated global data center capacity demand,[1] gigawatts

+22% CAGR

+39% CAGR — Generative AI workload

+16% CAGR — Other workload

Demand for advanced-AI capacity,[1] % of total data center capacity demand

+33% CAGR

[1]Midrange scenario is based on analysis of AI adoption trends; growth in shipments of different types of chips (application-specific integrated circuits, graphics processing units, etc) and associated power consumption; and the typical compute, storage, and network needs of AI workloads. Demand is measured by power consumption to reflect the number of servers a facility can house.
Source: McKinsey Data Center Demand model

McKinsey & Company

Capital expenditures, quarterly

$100 billion

$3 Trillion of Cumulative Data Center Capex through 2030

Meta
Google
Microsoft
Amazon

Note: Data are for calendar quarters and include finance leases.
Source: the companies

AI MODELS ARE IMPROVING FAST – ALL THE MODELS

Google
OpenAI
DeepSeek
xAI
Anthropic
Meta
Mistral AI

ADDITIONAL 100X-200X INCREASE IN ALGORITHM EFFICIENCY OVER NEXT 5 YRS
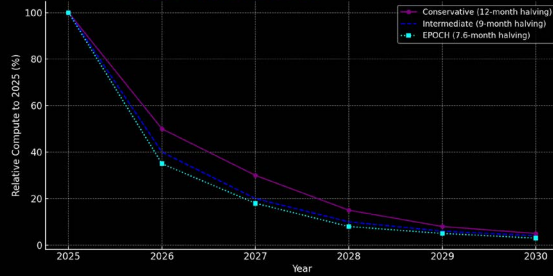
TODAY, 3 COMPANIES ARE SPENDING $152 BILLION ON AI (2024)
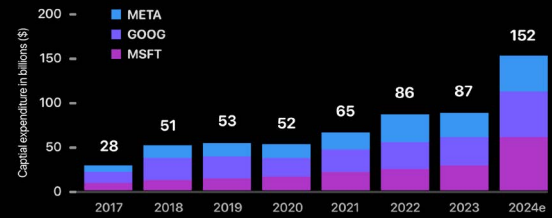
The global (AI) market size $1.6 trillion by 2030.

1 SEXTILLION X IMPROVEMENT IN COMPUTATION/$

Source: Ray Kurzweil, updated since 2008 by Steve Jurvetson, Future Ventures and UP.Partners analysis.
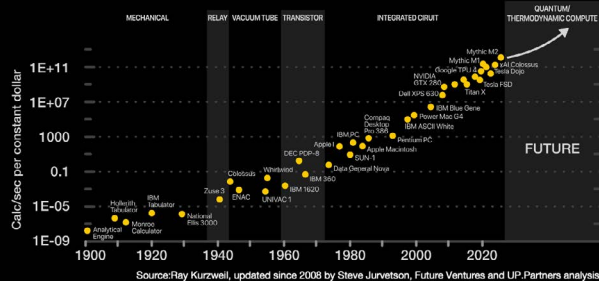
GLOBAL DATA CREATION IS ABOUT TO EXPLODE

Actual and forecast amount of data created worldwide 2010-2035 (in zettabytes)

1 zettabyte is equal to **1 billion terabytes**
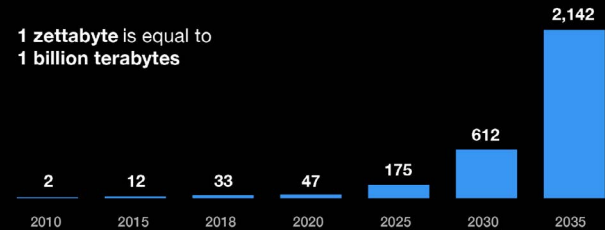
Source: Statista.com

HUMANOID ROBOTICS & AUTONOMOUS SYSTEMS (2035)

By 2035, humanoid robots and autonomous systems work alongside us as caregivers, coworkers, and creators—fundamentally redefining labor, companionship, and capability.

OPENING SCENE: IT'S 2035, AND...

The early morning quiet in a high-rise Tokyo apartment is gently interrupted by the soft whir of motion. Kei, a 92-year-old artist, is assisted out of bed by HANA-3, her humanoid support robot. HANA doesn't just lift her. She smiles, matches Kei's breathing rhythm, and offers a morning haiku in her late husband's voice. Kei laughs. Her robot remembers what she cherishes.

In the kitchen, a culinary robot prepares breakfast using home-grown ingredients from the aeroponic module on the balcony. Meanwhile, Kei's granddaughter walks to school accompanied by a school guardian drone that monitors air quality and ensures her safe arrival. These machines are familiar presences in everyday life. They assist, protect, and learn continuously.

Across town, an autonomous construction team reconfigures a modular housing unit. Human foremen supervise from mixed-reality control centers, while AI-driven swarm robots handle real-time structural analysis, materials transport, and adaptive design based on site conditions. The building learns as it is built.

Even in more intimate spaces, humanoid robotics have become companions. In care homes, emotionally intelligent bots support the elderly with conversation, physical therapy, and cognitive stimulation. In schools, bipedal teaching assistants act as project collaborators, theater partners, and multilingual coaches. Robots no longer provoke fear. They invite trust.

A VISION FOR 2035: By 2035, over 100 million humanoid robots have become integrated into the rhythms of daily life. Their dexterity, perception, and empathy have crossed the uncanny valley. Powered by edge AI and neuromorphic processors, they navigate complex social environments with grace and fluency.

In hospitals, robotic nurses equipped with bio-sensitive skins and emotion-sensing cameras provide round-the-clock care, lifting patients with mechanical precision and human-like compassion. They reduce burnout among staff and extend dignity to the most vulnerable.

Manufacturing Robotics

ARK Forecasts Global Manufacturing GDP
At ~$32 Trillion In 2030

		Productivity Uplift					
		10%	25%	50%	100%	200%	400%
Take Rate	10%	320	800	1,600	3,200	6,400	12,800
	20%	640	1,600	3,200	6,400	12,800	25,600
	50%	1,600	4,000	8,000	16,000	32,000	64,000

Revenue Opportunity*
($ Billions) **=** **~$13+ Trillion Opportunity**
(Average Of The Green Cells)

Humanoid Labor Cost ~ $1/HR

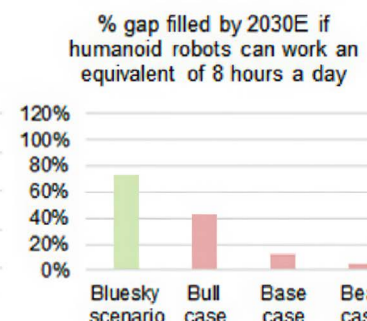| Factor	Details	Cost
Purchase Price	$30k Amortized over 5 years	$500/month
Software Fee	Monthly Subscription	$199/month
Total Monthly Cost		$699/month
Daily Cost	Assuming 30-day month	$23.30/day
Hours Available/Day	75% of 24 hours	18 hours
Cost per Hour		**$1.29/hour**

Source: ARK Invest

In industry, humanoids are deployed across logistics, manufacturing, and maintenance. They understand natural language, adapt to unstructured environments, and collaborate physically with human teams. Labor is no longer divided into "jobs humans do" and "jobs machines do." Instead, it is an orchestrated flow of strengths.

In homes and communities, humanoid assistants serve as memory extenders for Alzheimer's patients, caretakers for toddlers, or wellness coaches trained on personal preferences. The result is a society where aging no longer equals isolation, and disability no longer means dependence.

US manufacturing labor surplus/(shortage) (mn ppl)

% gap filled by 2030E if humanoid robots can work an equivalent of 20 hours a day

% gap filled by 2030E if humanoid robots can work an equivalent of 8 hours a day
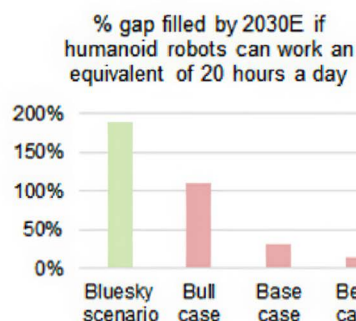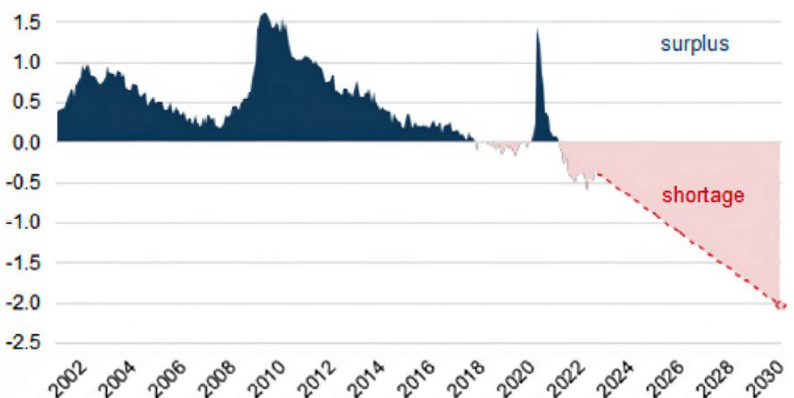
Source: OECD, Deloitte, FRED, Goldman Sachs Global Investment Research

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs needed to make this 2035 vision of humanoid robotics and autonomous systems a reality:

1. **Advanced Soft Robotics & Haptic Actuators:** Delicate, human-like touch through compliant materials and precise force control enables safe, gentle interaction in caregiving and home settings.

2. **Autonomous Dexterous Hands & Fine Manipulation:** Human-level hand dexterity——capable of handling fragile objects like utensils, tools, plants, or medical devices——is essential for domestic and industrial tasks.

3. **Neuromorphic & Edge AI Processors:** Real-time, low-latency cognition for perception, locomotion, and emotion-sensing at the edge (i.e., embedded onboard), without relying on cloud connectivity.

4. **Emotionally-Stable AI & Social Intelligence:** Robust emotion detection, empathy generation, and cultural-linguistic fluency let robots genuinely communicate, comfort, and adapt to human partners.

5. **Lifelong Learning & Adaptive AI:** Robots that learn and evolve through everyday experience, continuously refining skills from caregiving to construction, no retraining required.

6. **Safe Human–Robot Collaboration Protocols:** Advanced safety frameworks (power-limited joints, predictive motion planning, shared intent understanding) enable robots to operate closely with humans.

7. **Autonomous Multi-Robot Coordination:** Swarm intelligence, with dynamic leader-follower models and semantic task-sharing, empowers large-scale automated construction and logistics fleets.

8. **High-Fidelity Bio-Sensing Skins & Wearables:** Sensitive, durable sensor skins capture touch, heart rate, posture: enabling health-aware assistance and real-time physical monitoring in eldercare or therapy.

9. **Energy-Efficient, Portable Power Systems:** Innovations in solid-state batteries, fuel cells, or new energy sources provide humanoids with 8+ hours of active working capacity on a single charge.

10. **Scalable, Trustworthy Ethical AI Systems:** Transparent, explainable decision-making assures users that robotic caregivers make safe, bias-free judgments consistent with cultural and ethical norms.

LEADING HUMANOID ROBOT MODELS
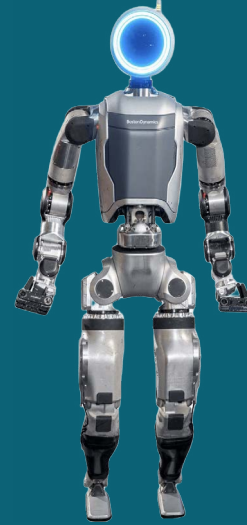

1X Technologies

"NEO"

Agility Robotics

"Digit"

Apptronik

"Apollo"
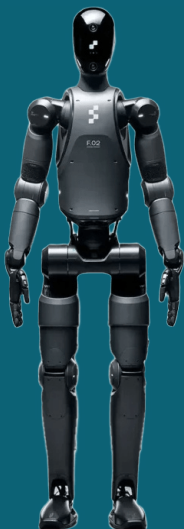

Boston Dynamics

"Atlas"

Clone Robotics

"Clone Alpha"

Figure AI

"Figure 02"

Fourier Robotics

"GR-2"

Humanoid

"HMND 01"


Tesla

"Optimus Gen 3"

Unitree Robotics

"H1"

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Elder Care & Home Care Robotic Assistant: Robots support daily routines—bathing, dressing, medication, companionship—especially for aging and mobility-limited individuals. Aging populations are supported by 24/7 emotionally and physically responsive robotic caregivers.

Global elderly caregiver demand (mn ppl)
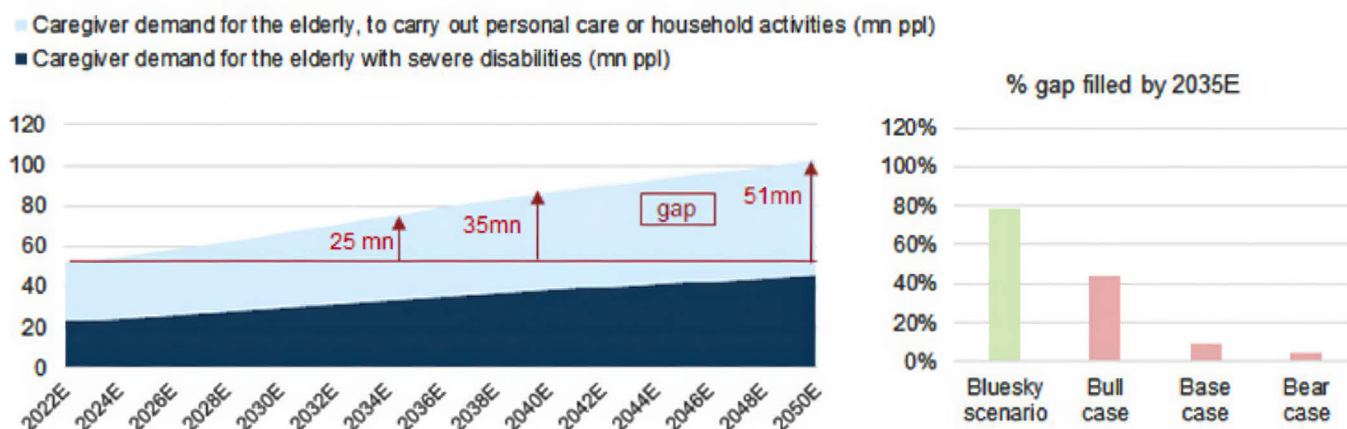
2. Elderly Loneliness Is Nearly Eliminated by Companion Robots: With social cognition, memory modeling, and lifelike presence, humanoid robots become trusted companions, helping elders stay mentally sharp and emotionally connected.

3. Domestic Robots Handle 80% of Household Chores: Cleaning, cooking, organizing, gardening: all delegated to humanoid or modular home robots, freeing up 20+ hours a week per household. They provide 24x7 support as required at a price 10-fold below the human minimum wage.

4. Robotics Redefine Mental Health & Special Needs Support: AI powered robots trained in empathy, facial recognition, and affective dialogue provide personalized therapy, grief counseling, and companionship to millions including those who are neurodivergent and require special care.

5. Autonomous Construction & Maintenance Teams: Robot and drone swarms handle 24/7 construction—adapting to terrain, weather, and design changes—reducing build time and cost by over 80%. These robotic systems work side-by-side with humans in complex, unstructured environments: learning workflows, collaborating safely, and accelerating production timelines.

6. Robot-Enabled Extreme Environment & Space Construction: Robotic systems sent in advance to the Moon, Mars, and to far-off asteroids are able to operate in extreme and dangerous conditions. They prepare the way for future human settlers and accelerate our settlement of the solar system.

7. Autonomous Large-scale Logistics Powered by Coordinated Robot Swarms: Warehouses, ports, and delivery chains are run by fleets of robots, coordinating via swarm intelligence for real-time routing and error recovery. Cities are built and maintained by drones and humanoid constructors operating with adaptive AI.

8. Retail & Hospitality Bots: Autonomous staff in malls, hotels, and restaurants handle service with warmth and linguistic fluency across cultures.

9. Last Mile/Last 100-meter Delivery Robots: Autonomous vehicles (vans and cars) deliver robots to local communities where robots transit and deliver packages the last 100 meters to your doorstep.

10. Robots Serve as Remote-Viewing / Remote-Action Platforms: By 2035, early implementation of human-BCI-robotic interfaces will begin where humans using devices such as Neuralink will be able to remotely pilot and occupy a humanoid robot.

DARK SIDE OF ABUNDANCE

While a future of humanoid robotics offers profound benefits, it also brings potential dark sides, unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. Human De-skilling & Dependency: As robots take over physical and cognitive tasks—from caregiving to cooking to construction—humans may lose basic life skills, manual dexterity, and confidence in self-reliance. Consequence: societal resilience decreases, and generational knowledge gaps widen. Humans may become overly dependent on robotic systems to function day-to-day.

2. Emotional Displacement & Synthetic Relationships: Emotionally intelligent robots risk replacing or distorting human relationships. Children, the elderly, and isolated individuals may form bonds with humanoids that displace authentic human connection. As robots handle more tasks, human-to-human interaction may decline. Consequence: psychological development may be warped, and emotional isolation masked by the illusion of companionship.

3. Mass Labor Displacement & Inequality: While robots enable economic abundance, they also threaten to automate entire sectors—from hospitality to healthcare—faster than new roles are created or reskilling can occur. Tens of millions of jobs are replaced faster than society can reskill workers. Hundreds of millions of jobs are at risk. Consequence: job polarization deepens, widening inequality across demographics and geographies. A new class divide may emerge between those with robot labor and those replaced by it.

4. Ethical Ambiguity in Care & Autonomy: When humanoids make decisions in care settings (e.g., lifting patients, responding to distress, or managing medication) the ethical line between tool and autonomous actor blurs. Delegating emotional labor to machines blurs ethical lines and causes the erosion of family bonds. Consequence: legal and moral accountability becomes unclear. Who's responsible when harm occurs: robot, maker, or user?

5. Surveillance & Privacy Erosion: Ubiquitous robots equipped with sensors, cameras, and microphones embedded in homes, hospitals, and public spaces may unintentionally (or intentionally) create a panopticon. Consequence: every intimate act, conversation, or moment may be recorded, analyzed, or exploited: raising serious concerns around consent and digital rights.

WISDOM FOR AN EXPONENTIAL AGE (ROBOTICS):

Following are thoughts worth reflecting up during our decade ahead:

> "The true measure of progress is not how human our robots become, but how humane we remain in their presence."

> "As we grant machines new powers, let us remember that empathy must scale with intelligence."

> "Robots will not replace our humanity. They will reflect it. How we program them reveals who we are and what we value."

> "Automation need not erase purpose; it can elevate it—freeing humans to focus on meaning, creativity, and connection."

> "In designing robots to care for us, we're called to care more deeply for one another. Technology expands our reach, but only our values define the impact."

Exhibit 4: Humanoid robot's BOM costs may fall below $17k by 2030, when annual shipments reach 1mn
Humanoid robot shipments vs. BOM costs (in China)
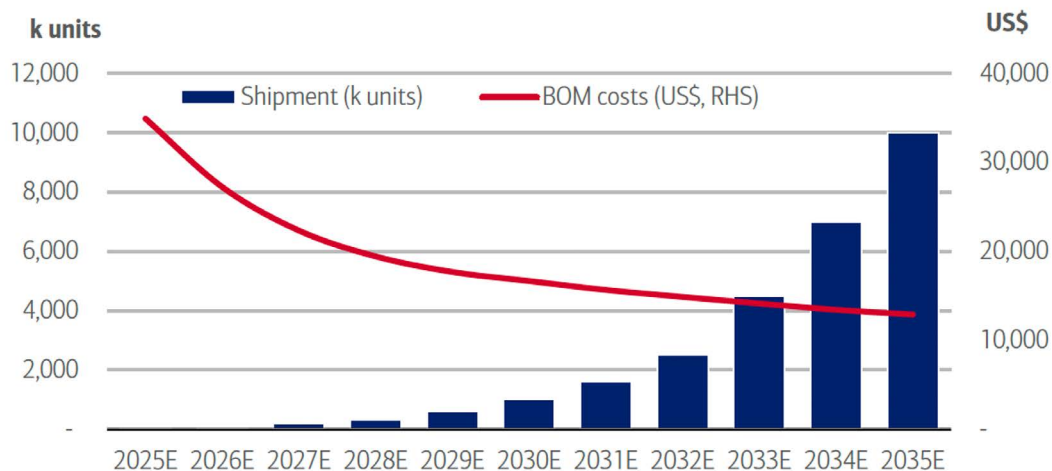
Source: BofA Global Research estimates

Annual installations of industrial robots 2018 -2023 and 2024*-2027*
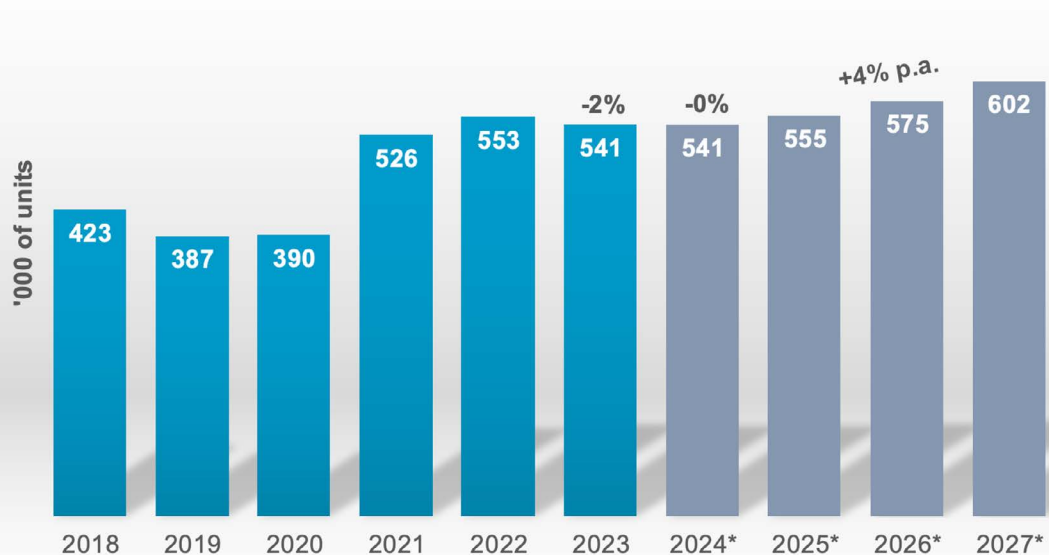
*forecast

Source: World Robotics 2024

LONGEVITY, MEDICINE & BIOTECHNOLOGY (2035 VISION)

By 2035, aging is optional, medicine is predictive and personalized, and biotechnology enables humans to reprogram biology as easily as software.

OPENING SCENE: IT'S 2035, AND...

The sunrise in Sardinia glows golden across the coastal biospa where Anika, age 102, finishes her morning yoga and sips a nutrigenomic tea tuned to her methylation age. Her skin glows, her cognition sharp. Every aspect of her physiology is continuously monitored by nanosensors and real-time blood diagnostics embedded in her skin. She hasn't visited a doctor in years, because disease hasn't had a chance to emerge.
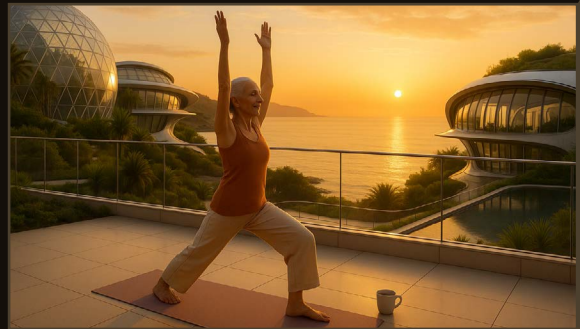
Inside her longevity dashboard, her AI health agent highlights a minor mitochondrial imbalance flagged during last night's sleep. With one tap, she authorizes a gene expression modulator—a personalized mRNA update—to be synthesized and delivered to her smart patch within the hour. No hospital. No prescription. No waiting.

Meanwhile, in São Paulo, 27-year-old João begins his first shift as a neural interface therapist. He works with stroke patients using a wearable BCI device that pairs with lab-grown neuron clusters to "retrain" injured motor systems. What used to take months of therapy now takes days, since the treatment is guided by real-time simulations of the patient's unique nervous system run on AI-enabled digital twins.

In Boston, a six-year-old child born with a rare genetic condition walks into school without symptoms. Her condition was edited out in utero using base-precision CRISPR tools, and her cellular health has been monitored and fine-tuned since birth. She will likely live to 120 or beyond. And she'll remain healthy, active, and vibrant nearly all the way there.

Across the ocean, in London, 38-year-old Lucas is finishing a VR consult regarding his bioengineered cloned heart. After a genetic predisposition to cardiomyopathy was flagged at age 25, Lucas opted for a tissue-printed, stem-cell-matched organ replacement. Not only did it eliminate his risk—it upgraded his performance. He runs triathlons with a resting heart rate of 37 BPM and no medication. His "organ dashboard" now lives beside his financial portfolio.

A VISION FOR 2035: By 2035, medicine has shifted from reactive to anticipatory. Instead of waiting for disease to appear, continuous health platforms scan trillions of biomarkers across the global population in real time, identifying patterns, threats, and optimizations long before symptoms manifest.

Projected spending shift from treatment to prevention
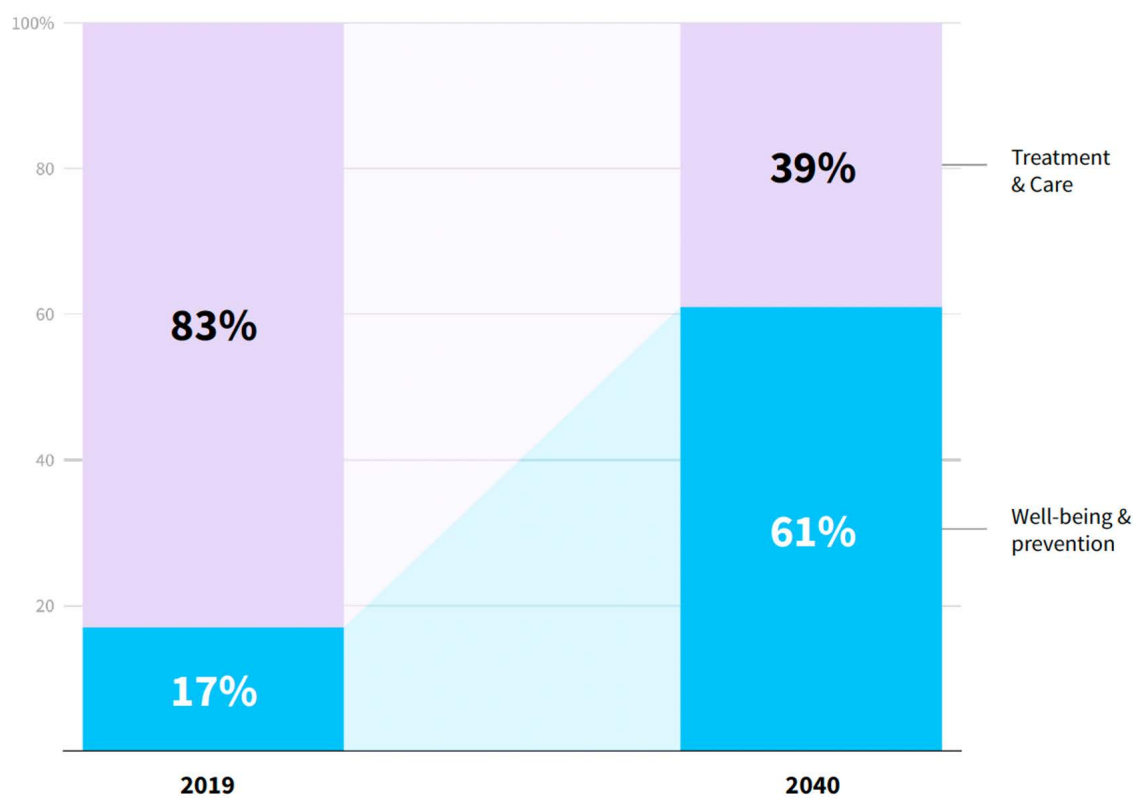
Source: Speedinvest

Longevity optimization has become a global industry. Cellular reprogramming, senolytic therapies, and rejuvenation gene therapies are accessible not just to elites but to anyone with a smartphone and access to a clinic-in-a-box. The result is an explosion in productivity as healthspan is extended by decades. In this new world, people in their 80s routinely train for marathons, start companies, or go back for advanced degrees.

Biotechnology has become our second language. Organs are printed on demand using patient-derived stem cells. Cancer specific mRNA therapies are designed by AI in hours to target and eradicate your unique cancer. Microbiome modulation is as common as brushing teeth.

Every citizen has a digital twin: a comprehensive, AI-simulated version of their biology trained on personal health records, wearables, family history, and population-wide datasets. These twins don't just track, they simulate. When new therapies emerge, they're first tested on your twin to predict side effects, effectiveness, and lifespan impact. Treatment begins before disease does.

In major cities, bioreactor pharmacies generate individualized pharmaceuticals on-demand, tailored to your genes, circadian rhythm, and environmental context. Cancer is no longer a death sentence, it's instead an algorithmic anomaly quickly corrected.

Global "Population Pyramids" To The Year 2100
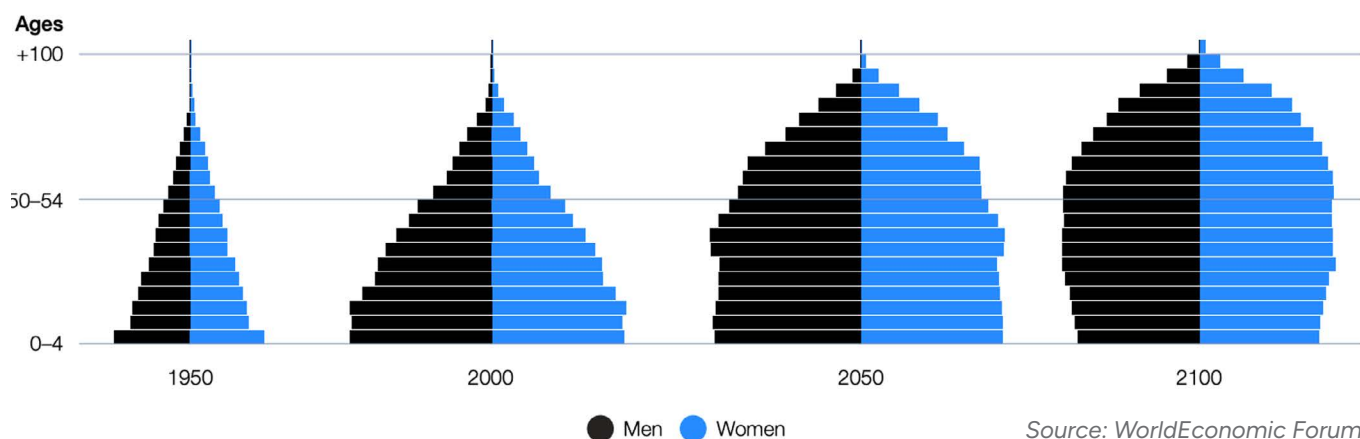
Source: WorldEconomic Forum

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to make the Longevity, Medicine & Biotechnology Metatrend vision a reality:

1. Real-Time Multi-Omics Monitoring: Continuous, minimally-invasive sensors track genomics, proteomics, and more: detecting disease before it starts and enabling truly personalized health optimization.

2. Personalized mRNA & Epigenetic Therapy Engines: On-demand biologics adjust gene expression in real time, tuned to your current health state for preventive and regenerative care.

3. Safe Partial Cellular Reprogramming: Targeted use of transcription factors reverses cellular aging without erasing cell identity, restoring youthful function across tissues.

4. AI-Simulated Personal Digital Twins: Your AI twin models your biology in real time, allowing treatments to be safely tested virtually before they reach your body.

5. Whole-Body Bioprinting & Smart Organoids: Customized, lab-grown organs and tissues replace or upgrade failing systems, eliminating transplant waitlists and rejection risks.

6. Autonomous Health AI Agents: 24/7 AI copilots analyze your biology, predict disease, and optimize interventions: integrated across your devices, calendar, and lifestyle.

Cellular Foundation Model Training

Source: ARK Invest

7. Nanorobotics for Intracellular Repair: Nanobots operate inside cells to detect damage, deliver therapies, and enhance immune response at the molecular level.

8. AI-Designed Longevity Drug Libraries: AI models simulate and design new geroprotective compounds, personalized to your genetics and real-time biological needs.
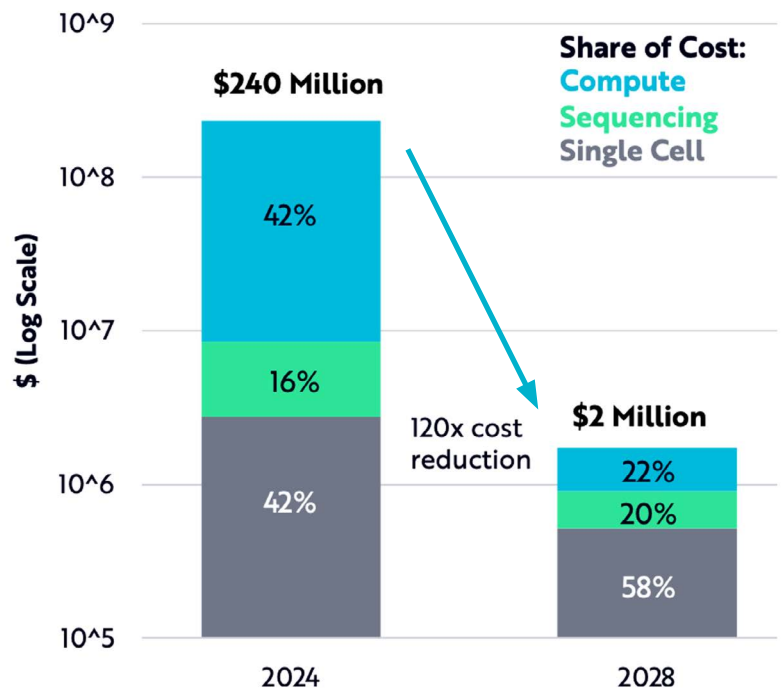
Drug Development Average Cost

INDUSTRY AVERAGE 2024
- $2.4 billion total
- $1.1 billion pre-clinical
- 7.5 human trial failures
- 13 years time-to-market

INITIAL AI-DRIVEN DRUG EFFORTS
- $1.5 billion total
- $0.6 billion pre-clinical
- 4.3 human trial failures
- 11 years time-to-market

FUTURE AI-DRIVEN DRUG DESIGN
- $0.6 billion total
- $0.13 billion pre-clinical
- 1.4 human trial failures
- 8 years time-to-market
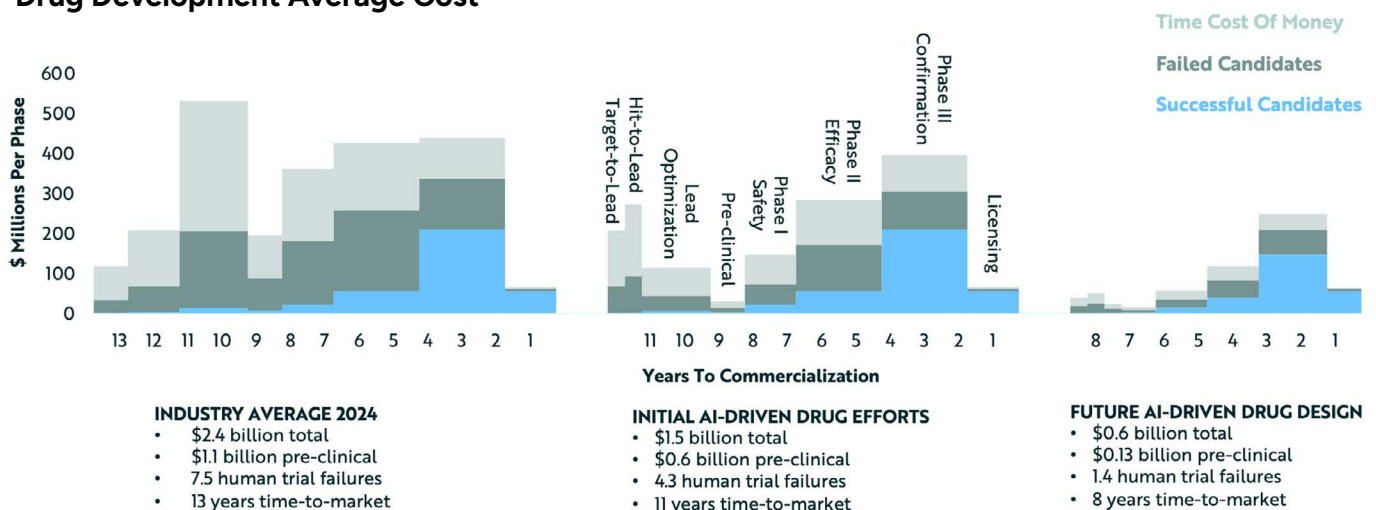
Source: ARK Invest

9. Self-Healing Wearable Bioreactors: Smart skin patches synthesize and deliver nutrients, peptides, and hormones on demand. No pills, no injections, no doctor.

10. CRISPR 4.0: Precision In-Body Gene Editing: Next-gen CRISPR tools offer safe, multiplexed genome edits inside the body to correct mutations and enhance longevity.

CRISPR Clinical Trials Progress - 2025
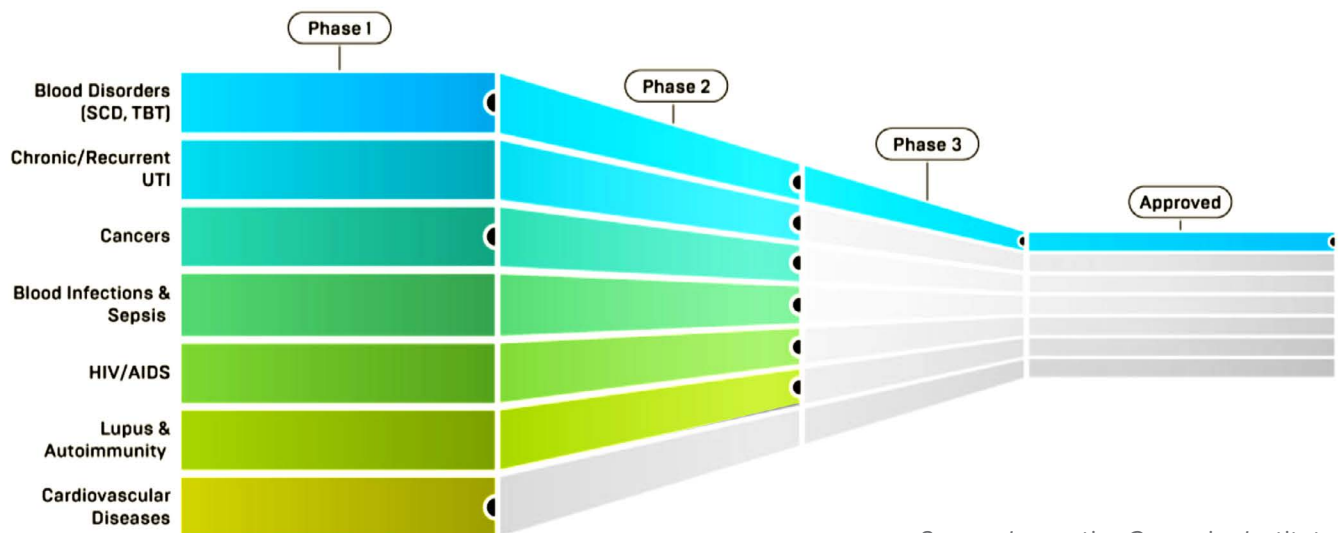
Source: Innovative Genomics Institute

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Longevity-as-a-Service (LaaS) Subscriptions: Monthly services that bundle age-reversal therapies, AI diagnostics, digital twin access, and supplement optimization—all delivered to your home or wearable.

2. Personal Health Operating Systems (pHOS): A unified platform that manages your real-time biological data, curates therapies, coordinates care, and interfaces with your AI health agent.

3. Home Bioreactor Pharmacies: Countertop devices that manufacture pharmaceuticals, peptides, or mRNA therapies tailored to your health status. Like a Keurig for personalized medicine.

4. Concierge AI Longevity Coaches: AI-driven avatars that guide lifestyle, nutrition, supplements, and sleep based on your biological rhythms, stress levels, and performance goals.

5. BioAge Insurance Plans: Health insurance and life insurance premiums and coverage determined by your biological (not chronological) age, encouraging proactive healthspan extension.

Prenuvo Whole Body Scans

Fountain Life facility

6. Digital Twin Simulated Clinical Trials: Before trying a new treatment, it's tested on your personal digital twin. Providers offer twin-based outcome guarantees for efficacy and safety.

7. Smart Skinwear for Continuous Therapy: Wearables that combine diagnostics and biomanufacturing: delivering hormones, nootropics, or immune boosters transdermally as needed.

8. Fertility & Genomic Optimization Packages: Gene-editing concierge services for prospective parents, including rare disease elimination, epigenetic tuning, and enhanced resilience programming.

9. OrganSwap Marketplaces: Certified digital marketplaces for ordering lab-grown organs, vetted for compatibility, performance upgrades, and delivery timelines.

10. Biotech Retirement Accelerators: Retirement communities that focus on age-reversal, cognitive enhancement, and purpose-finding. These are positioned more like accelerators than senior homes.

DARK SIDE OF ABUNDANCE (LONGEVITY & BIOTECH):

While a future of longevity technologies offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. Inequality of Access: Despite falling costs, cutting-edge therapies—like epigenetic reprogramming, AI-driven concierge care, and organ printing—may remain inaccessible to billions in underserved regions. Consequence: a biological divide emerges between those who can afford extended youth and those left behind, exacerbating global inequality and driving a new class of "longevity elites."

2. Over-Optimization of the Human Body: Constant fine-tuning of physiology through AI and gene modulation may incentivize hyper-optimization, treating natural aging or mood variation as faults to be corrected. Consequence: a loss of diversity in human experience and potential mental health impacts from constant self-monitoring or fear of imperfection.

3. Genetic Discrimination & Eugenics Resurgence: As gene editing and in utero enhancements become normalized, so too does the potential for abuse (e.g., designing for "desirable traits," or denying care based on genetic risk). Where do we draw the line between healing and upgrading? Consequence: ethical boundaries blur, reviving concerns about neo-eugenics, ableism, and the commodification of human life.

4. Data Privacy & Bio-Surveillance Risks: Pervasive biosensors, AI health agents, and digital twins require constant harvesting of intimate biological data. Consequence: individuals may lose sovereignty over their own bodies and health records, with potential misuse by insurers, employers, or governments.

5. Longevity Without Meaning: Extending lifespan without equally investing in purpose, social connection, and mental wellbeing could lead to existential boredom, alienation, or depression. Living to 120+ may force psychological reckoning with purpose, reinvention, and existential fatigue. Consequence: a society filled with healthy centenarians who feel directionless, challenging the narrative that longer life automatically equals better life.

WISDOM FOR AN EXPONENTIAL AGE (LONGEVITY):

Following are thoughts worth reflecting up during our decade ahead:

"Living longer is not the goal… living fully, purposefully, and ethically is."

"In mastering our biology, we are challenged to master our humanity."

"To extend life without extending meaning is to add years, not vitality. True longevity demands purpose as much as progress."

"When biology becomes programmable, health becomes a choice— but so does responsibility. Mastery over aging must come with mastery over ethics."

"In curing disease and reversing age, we must not forget the wisdom gained from fragility. A perfect body means little without a well-evolved soul."

DNA Sequencing Cost Per Whole Human Genome

Source: ARK Invest

Compute Time For Analysis Of One Human Genome
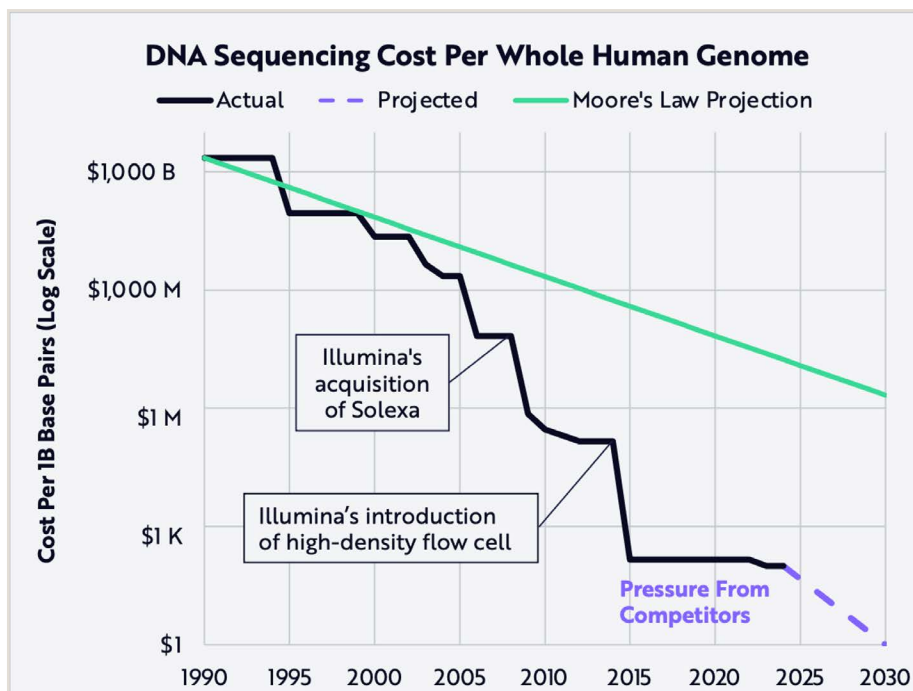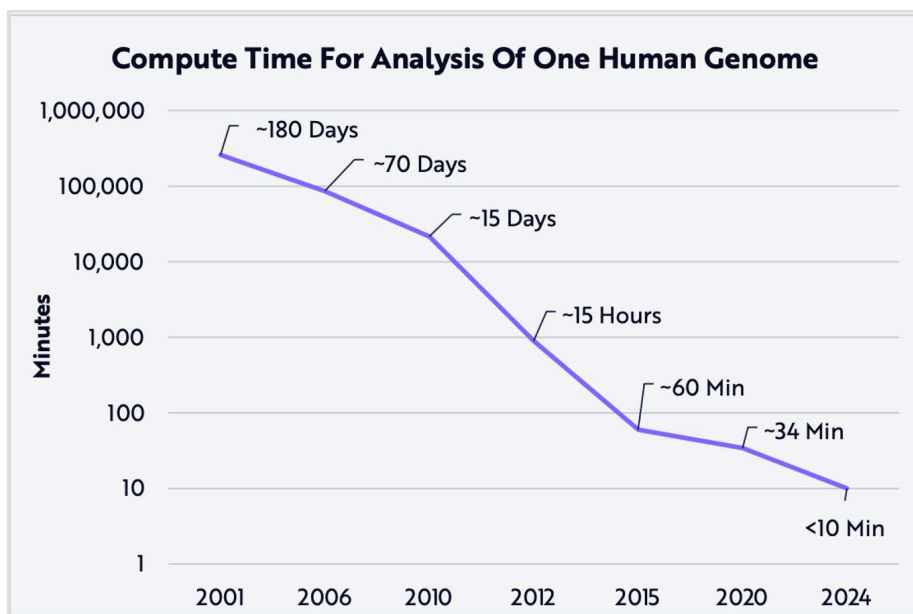
Source: ARK Invest

DIGITAL CURRENCIES, CRYPTO & DEFI (2035 VISION)

By 2035, decentralized finance and programmable currencies have replaced legacy banking for billions—giving individuals sovereign control over money, markets, and identity.

OPENING SCENE: IT'S 2035, AND...

At a street café in Accra, Kweku closes a deal with a Canadian investor using a voice-activated smart contract. The transaction clears in under three seconds, confirmed across a dozen blockchains, and denominated in a stablecoin pegged to a diversified basket of clean energy futures. Kweku never visited a bank, never filled out paperwork, and never worried about currency controls. His reputation score—an open-source blend of on-chain history, community staking, and AI risk analysis—handled the underwriting.

In Jakarta, 26-year-old Ayu receives her salary not in fiat, but in a blend of "civic tokens" issued by her city for verified climate contributions and a governance token from her company's DAO. Her wallet is a wearable ring. Her taxes are streamed in real-time to local services. Her savings auto-convert into a yield-generating protocol governed by her values: climate-positive, women-led, censorship-resistant.

Meanwhile in Buenos Aires, Maria checks her family's "survival wallet": a multisig crypto vault linked to her daughter's biometric ID and geofenced for withdrawal only in emergencies. It's part of a network of community resilience pools designed to withstand inflation, political upheaval, or natural disasters. The system, co-built by NGOs and decentralized dev collectives, replaced cash aid and microloans a decade ago.

Today, digital money isn't just borderless. It's identity-aware, values-aligned, self-custodied, and programmable. The unbanked didn't get banks. They got sovereignty.
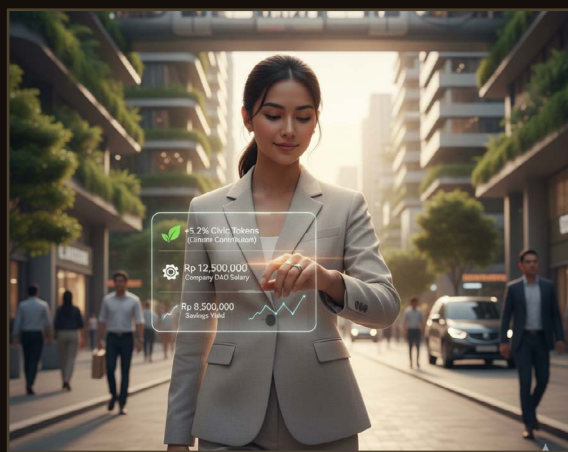
A VISION FOR 2035: In 2035, central bank digital currencies (CBDCs), stablecoins, and decentralized crypto assets coexist in a layered ecosystem. National currencies remain for taxation and macroeconomic policy, but everyday life runs on programmable tokens governed by communities, creators, and code.

Traditional banks have morphed into protocol curators, offering white-labeled access to DeFi infrastructure. Savings accounts are vaults in yield-optimized smart contracts. Loans are matched peer-to-peer by algorithmic underwriters that price risk based on thousands of on-chain behaviors, not static credit scores. Financial services are now composable, built like Lego blocks by anyone with code and conviction.

Entire economies operate as DAOs. A cooperative of regenerative farmers in Brazil runs a tokenized carbon market. A sci-fi production studio in Seoul launches equity NFTs to fund a new film trilogy. Global basic income pilots succeed not because governments found the money, but because digital currencies embedded logic into distribution, behavior, and fairness.

Crypto wallets become passports to the internet economy. With zero-knowledge proofs, people prove who they are, without revealing who they are. Transactions are private, auditable, and interoperable across chains. Corruption fades when contracts are transparent. Fraud shrinks when identity is cryptographic. Ownership becomes liquid, and value flows where attention, trust, and impact go.

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to Enable this future vision of Digital Currencies, Crypto and DeFi:

1. Sovereign Digital Identity Networks: Global, self-custodied identity systems using biometrics and zero-knowledge proofs (ZKPs) to verify trust without revealing personal data.

2. AI-Powered Decentralized Credit Protocols: Autonomous agents assess lending risk in real time from behavioral, social, and DAO-based data. This replaces static credit scores with fluid, inclusive underwriting.

3. Multichain Atomic Settlement Layers: Universal protocols enable instant, trustless transactions across multiple blockchains: no middlemen, no delays, no reconciliation risk.

4. Zero-Knowledge Proof Wallets: Wallets use ZKPs to prove identity, location, income, or age, offering compliance with total privacy across any blockchain interaction.

5. Programmable Stablecoins & CBDCs: Currencies with built-in rules: they expire, change yield, or unlock only under verified civic actions, enabling policy enforcement via code.

Stablecoin Supply VS. Fiat Global M2

2019 To 2030 (2025-2030 Forecast)
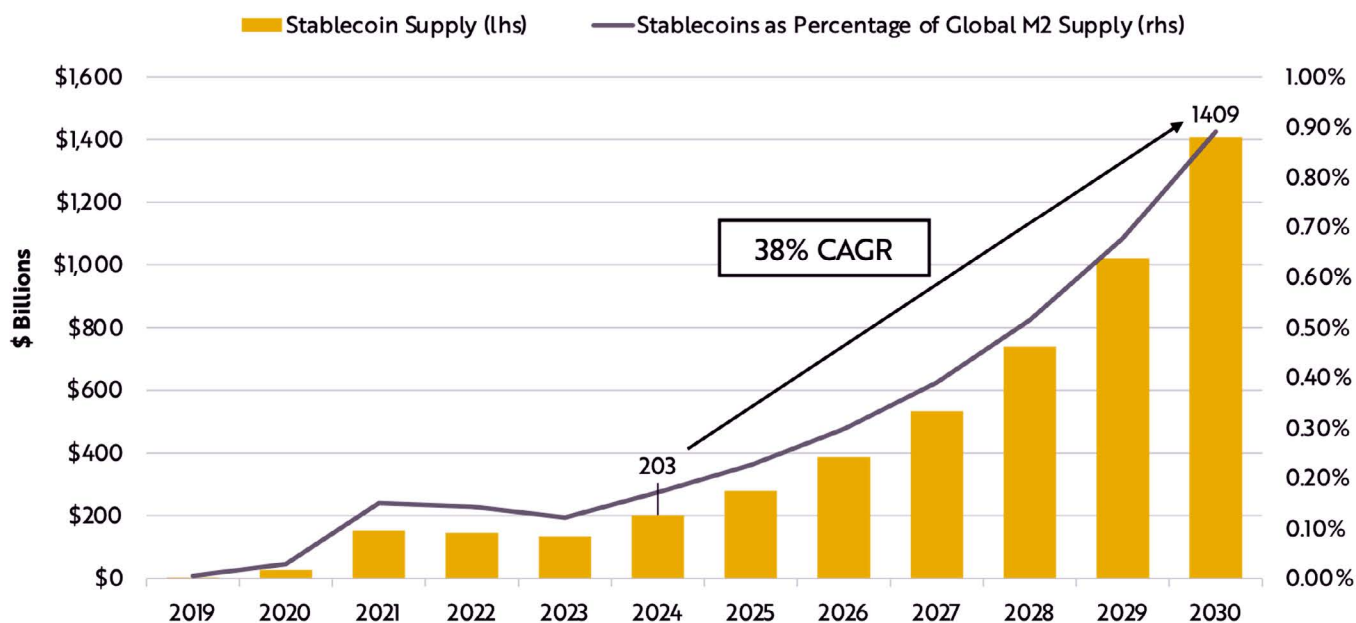
Source: ARK Invest

6. AI-Governed Mission-Aligned DAOs: Autonomous organizations deploy capital aligned with environmental, social, or community goals. They use AI to optimize token flows for impact, not just profit.

7. Composable Finance Legos: Plug-and-play DeFi tools let anyone build savings, lending, and insurance apps: stackable, permissionless, and rapidly evolvable by open-source developers.

8. Smart Tax Infrastructure: Taxation is embedded in smart contracts—automated, auditable, and tamper-proof—removing bureaucracy and reducing corruption in real time.

9. Tokenized Real-World Asset Protocols: Everything—real estate, carbon credits, mining rights, oil rights, royalties—becomes fractional, liquid, and tradable via digital tokens tied to verified on-chain metadata.

10. Survival Wallets with Biometric Multisig: Resilient, geofenced crypto vaults secured by family biometrics, designed for humanitarian aid, disaster response, and financial safety nets.

The exponential flywheel: AI + crypto + identity + programmable logic → a civilization where finance is decentralized, sovereign, and automated.

Forecasted market size of real-world asset tokenization in several industries, including real estate, from 2023 to 2030 (in trillion U.S. dollars)
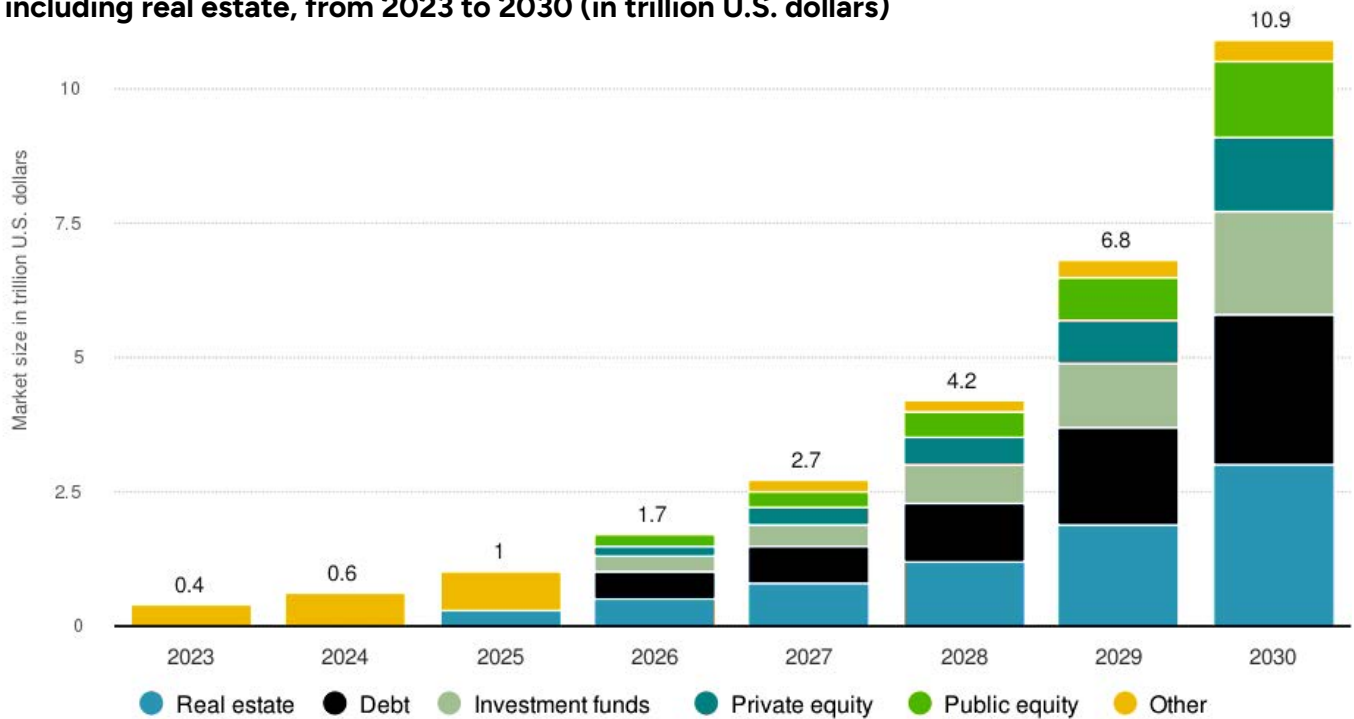
Source: Roland Berger © Statista 2025

Additional Information: Worldwide; October 2023; Individual segments for 2023, 2024 and 2025 were too small to display here. See the "Details" tab for more information.

10 PREDICTIONS FOR 2035: NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Smart Wallet Rings & Wearables: Fashionable, biometric-enabled devices that serve as your crypto wallet, ID, payment terminal, and personal finance manager—fully encrypted and voice-activated.

2. AI Financial Copilots for DeFi: Personal AI agents that manage your crypto portfolio, auto-delegate capital to yield strategies, and warn you of scams or risk—customized to your ethics and goals.

3. Civic Token Marketplaces: Platforms where users earn, trade, and redeem location-specific tokens for voting, volunteering, or environmental actions—gamifying citizenship and civic participation.

4. Global DAO Work Platforms: Decentralized talent marketplaces where individuals work for DAOs instead of companies, earning governance tokens and reputational weight instead of traditional salaries.

5. Real-Time Programmable Tax Wallets: Every transaction routes taxes to smart contracts that instantly allocate funds to local infrastructure, public health, or schools—fully transparent, automated, and tamper-proof.

6. Reputation-as-Credit Services: Platforms that convert your on-chain history, staking patterns, DAO activity, and peer ratings into a dynamic, borderless credit score.

7. Geo-Locked Survival Vaults: Multisig crypto wallets activated only in verified emergencies—linked to biometric ID and geolocation—used for disaster relief, conflict zones, or hyperinflation defense.

8. NFT Investment Collectives: Communities co-own IP, art, or real estate via tokenized NFTs that earn royalties, dividends, and governance rights across sectors.

9. Universal Basic Income Engines: Municipal or NGO-run smart contracts that stream programmable UBI tokens. They expire if not used, grow if invested locally, and adapt based on user needs.

10. Tokenized Impact Funds: Investment platforms where every dollar (or token) deployed is traceable for ESG impact—climate, health, education—powered by on-chain transparency and AI verification.

Estimated Growth in Tokenization Through 2033

Optimistic scenario: 23.4

Conservative scenario: 12.5

Per asset class in USD trillion   +53%

- Funds
- Fixed Income
- Equities
- Real Estate
- Other alternative investments and RWA
- Deposits
- Stablecoins
- Lending & credit
- Treasury & liquidity
- Derivatives
- Alternative investments (PE, Hedge Funds)

2025 2026 2027 2028 2029 2030 2031 2032 2033

Source:https://ripple.com/ripple-press/global-financial-infrastructure-entering-a-new-era/

THREE SIGMA

DARK SIDE OF ABUNDANCE (CRYPTO & DIGITAL ASSETS)

While a future of Crypto and Digital Currencies offers profound benefits, it also brings potential dark sides, unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. Algorithmic Inequality & Financial Discrimination: As creditworthiness and access to services are determined by AI analyzing on-chain behavior, biases in algorithms or insufficient data histories may exclude or misjudge individuals. Consequence: a new form of digital redlining emerges, where the unbanked are now "unscored," and algorithmic prejudice replaces human bias.

2. Programmable Surveillance & State Overreach: CBDCs and programmable tax systems can be weaponized by authoritarian regimes to track, limit, or punish dissent through financial control and behavior-linked currency expiration. Consequence: privacy erosion and political manipulation become embedded in the money itself, turning programmable currency into a tool for digital authoritarianism.

3. Loss of Recourse & Accountability: DeFi eliminates intermediaries, but also removes customer support, fraud protection, and legal recourse in disputes. Consequence: when smart contracts fail, wallets are hacked, or value vanishes due to bugs or exploits, users have no fallback. Code is law... until it breaks.

4. Governance Capture by Token Whales: Tokenized governance often ends up controlled by early adopters or capital-rich entities, skewing DAO decisions toward elite interests. Consequence: instead of democratizing finance, decentralized systems risk reproducing old power structures in new cryptographic clothing.

5. Hyper-financialization of Daily Life: As every action becomes tokenized—volunteering, voting, exercising, learning—the boundaries between intrinsic motivation and transactional behavior blur. Consequence: meaningful civic or altruistic acts may be reduced to earning mechanisms, eroding social trust and intrinsic community bonds.

6. Digital illiteracy: Billions may still lack the skills to navigate decentralized systems, creating new classes of exclusion.

WISDOM FOR AN EXPONENTIAL AGE (CRYPTO/DIGITAL ASSETS):

Following are thoughts worth reflecting up during our decade ahead:

> "With great decentralization comes great responsibility, and the need for upgraded institutions."

> "True wealth in the digital age isn't stored in banks—it's embedded in trust, transparency, and the code that governs them."

> "Financial sovereignty means owning your identity, your data, and your destiny… without asking permission."
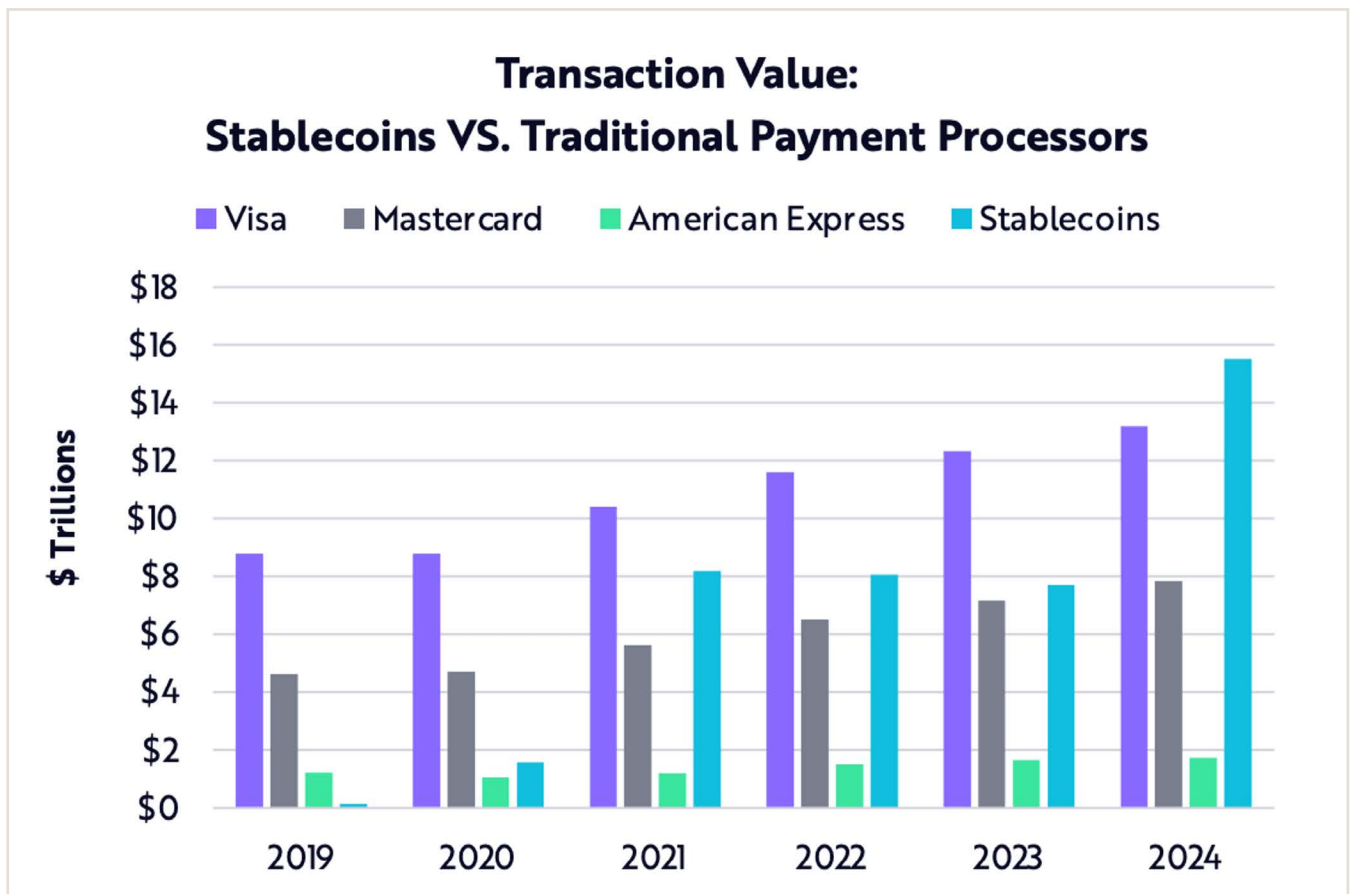
> "When money becomes programmable, justice can be too. But only if the code reflects our highest values."

> "The future of finance isn't faster transactions, it's fairer systems where value flows to contribution, not control."

Transaction Value:
Stablecoins VS. Traditional Payment Processors

Source: ARK Invest

TRANSPORT – ROBOTAXIS, FLYING CARS & DRONES (2035 VISION)

By 2035, autonomy and vertical mobility have redefined how the world moves—making transportation electric, autonomous, and airborne.

OPENING SCENE: IT'S 2035, AND...

In the heart of Dubai, Zara finishes her coffee on the 58th floor and steps onto the launch deck of her apartment's skyport. Her ride is already waiting: a sleek, four-seat autonomous eVTOL (electric vertical takeoff and landing) craft, powered by solar-charged graphene batteries. As the gull-wing doors close, the AI pilot confirms her destination, altitude clearance, and weather conditions. Within seconds, the craft lifts with a low hum into the morning sky. No pilot, no traffic, no emissions.

Meanwhile, in Austin, delivery drones weave through downtown, carrying fresh groceries, lab samples, and library books. On the ground, Level 5 autonomous electric shuttles glide down smart roads. They coordinate with traffic lights via blockchain-verified urban control layers. Children ride alone with full parental visibility. There hasn't been a pedestrian death in over five years.

In Nairobi, Abdul remotely supervises a swarm of autonomous tractors as they till, seed, and water acres of regenerative farmland. His dashboard uses AI to recommend optimal flight patterns for crop-monitoring drones, weather-predictive irrigation, and pricing futures linked to regional climate tokens. Autonomous mobility isn't only for cities, it's transforming the rural world.

Up above, a new class of stratospheric drones maintains high-altitude infrastructure: 5G mesh coverage, atmospheric sensors, and emergency response coordination. Transportation is no longer confined to roads or rails. It is everywhere, intelligently coordinated and invisible until needed.

A VISION FOR 2035: By 2035, transportation is fully on-demand, autonomous, and increasingly vertical. Personal vehicle ownership is declining in favor of Mobility-as-a-Service (MaaS) ecosystems where users summon modular pods, airborne taxis, or long-haul electric convoys. All coordinated by AI.

Global Autonomous Vehicle Adoption Forecast

Source: ARK Invest
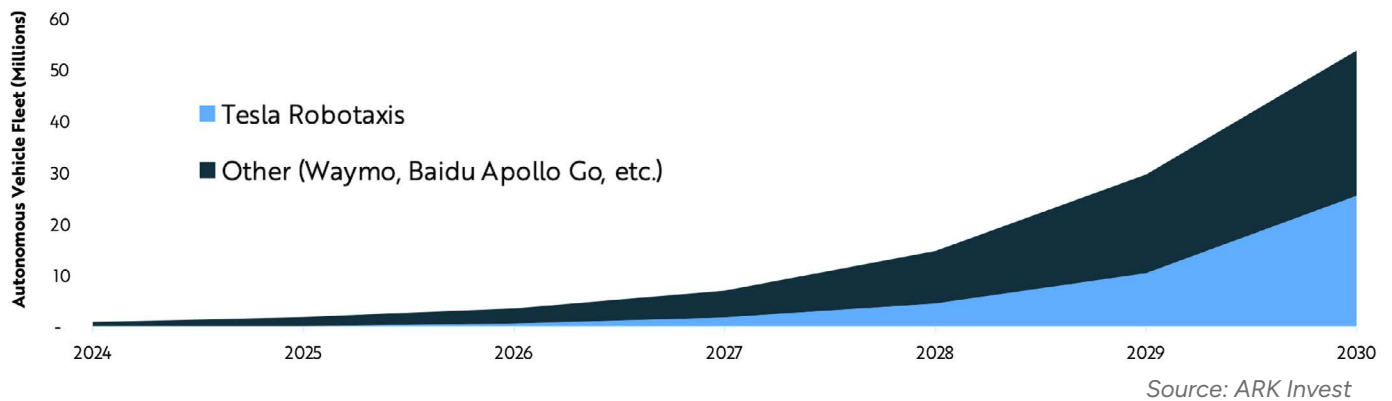
Flying cars are no longer science fiction. Dozens of urban air mobility (UAM) networks operate globally, providing point-to-point air travel across megacities and remote regions alike. What used to take 90 minutes on a congested highway now takes 12 airborne minutes. Noise is minimal, emissions nonexistent, and costs lower than legacy taxis were in 2020.

Highways have evolved into dynamic lanes that shift based on real-time traffic patterns and are maintained by robotic systems. Trucks drive themselves, monitored by human logistics experts in virtual control centers. Freight moves faster, cleaner, and safer than ever before.

Transport is now a global nervous system: smart, decentralized, electric, and increasingly airborne. For the first time in history, geography is losing its grip on opportunity.

The global fleet of eVTOL aircraft could grow to 12,000 by 2035

Estimated global fleet size of eVTOL aircraft, in thousands

Source: Bain analysis
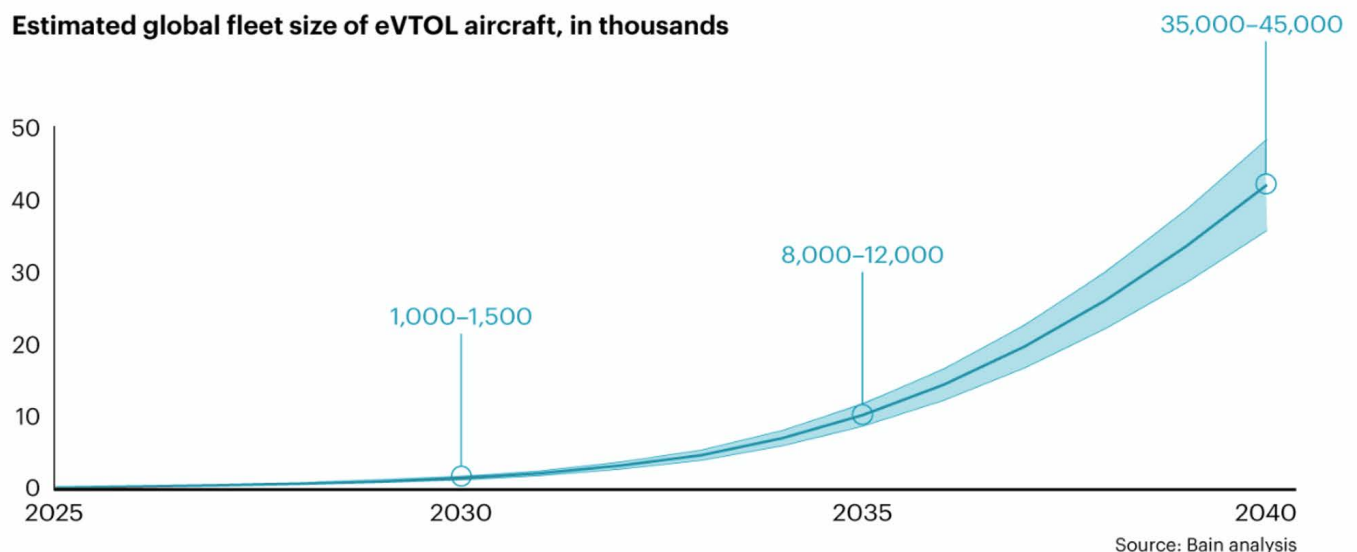
TOP TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to make this future vision of Autonomous Robotaxis, Flying Cars and Drones a reality:

1. Level 5 Generalized Autonomy: Vehicles navigate any terrain, weather, or traffic condition with zero human input: paving the way for fully driverless transport across all environments.

Autonomous vehicle penetration is forecast to grow in major economies
Key regions level 3/4/5 penetration rate

China 90%
Europe 79%
Japan 73%
US 65%
India 12%

Source: Company data, Goldman Sachs Research

Goldman Sachs
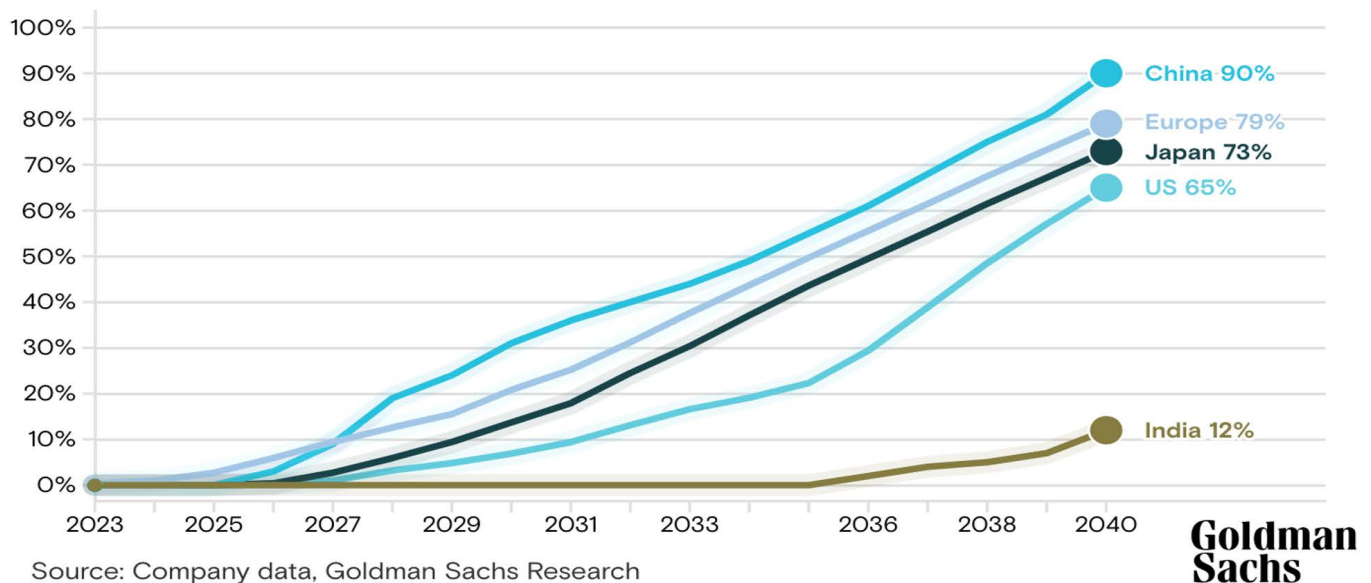
2. AI-Piloted eVTOL Systems & Regulations: Autonomous electric air taxis fly safely through urban airspace, with AI managing routing, collision avoidance, weather, and passenger experience. No pilot required. Updates to FAA/DOT regulations allow autonomous systems to operate within airspace corridors with beyond-line-of-sight approvals.

Autoflight EVTOL vehicle

Joby EVTOL vehicle

Forecasted Autonomous Delivery Revenue ($ Billions, 2030)
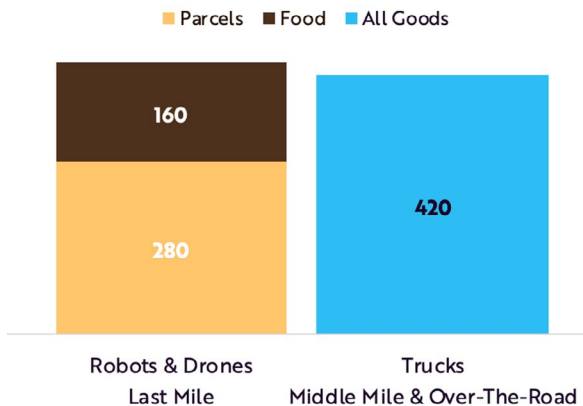
Source: ARK Invest

Starship, a leading drone company

3. Smart Infrastructure-to-Vehicle (V2X) Networks: Roads, skyports, and intersections communicate with vehicles in real time: coordinating traffic flow, charging availability, and hazards through intelligent edge computing.

4. Battery Breakthroughs, Rapid Charging & 2X Energy Storage Density: High-density, ultra-light batteries with rapid charging and long lifespans power drones, eVTOLs, and EVs—enabling vertical mobility and high-frequency logistics.

5. Multimodal Mobility-as-a-Service Platforms: Integrated platforms combine air taxis, robo-shuttles, and drones into seamless on-demand travel. These are coordinated by AI and accessed via a single subscription or app.

6. eVTOL Noise & Safety Engineering: Breakthrough rotor designs and adaptive AI control reduce acoustic impact and maximize passenger safety, making aerial transit neighbor-friendly and regulator-approved.

Google Wing drone

7. Drone Delivery Interoperability Meshes: Airspace coordination allows hundreds of drones from different providers to operate safely and efficiently in shared airspace. Last-mile delivery becomes faster, cheaper, and zero-emission.

8. Autonomous Freight Convoys: Self-driving long-haul trucks travel in platoons, optimizing energy and route efficiency while coordinating with dynamic infrastructure. Global supply chains become faster, cheaper, and more resilient.

9. Resilient Positioning & Communications: Multi-source navigation (GNSS, vision, beacons) and redundant 5G/LEO links give vehicles cm-level accuracy and reliability in any environment. This enables safe autonomy for eVTOLs, drones, and robotaxis even in GPS-denied areas.

10. City-Scale Digital Twins: Real-time virtual models of roads and airspace allow regulators and operators to test, certify, and monitor autonomy through simulation: cutting approval times, boosting safety, and speeding rollout of new transport systems.

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Air Taxi Subscriptions: Monthly flight plans for urban air mobility offering unlimited eVTOL commutes across city corridors, complete with in-flight entertainment, noise-canceling cabins, and dynamic rerouting.

Passenger advanced air mobility operators could soon rival the largest airlines in terms of fleet size and flight operations.

■ Representative large airline (2019, mainline only)
■ Representative AAM operator (early 2030s, estimated number)

	Fleet size	Flights per day	Network nodes	Active pilots	Passengers per day	Average flight time	Revenue per year
Large airline	~0.8k	~2.2k	~200	~10.5k	~400k	~2.3h	~$33Bn
AAM operator	~1k	~20.0k	~110	~4.5k	~70k	~18 min	~$3Bn
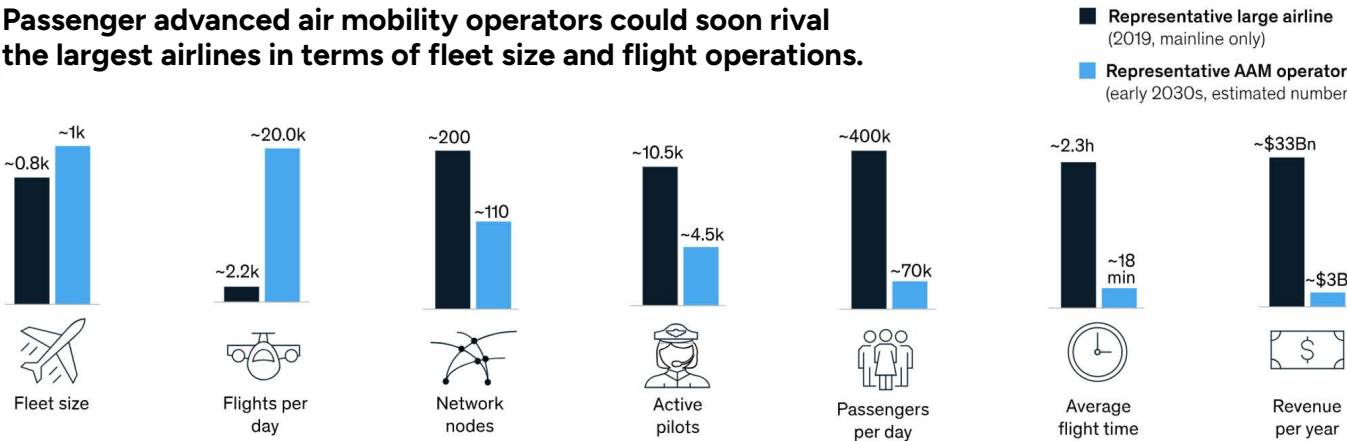
Source: 2019 BTS, Cirium, investor presentations

2. RoboFleet-as-a-Service (RaaS): Turnkey autonomous vehicle fleets for cities, campuses, and private developments. Vehicles come pre-trained, fully electric, and V2X-integrated for dynamic grid participation.

3. DronePort Infrastructure Kits: Modular rooftop kits for buildings to install and manage autonomous drone delivery and eVTOL services, complete with charging hubs and weather sensors.

4. AI Mobility Concierge Apps: Personal AI agents monitor your schedule and GPS location and "auto-magically" coordinate multimodal travel—ground, air, or delivery—with carbon optimization, cost efficiency, and schedule-aware decision-making built in.

Baidu robotaxi

Waymo robotaxi

5. Autonomy-Ready Smart Roads & "Bid For Access" Services: Subscription-based access to smart infrastructure: roads embedded with sensors, wireless charging coils, dynamic lanes, and real-time LIDAR broadcast for autonomous vehicles. Autonomous vehicles in a rush can pay extra fees that will incentivize cars and trucks ahead of them to move out of the way and clear the route for rapid access.

6. FarmBot Autonomy Packs: Solar-powered tractor and drone bundles for smallholder farms: autonomous systems that till, plant, irrigate, and monitor crops, managed remotely via smartphone.

7. Emergency eVTOL Dispatch Networks: Decentralized fleets of autonomous air ambulances and disaster drones, dispatched instantly using geolocation and smart triage AI.

8. Mobile Battery Swarm Services: Robo-vehicles with surplus battery capacity serve as grid balancers, moving to neighborhoods, charging stations, or industrial zones on demand during peak energy needs.

9. Air Rights Management Platforms: Digital marketplaces for buying, leasing, and regulating vertical airspace over buildings, with AI-powered congestion pricing and flight corridor arbitration.

10. Autonomous Freight DAO Cooperatives: Decentralized networks where freight owners, autonomous vehicle operators, and logistics AI collaborate via token incentives to move goods globally without central intermediaries.

DARK SIDE OF ABUNDANCE (AUTONOMOUS TRANSPORTATION):

While a future of Autonomous Transportation offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. Job Displacement at Massive Scale: As autonomous vehicles dominate logistics, delivery, farming, and ride-hailing, millions of drivers, pilots, and warehouse workers become obsolete. Consequence: entire job sectors vanish faster than labor markets can adapt, leading to economic unrest, unemployment spikes, and widening inequality in regions dependent on transport labor.

2. Surveillance Infrastructure Creep: Smart mobility requires constant sensing: LIDAR, cameras, drone monitoring, location tracking, and biometric access. Consequence: cities become "transparent by design," where every movement is monitored, raising significant concerns about civil liberties, data exploitation, and government or corporate overreach.

3. Urban Air Congestion & Class Stratification: eVTOLs offer speed, but also introduce a new vertical class divide: those who fly above traffic and those still stuck below. Consequence: airspace becomes a battleground, with privileged access reinforcing inequality while underserved communities remain grounded, both literally and economically.

4. Weaponization & Malicious Hijacking of Autonomous Systems: Unsecured drones and vehicles may be exploited for smuggling, terrorism, or cyberwarfare. A hijacked freight convoy or air taxi poses massive risks. Consequence: the line between convenience and vulnerability blurs, with each autonomous node becoming a potential attack vector.

5. Environmental and Spatial Overload: Even electric vehicles and drones require materials, power, and airspace. Widespread deployment without strict ecological governance may lead to silent forms of pollution: acoustic, visual, and electromagnetic. Consequence: skies buzz with constant drone traffic, rural tranquility erodes, and pristine environments are compromised by constant sensor-laden flyovers.

WISDOM FOR AN EXPONENTIAL AGE (AUTONOMOUS TRANSPORT):

Following are thoughts worth reflecting up during our decade ahead:

"The freedom to move must be matched with the wisdom to guide."

"Speed without direction is chaos. Autonomy demands vision, not just velocity."

"When vehicles drive themselves and cities lift into the sky, mobility becomes a human right and not a privilege of geography."

"Autonomy liberates us not only from the steering wheel, but from the tyranny of wasted hours and wasted potential."

"The greatest leap isn't vertical, it's ethical: ensuring that our most powerful transportation technologies serve all of humanity, not just the fastest or the first."

Estimated Market Share (Gross Bookings) – 8/23-4/25, San Francisco Operating Zone, per YipitData
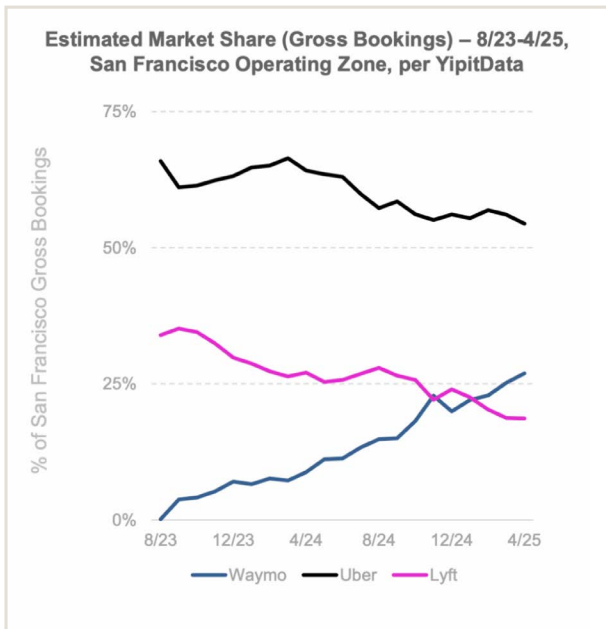
Source: The Road to Autonomy

Autonomous Deliveries

Exhibit 1: Key Changes to 2040 TAM by End Market ($Bn)
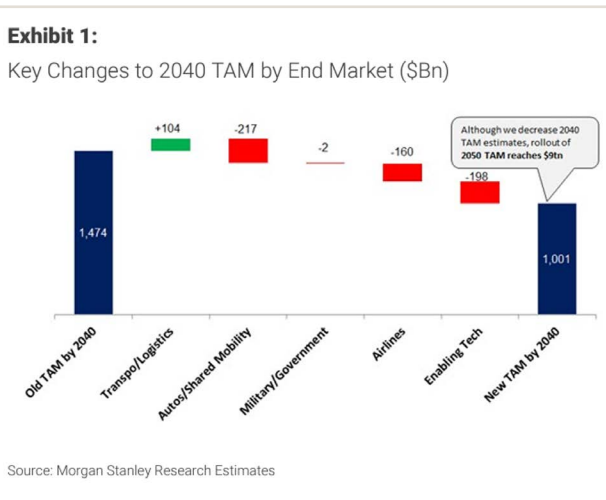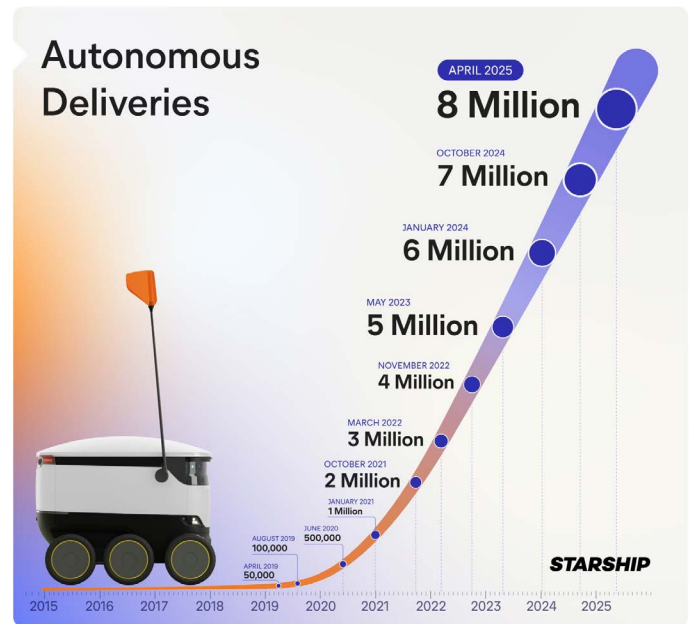
Source: Morgan Stanley Research Estimates

Volume of B2C drone deliveries worldwide from 2024 to 2034 (in million U.S. dollars)

Local Batch Delivery Cost (Per Trip) / Local Small Item Delivery Cost (Per Trip)

Source: ARK Invest

Ride-Hail Addressable Market*

Price Points ($):
- 4.00
- 3.00
- 2.00
- 1.10
- 0.60
- 0.50
- 0.25

$134B: Existing addressable market for ride-hail companies in Western markets charging $2-$4 per mile

$4B
$30B
$100B

$1T: Addressable ridership in Western markets at ~$1

$2.4T: Non-commuting miles in higher income countries priced at ~$0.60 per mile

$2.75T: Long tail of demand priced at human driven ride-hail prices of $0.50 per mile in lower income countries

$5T: Low cost, accessible autonomous travel at $0.25 per mile

Price Per Mile (y-axis): $0.00, $0.50, $1.00, $1.50, $2.00, $2.50, $3.00, $3.50, $4.00, $4.50

Miles (Trillions) (x-axis): 0, 1, 5, 10, 30

Source: ARK Invest

Value of Goods Delivered by Drones by Region and Type of Goods, 2034, $ million

Region
- North America
- South America
- Asia-Pacific
- Europe
- Middle East & Africa
- Not covered

Type of goods delivered
- Parcel & e-commerce
- Prescription medicine
- Food
- Other goods

Values on map:
- 15,105 (North America)
- 20,968 (Europe)
- 24,532 (Asia-Pacific)
- 1,384 (Middle East & Africa)
- 3,188 (South America)

Value of Goods Delivered by Drones by Type of Goods, 2024-2034, $ million

+74%

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
251	431	729	1,231	2,133	3,720	6,529	11,530	20,501	37,173	65,177

CAGR '24-34
- 64%
- 87%
- 66%
- 80%

Source: PwC Drone Powered Solutions - Global Center of Excellence in Drone and Geospatial Technologies. 2024. "Drone Deliveries: Taking Retail and Logistics to New Heights."

NETWORKS & SENSORS – SATELLITES, BCI, WEARABLES & THE TRILLION-SENSOR WORLD (2035 VISION)

By 2035, humanity is embedded in a living mesh of sensors, satellites, and neural interfaces—creating a world that sees, feels, and responds in real time.

OPENING SCENE: IT'S 2035, AND...

In the highlands of Bhutan, a shepherd adjusts a translucent earbud: his neural interface to a satellite-powered mesh that tracks herd movements, predicts weather shifts, and monitors soil regeneration via sensors embedded in the terrain. As he moves, his augmented reality lenses surface suggestions: graze northeast, conserve this patch, trade 5 carbon tokens earned this morning. He nods, and the system responds.

In Seoul, a teenager rehearses a piano concerto. Her brain-computer interface (BCI) tracks concentration levels, neurofeedback loops optimize her practice in real time, and her digital twin critiques posture using her smart shirt's haptic tension sensors. Her "mentor" is an AI trained in every master pianist's style and is integrated directly into her cognition.

Meanwhile, in Nairobi, a smart ambulance arrives at a crash site before a bystander can place a call. Nearby lamppost sensors triangulated the sound, thermal, and vibration signatures of impact. Drones launched autonomously. The patient's biosensors streamed vitals to emergency teams en route. No time was wasted. No decision uninformed.

Above it all, a dynamic shell of 100,000+ low-Earth orbit satellites blankets Earth, orchestrating this planetary-scale symphony of awareness. Every field, face, forest, and fleet is connected, sensed, and responsive. The planet itself is now intelligent.

A VISION FOR 2035: By 2035, the world is wrapped in a trillion-sensor web: an ambient nervous system built from satellite networks, edge sensors, wearables, and BCIs. Everything meaningful is measured. Every signal is contextualized. Every decision is optimized in real time.

OUR TRILLION SENSOR FUTURE

Space-based Comms & Imaging
100,000 of Satellites (12+)

Drones & Flying Cars
10's of Millions (10+)

Smart Phones	Autonomous Cars	Robots	Wearables	Smart Homes	IoT / Smart Factory
8 Billion (20)	8 Billion (20)	10 Billion (20+)	2 Billion (20+)	1 Billion (20+)	1 Billion (100+)

Smart cities are more than connected, they're predictive. Traffic flows adjust dynamically based on commuter data. Energy grids respond to household moods, shifting lighting and temperature in sync with occupant circadian rhythms. Garbage bins track methane emissions. Cities dynamically reconfigure themselves (lighting, noise, traffic) based on aggregated biometric and cognitive feedback from residents, enhancing well-being at scale. Safety in all parts of the city is now at 100% given that any indication of malintent can be quickly identified and perpetrators convicted. The result: an urban ecosystem that feels alive, adaptive, and intimately aware of its inhabitants.

Ambient planetary intelligence emerges as every square meter of Earth is sensed, mapped, and monitored: powering predictive agriculture, climate stabilization, and global risk forecasting. No environmental accident or transgression goes without knowing exactly who is to blame. Forests send early warnings about stress, drought, or disease.

Illustration of Starlink satellite coverage

At the personal level, our bodies stream data into private neural health graphs. Wearables embedded in skin, abdomen and clothing collect continuous data on hydration, inflammation, blood chemistry, and emotional state. When anomalies arise, AI health copilots intervene, sometimes years before symptoms appear.

Most transformative of all, brain-computer interfaces have entered into mainstream society. Initially adopted by patients with paralysis, they're now worn by creatives, CEOs, and students. Users think and google. They flex and machines respond. Thoughts sculpt software. Empathy is transmitted across networ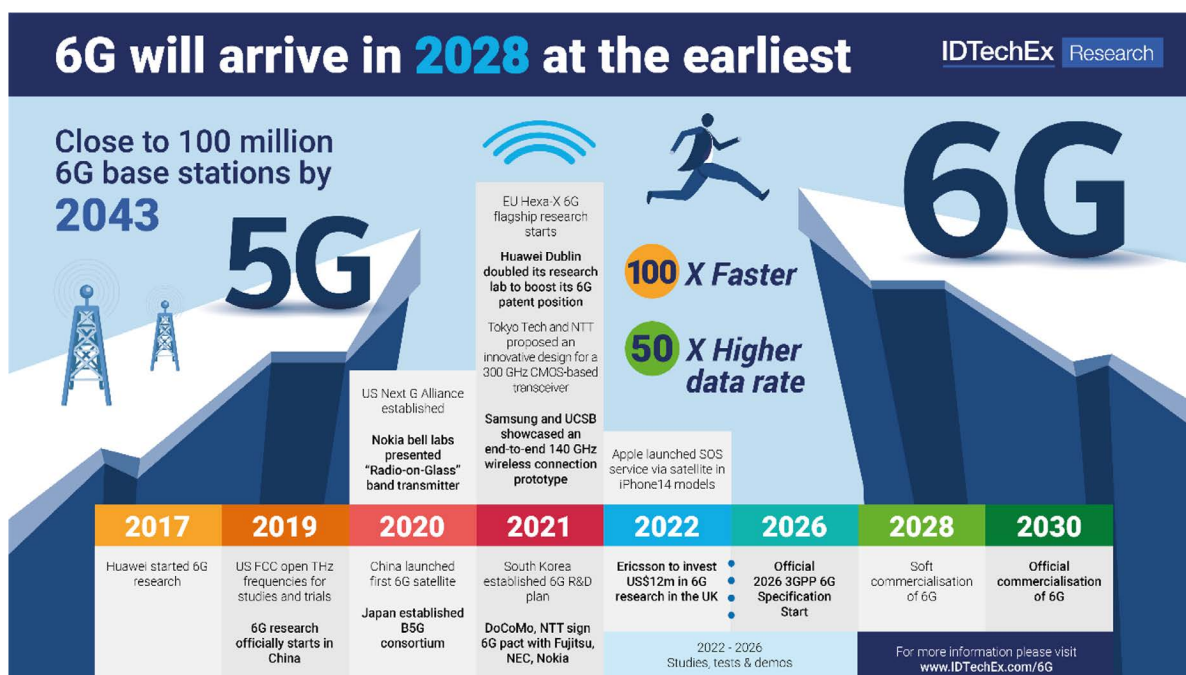ks. The boundary between mind and machine has blurred. BCIs allow users to type, search, design, and collaborate at the speed of thought—

Hilo band wearable

revolutionizing learning, creativity, and mental health. The speed of creativity has skyrocketed.

Beinao-1 brain-computer interface (BCI) device

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to make the Networks and Sensors Metatrend vision a reality:

1. Ultra-Low-Power Ambient Sensors: Batteryless, energy-harvesting sensors that continuously monitor environmental, biological, or structural data: at scale, with minimal maintenance or replacement. Sensors scavenge energy from the environment.

2. Networks for Massive Sensor Data Backhaul: Over the next decade, **Wi-Fi HaLow**, **5G Advanced (and 6G)**, and **LoRaWAN/NB-IoT** will become foundational for backhauling massive sensor networks. Wi-Fi HaLow will dominate smart homes and wearables with low-power, long-range connectivity. Meanwhile, 5G Advanced and LoRa/NB-IoT will power industrial IoT, smart cities, and rural sensing with scalable, energy-efficient infrastructure.

6G will arrive in 2028 at the earliest — IDTechEx Research

Close to 100 million 6G base stations by 2043

5G → 6G

100 X Faster

50 X Higher data rate

EU Hexa-X 6G flagship research starts

Huawei Dublin doubled its research lab to boost its 6G patent position

Tokyo Tech and NTT proposed an innovative design for a 300 GHz CMOS-based transceiver

Samsung and UCSB showcased an end-to-end 140 GHz wireless connection prototype

US Next G Alliance established

Nokia bell labs presented "Radio-on-Glass" band transmitter

Apple launched SOS service via satellite in iPhone 14 models

2017	2019	2020	2021	2022	2026	2028	2030
Huawei started 6G research	US FCC open THz frequencies for studies and trials; 6G research officially starts in China	China launched first 6G satellite; Japan established B5G consortium	South Korea established 6G R&D plan; DoCoMo, NTT sign 6G pact with Fujitsu, NEC, Nokia	Ericsson to invest US$12m in 6G research in the UK	Official 2026 3GPP 6G Specification Start	Soft commercialisation of 6G	Official commercialisation of 6G

2022 - 2026 Studies, tests & demos

For more information please visit www.IDTechEx.com/6G

**Projected Number of IoT Connections (Billions)**
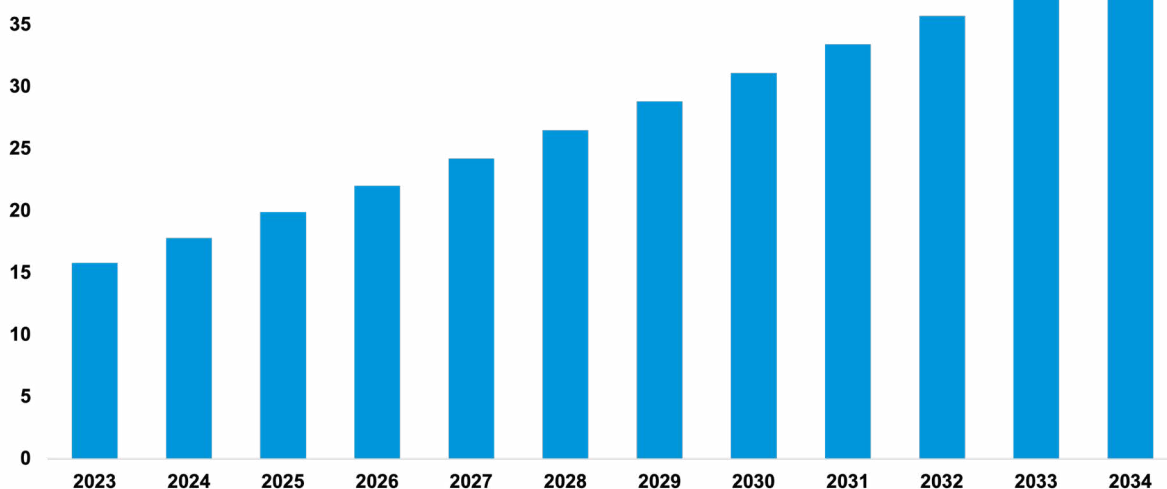
Source: Transforma Insights

3. Biometric Sensors: Low-power continuous and adaptive biometric sensors embedded in skin patches, fabrics, earbuds, and even contact lenses monitoring heart rate and oxygen, but stress, hydration, inflammation, neurotransmitters, and brain activity, fueling real-time personalized health insights.

4. Micromachine & Nanotechnology Sensors: Development of **MEMS** (micro-electromechanical systems), **nanobiosensors** small enough to embed in paint, clothing, packaging, or even cells; **graphene-based nanosensors** for chemical detection and metabolic monitoring; **smart dust (millimeter-scale)** for environmental and structural sensing; **bio-hybrid nanorobots** for targeted drug delivery or cellular diagnostics and flexible electronic tattoos and hydrogel-based implants that seamlessly conform to skin or organs

5. Neural Interface Wearables: Non-invasive brain-computer interfaces that translate thoughts, emotions, and intent into digital actions. Safe, affordable, and wearable for everyday consumers.


Paradromics & Synchron BCI devices
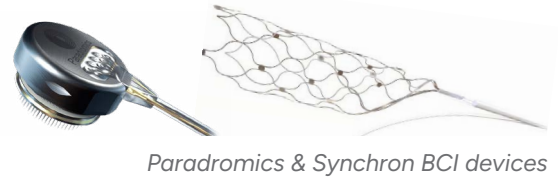
6. Edge AI Sensor Fusion Chips: Ultra-small chips that locally process sensor data and reduce bandwidth needs, preserve privacy, and enable real-time responsiveness at the edge.

7. Global Satellite Mesh Networks: Tens of thousands of LEO satellites forming an always-on, low-latency backbone for sensor communication, drone navigation, and planetary-scale coordination.

Projected total number of satellites in orbit

Projected number of satellites in GEO and non-GEO orbits, 2021-2030. Increasing rate of launch will lead to increased congestion, especially in LEO.
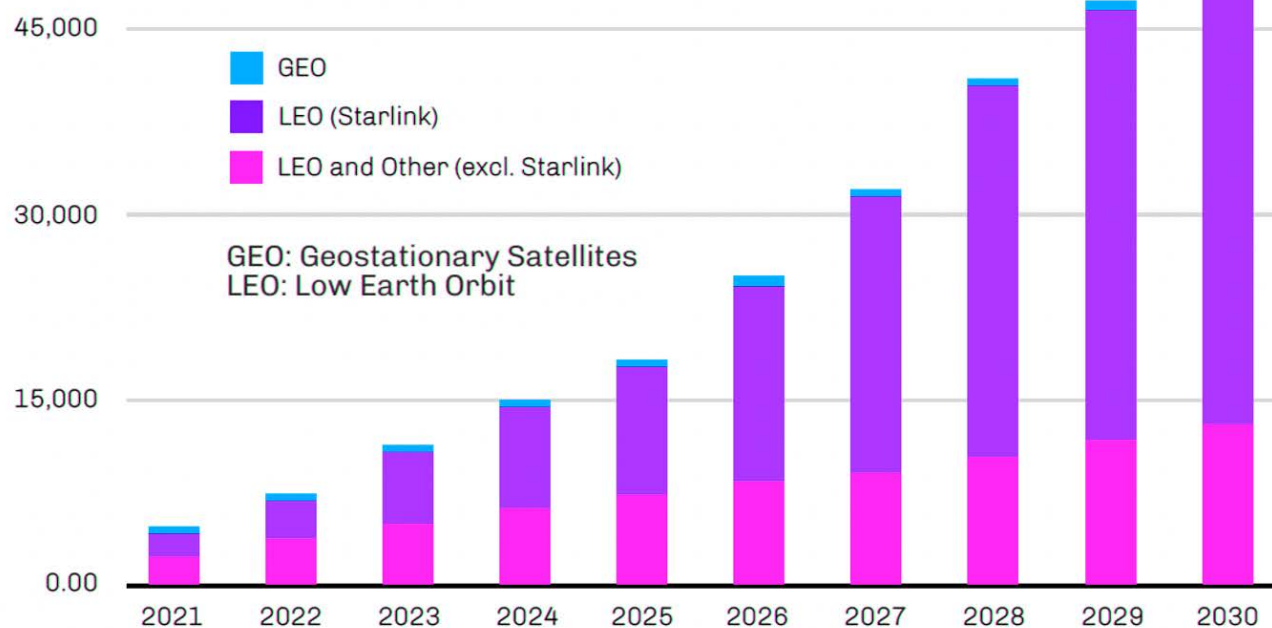
Source: UP Partners

8. Wireless Power Transmission (WPT): Many edge sensors will be deployed in remote, hard-to-reach, or mobile locations (e.g., walls, soil, clothing, drones) where WPT will eliminate battery replacement and enable true zero-maintenance sensing. WPT will also make possible continuous brain-computer interface use (e.g., earbuds, headbands, neural tattoos), providing steady power without bulk. Wireless charging from furniture, walls, or body heat ensures uninterrupted operation.

9. Real-Time Environmental AI Dashboards: Integrated, planetary-scale visualization systems combining climate, seismic, biological, and geopolitical data that allow early warning and preemptive action by governments and communities.

10. Open Sensing Marketplace-Platforms: Decentralized marketplaces where users monetize their sensor data to power citizen science, participatory AI, and public goods generation without corporate gatekeepers.

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Reality Replay – Historical Reconstruction-as-a-Service: Using fused sensor data from drones, AR glasses, autonomous vehicles, and public infrastructure, Reality Replay allows users to reconstruct any physical scene—sights, sounds, conversations—with timestamped accuracy. Ideal for personal memory retrieval, insurance disputes, or criminal forensics.

2. On-Demand Searchable Planetary Awareness: Tap into a live, searchable planetary index fusing cameras, satellite feeds, drones, and autonomous vehicles. Want to know which streets are flooding, where your friend's car is, or what the vibe is outside a cafe in Tokyo? Just ask.

3. BioChef – AI Cuisine Tailored to Your Bloodstream: Your wearable streams glucose, inflammation, hydration, and hormonal data to your home's robotic kitchen, which formulates and 3D-prints the perfect meal in real time: designed to heal your gut, optimize cognition, or prep for sleep.

4. Synaptic Telepresence – Full BCI Control of Humanoid Robots: Forget VR. You don't see through the robot, you become the robot. Synaptic telepresence uses a high-bandwidth BCI to stream motion, haptics, and audio in both directions, enabling remote labor, caregiving, or exploration from anywhere on Earth.

5. SenseMarket – The Global Exchange for Sensor Data: Every drone, car, wearable, and smart wall is a node in a decentralized data economy. Need proof of noise pollution, weather anomalies, or who was speeding past your house at 3am? Buy or sell real-time sensory receipts in seconds.

6. HyperSpec AI – Financial Arbitrage for the Physical World: A real-time analytics engine that monitors crop yields, energy flows, construction activity, and climate shifts to exploit arbitrage opportunities across markets. Used by hedge funds, supply chain managers, and climate investors to predict future value with unmatched precision.

7. Neural Echo – Empathy-as-a-Service Channels: Broadcast your emotional state to loved ones or coworkers via encrypted biosignals (EEG, HRV, cortisol). Designed to reduce miscommunication, create "emotional mirrors," and train AI assistants to better support human needs across relationships and teams.

8. GhostFeed – Live Monitoring of the Dead, Past, or Hidden: Ancestral data, sensor footprints, and memory-layer reconstructions allow you to "converse" with long-lost relatives, observe your child's first steps again, or uncover secrets hidden in walls, rooms, or servers, all based on environmental and biometric residue.

9. Autonomous Factory Optimization-as-a-Service: OmniLoop is a continuous, closed-loop AI optimization platform that overlays industrial environments with a real-time sensor fusion grid: ingesting data from conveyor cameras, robotic joints, temperature sensors, human wearables, drone inspectors, and energy meters.

Edge AI chips on-site run micro-adjustments every second: rerouting workflows, tuning robotic speeds, balancing energy loads, and even modifying shift rotations based on worker fatigue and stress signals. The result is a factory that thinks faster than humans, adapts in real time, and evolves daily toward peak throughput, minimal downtime, and human-machine symbiosis.

10. Autonomous Witness Agents for Legal Verification: Wearables and environmental sensors record events with time-synced, AI-certified integrity. These "witness nodes" can verify contracts, detect lies, reconstruct accidents, or exonerate you in court, with truth rendered as code, admissible in any jurisdiction that recognizes blockchain-based reality records.

DARK SIDE OF ABUNDANCE (NETWORKS & SENSORS):

While a future of Networks and Sensors offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. **Hyper-surveillance:** Ubiquitous sensing can empower authoritarian regimes or erode privacy if not governed by strong consent architectures. With every movement, emotion, and thought captured in real time, societies risk trading privacy for convenience. Governments and corporations may exploit ubiquitous sensing to exert unprecedented behavioral control, turning "ambient intelligence" into ambient authoritarianism.

2. **Cognitive Hacking & Mental Intrusions:** Brain-computer interfaces open the door to neuro-manipulation. Malicious actors could hijack thoughts, implant suggestions, or induce false memories—shattering mental sovereignty and ushering in a new era of "brain malware." Constant sensing and feedback loops can induce burnout, paranoia, or identity erosion.

3. **Sensor Inequality & Cognitive Class Divide**: Access to advanced neural wearables and personalized digital twins may be stratified by wealth, deepening the divide between cognitive elites (hyper-optimized, AI-augmented) and the digitally disenfranchised (unmonitored, unsupported, and unseen). Those who control the sensing platforms may dominate markets, narratives, and governance.

4. **Eco-Exhaust from Over-Sensing**: A trillion sensors and 100,000+ satellites demand vast materials, rare earths, and energy. The environmental toll of manufacturing, deploying, and powering planetary-scale awareness may paradoxically accelerate climate degradation under the guise of optimization.

5. **Collapse of Organic Human Experience**: When every feeling is tracked, predicted, and algorithmically optimized, spontaneous joy, mystery, and free will may erode. Life risks becoming a quantified simulation—less felt, more managed—curated by unseen AI copilots we no longer question. Thought-level access raises terrifying prospects: mind-reading hacks, emotional manipulation, or behavior control.

WISDOM FOR AN EXPONENTIAL AGE (NETWORKS & SENSORS):

Following are thoughts worth reflecting up during our decade ahead:

" **"Awareness is power. But power, unbalanced, risks oppression."**

" **"In a world that knows everything, the real question becomes who decides what matters?"**

" **"When everything is sensed, nothing is truly invisible: not injustice, not illness, not opportunity."**

" **"A trillion sensors can either liberate us or surveil us. Wisdom lies in how we wield awareness."**

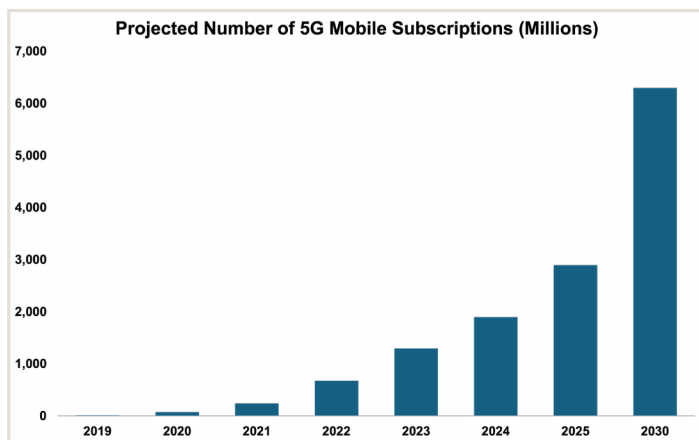" **"In a world where people are observed, their behavior changes. No longer will the tyrants oppress the masses when the world is watching."**
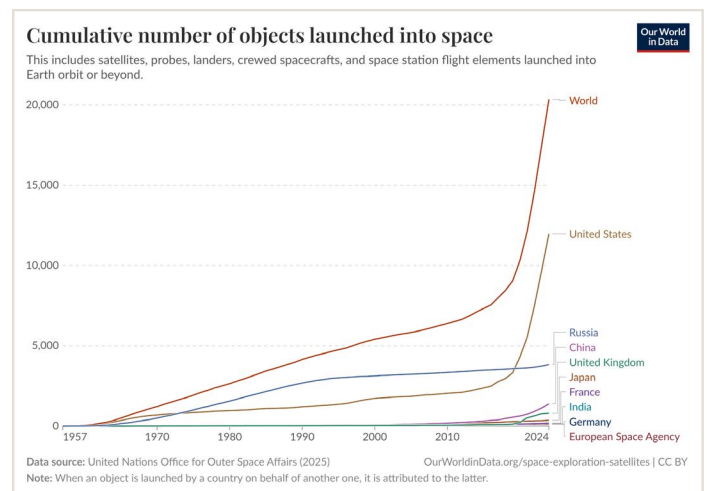
Leading BCI Companies" and add the source as PatentVest

Company	Country	Tech Type	Key Product/Tech	Main Application
Beijing Xinzhida Neurotechnology	China	Invasive	Neural implants, AI integration	Rehab, stroke, cognitive
Blackrock Neurotech	USA	Invasive	Utah Array, NeuroPort, MoveAgain	Research, clinical
BrainCo	China/USA	Non-invasive	Focus headbands, prosthetic hands	Education, rehab, consumer
BrainUp	China	Non-invasive	SleepUp EEG device	Sleep, neural modulation
CorTec	Germany	Invasive	BrainInterchange, closed-loop BCI	Pain, Parkinson's, epilepsy
Emotiv	USA	Non-invasive	EPOC, Insight, MW20 headphones	Consumer, research, wellness
Kernel	USA	Non-invasive	Kernel Flow headset	Cognitive, health
Maschine Robot	USA/China	Hybrid	A/X/S BCI platforms	Dream AI, ALS, memory storage
MindMaze	Switzerland	Non-invasive/Hybrid	MindMotion PRO	Neurorehab, stroke, TBI
NeuraMatrix	China	Minimally invasive	"Electronic skull" chips	Parkinson's, epilepsy, rehab
Neuralink	USA	Invasive	N1 chip, R1 robot	Clinical, AI, motor
Neuracle	China	Non-/Minimally invasive	EEG/NEO system	Clinical, rehab, research
NeuroXess	China	Semi-invasive	Flexible silk electrodes	ALS, epilepsy, research
Paradromics	USA	Invasive	Connexus DDI, Argo array	Medical, research
Precision Neuroscience	USA	Minimally invasive	Layer 7 cortical interface	Motor/neurological rehab
Synchron	USA/Australia	Minimally invasive	Stentrode	Paralysis, ALS, clinical

Projected Number of 5G Mobile Subscriptions (Millions)

Source: Ericsson; Omdia

Cumulative number of objects launched into space

This includes satellites, probes, landers, crewed spacecrafts, and space station flight elements launched into Earth orbit or beyond.

Data source: United Nations Office for Outer Space Affairs (2025) OurWorldinData.org/space-exploration-satellites | CC BY
Note: When an object is launched by a country on behalf of another one, it is attributed to the latter.

DIGITAL MANUFACTURING – NANOTECH, 3D PRINTING & ROBOTICS CONSTRUCTION (2035 VISION)

By 2035, we manufacture matter like software—designing, fabricating, and recycling anything, anywhere, on demand.

OPENING SCENE: IT'S 2035, AND...

In a quiet town in Vermont, Maya unpacks a sleek desktop fabricator the size of a microwave. She uploads a schematic for a custom-fit hiking boot, adjusted for the uneven terrain and her unique gait profile. In 17 minutes, the machine weaves a seamless, biodegradable sole using locally available mycelium resin and carbon thread, grown in an adjacent countertop bioreactor.

In Shenzhen, an 80-story smart skyscraper is self-repairing after a mild quake. Nanomaterial sensors embedded in its beams signal damage to swarm bots, which 3D-print lattice reinforcements directly inside the structure. Maintenance used to mean disruption. Now it's autonomous, invisible, and continuous.

On the Moon, robotic arms use regolith to manufacture building structures. No humans on-site. No material shipped from Earth. The basic infrastructure to enable an interplanetary civilization is being printed on location, by intelligent machines adapting to harsh environments in real time.


In Detroit, Malik runs a distributed factory from his garage. His AI scans global demand signals, licenses micro-designs from open creators, and fabricates everything from electric bike parts to medical stents using recyclable metal powder. His only staff? A swarm of AI agents driving powering robotic arms, 3D multi-metal printers, scanners, and a fleet of local drone couriers.

A VISION FOR 2035: By 2035, manufacturing has dematerialized, demonetized and democratized. Design, fabrication, and distribution are no longer centralized in megafactories. Instead, individuals and communities print what is needed, where it is needed, using smart materials and autonomous systems that self-learn and adapt.

Hyperlocal manufacturing hubs—some as small as a shipping container—dot cities, villages, and off-grid regions. The hubs serve as an "everything-depot" taking in orders from the local community. The hubs fabricate on demand, and deliver finished components and products via drone minutes to hours later depending on complexity. The hubs can even use locally sourced or recycled raw input, shrinking the production of waste. Supply chains collapse inward.

Nanotechnology designed and enabled by AI is going mainstream. Smart materials embedded with nanosensors detect structural fatigue, regulate temperature, and even repair themselves. Paint heals scratches. Concrete captures CO_2. Windows double as solar panels and touchscreen displays.

Global Nanotech Market Projections (USD Billion)
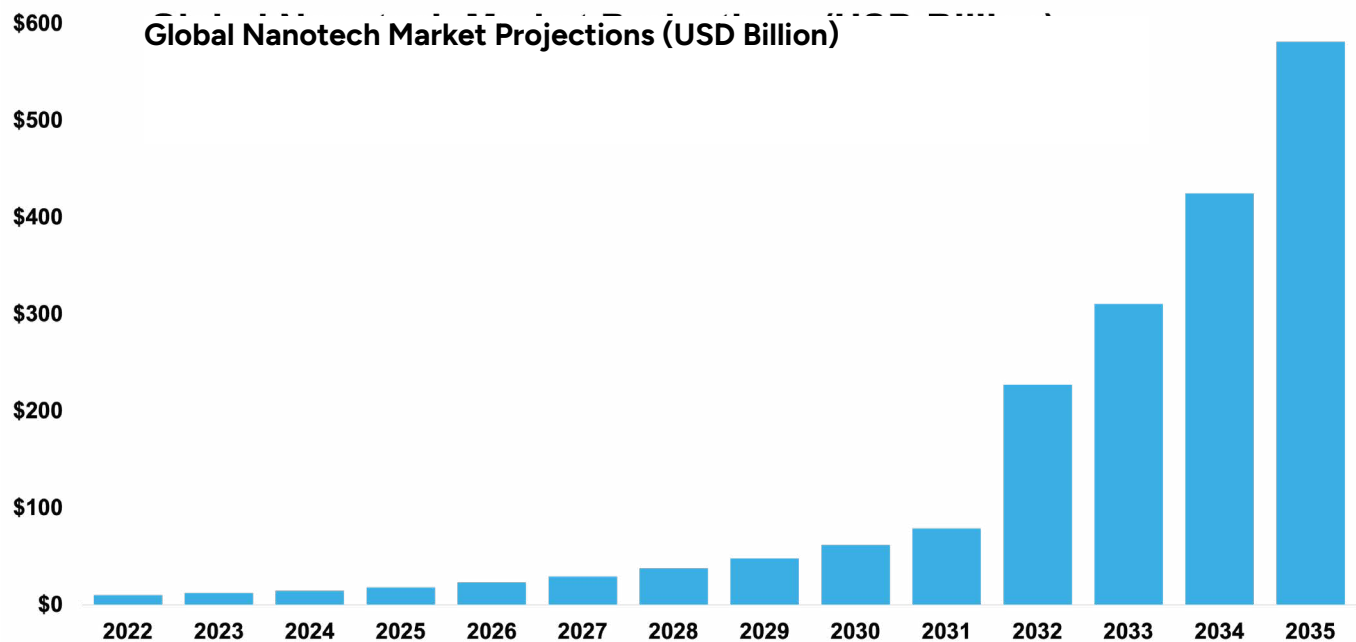
Sources: Data Bridge Market Research; Verified Market Research; Fortune Business Insights; Spherical Insights; Vantage Market Research; BCC Research; Future Market Insights; Precedence Research; Dimension Market Research; Astute Analytica

On a planetary scale, robotic construction swarms assemble bridges, data centers, and even floating solar farms using modular blueprints that adjust in real time. Architects become coders. Factories become algorithms. And anything you can imagine, you can manufacture.

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

1. Multi-Material 3D Printing at Micro & Macro Scales: Printers capable of switching between metals, ceramics, polymers, and living bioresins at micron-level precision, enabling seamless fabrication of complex machines, organs, or architecture in a single pass.

3D Printing Revenue Forecast (USD Billions)
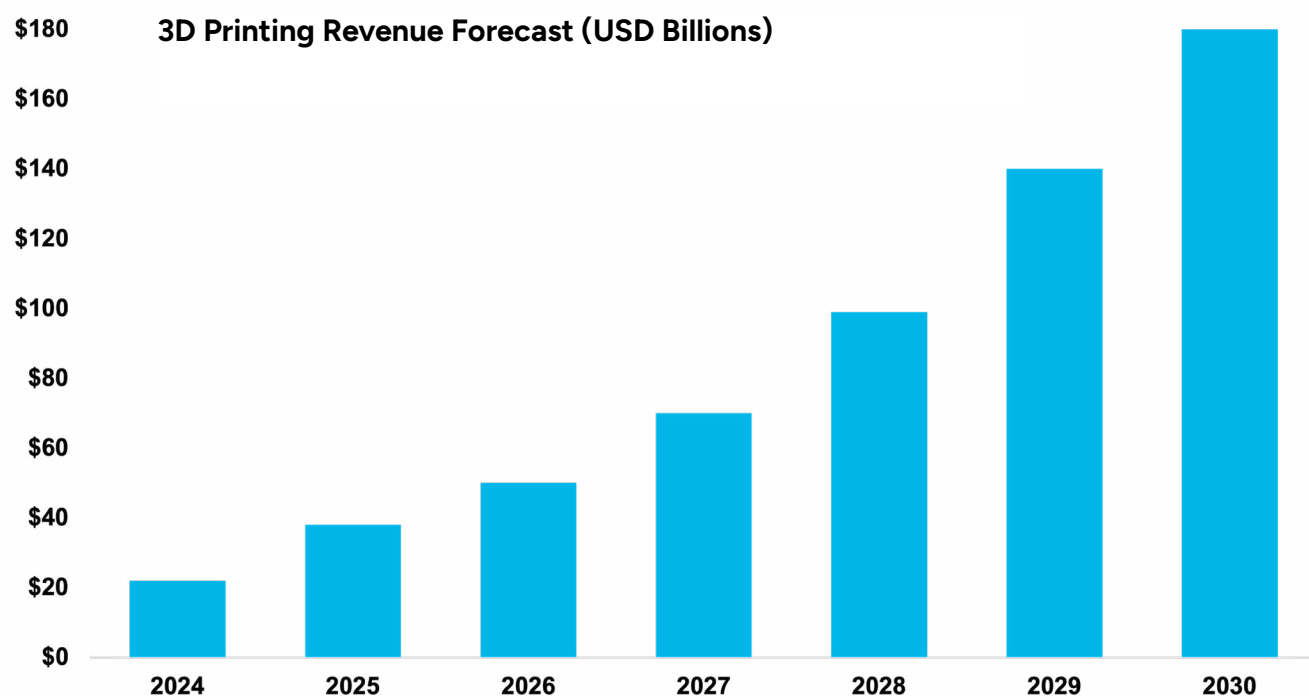
Source: ARK Invest

2. AI-Driven Generative Design Ecosystems: Autonomous design AIs synthesize optimized product blueprints in seconds based on user needs, environmental constraints, and available materials, radically compressing the idea-to-object pipeline.

3. Programmable Smart Materials with Embedded Logic: Matter that computes: nanomaterials with sensing, memory, and adaptive properties, enabling structures that self-monitor, self-heal, or morph on demand.

4. Swarm Robotics for Construction & Repair: Autonomous, cooperative bots that 3D-print and assemble structures—from homes to bridges to spacecraft—by coordinating in real time without human oversight.

5. Closed-Loop Micro Recycling Units: Compact machines that break down discarded goods into purified raw inputs (metal, plastic, biopolymers), allowing households and villages to recycle and reprint endlessly.

6. In-Situ Resource Utilization Fabricators: Portable units that convert local or extraterrestrial materials—sand, clay, regolith—into usable construction feedstock, enabling off-grid and off-world manufacturing.

7. NanoBot/Assembler Design Ecosystem: The creation of GenAI Nano-tech models that are able to design and iterate on various assemblers capable of operating on a range of materials and within biological systems as envisioned by the engineer Erik Drexler.

8. Nanomanufacturing Platforms: Atomic-scale assemblers and nanoscale lithography systems that enable molecular-level construction, from next-gen semiconductors to programmable textiles and bioengineered materials.

9. Distributed Fabrication Networks: A secure, decentralized network where fabrication nodes share schematics, verify material provenance, and coordinate production across cities, villages, and orbital habitats.

10. Hyperlocal Bioreactors for Material Synthesis: Countertop or containerized bioreactors that grow custom materials on demand—mycelium foam, bacterial leather, carbon-negative composites—tailored to user preferences and local ecological data.

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Nanobot/Assemblers for Medical Applications: A suite of sub-cellular nano-assemblers able to effect intra-cellular repair. Advanced bio-compatible nanobots will also take residence in the brain allowing precise BCI read-write capability for advanced high-bandwidth systems.

2. Organ and Tissue Bioprinting: Services that extract your DNA and are able to create induced pluripotent stem cells, then bioprint tissues and organs using cells that match your DNA

3. Living Machines: Bioprinted devices and appliances that integrate biological materials, self-grow components, and perform ecosystem services (e.g., air filtration, CO_2 absorption, water purification) as part of everyday infrastructure.

4. Personal Matter Printer: A countertop multi-material fabricator that prints clothes, tools, electronics, or meals from open-source blueprints. It scans your needs and available feedstock, then prints in minutes. Off-grid versions for remote use, connected via Starlink and powered by solar are also available.

5. Self-Healing Building Materials: Building structures built with programmable smart materials that detect microfractures, repair themselves using nanobonding agents, and dynamically adjust insulation or tint based on weather and occupancy.

6. Open-Market Advanced Printable Designs: A global, decentralized marketplace for downloadable, AI-optimized design files: covering everything from medical implants to drone parts to wearable tech. Users can remix, license, and co-fabricate collaboratively.

7. Modular Habitat Kits for the Moon and Mars: Pre-loaded, AI-coordinated robotic swarms and in-situ regolith printers assemble habitats in extreme environments without human builders, designed to evolve with mission needs over time.

8. Autonomous Construction Swarms-as-a-Service: On-demand fleets of robotic builders that 3D-print entire homes, roads, or vertical farms and operate 24/7 and adapt to real-time terrain and weather data.

Projected Global Construction Robots Deployment (2023-2035)
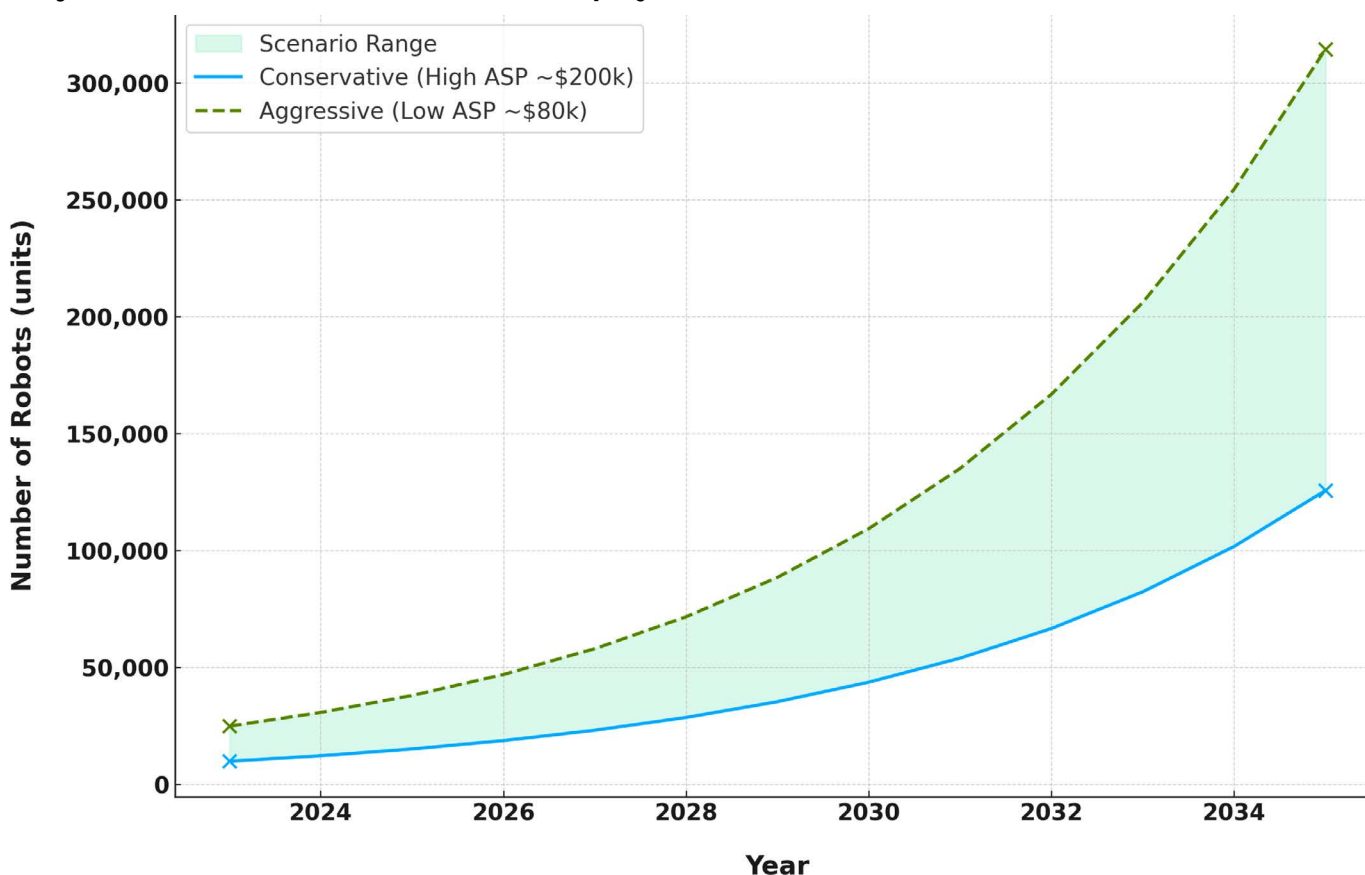
Sources: International Federation of Robotics Statzon/Apollo Civ Robotics; Dusty Robotics

9. City Recyclers – Urban Closed-Loop Depots: AI-driven recyclers disassemble products and recover materials for reprinting, reducing environmental impact to near-zero. Previous "dump-sites" become valued as feed stock of raw materials. Cities become self-sufficient circular economies. Waste is now valued, utilized and no-longer pollutes our communities.

10. Zero-Inventory Retail Engines: Stores and e-commerce platforms with no physical inventory. You select, personalize, and print products in-store or at home within hours, eliminating waste and shipping delays.

DARK SIDE OF ABUNDANCE (DIGITAL MANUFACTURING & NANOTECH)

While a future of Digital Manufacturing offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. **Weaponization of Fabrication**: Anyone with access to a desktop fabricator and open-source blueprints could potentially print weapons, drones, or bioterror materials. The democratization of manufacturing may outpace regulation, posing existential security risks.

2. **Design IP Theft & Economic Disruption**: Open design marketplaces could lead to rampant intellectual property infringement. Original creators may find their innovations copied, altered, and redistributed endlessly, undermining innovation ecosystems and income models.

3. **Job Displacement & Skills Obsolescence**: The collapse of traditional manufacturing will leave millions of low- and mid-skill workers unemployed, especially in countries reliant on factory labor. New skills may emerge, but not fast enough to prevent widespread socioeconomic disruption.

4. **Nano-scale Environmental Contamination**: Smart materials, nanobots, and micro-scale waste could become persistent environmental pollutants. Unlike plastic, nanomaterial contamination may be invisible, harder to clean up, and pose unknown biological risks.

5. **Supply Chain Black Markets & Untraceable Goods**: Decentralized, hyperlocal microfactories might enable gray or black market economies. From counterfeit pharmaceuticals to untraceable electronics, the system could bypass taxes, safety standards, and national oversight.

6. **Inequality in Tool Access:** Regions without access to advanced printers may fall behind despite overall abundance.

WISDOM FOR AN EXPONENTIAL AGE (DIGITAL MANUFACTURING):

Following are thoughts worth reflecting up during our decade ahead:

"Manufacturing has become software. Now we must ensure the code is open, safe, and shared wisely."

"When creation is democratized, imagination becomes the new capital."

"The factory of the future fits on a desk, but its reach is planetary."

"True sustainability begins when waste is not discarded, but reprogrammed."

"The tools to build the future must be as accessible as the dreams they enable."

Leading 3D Printing and Additive Manufacturing Companies" and add the sources as "Sources: Expert Market Research; Fabbaloo; Unionfab; Manufactur3D; Bullish Bears; Intellectia AI

Company Name	Headquarters	Key Applications/Industries
3D Systems	South Carolina, USA	Healthcare, aerospace, industrial, dental, prototyping
Bright Laser Technologies (BLT)	Xi'an, China	Industrial metal 3D printing: aerospace, automotive, medical
Desktop Metal	Massachusetts, USA	Volume production: automotive, heavy industry, machine design
Farsoon Technologies	Changsha, China	High-performance laser sintering: industrial, tooling, energy
Markforged	Massachusetts, USA	Industrial tooling, manufacturing, composites
Materialise	Leuven, Belgium	Medical devices, automotive, aerospace, software
Nano Dimension	Massachusetts/Israel, USA	Additive electronics: defense, aerospace, electronics
Protolabs	Minnesota, USA	Rapid prototyping & production: industrial, medical, consumer goods
Stratasys	Minnesota, USA/Israel	Prototyping, aerospace, healthcare, automotive
Xometry	North Bethesda, USA	On-demand digital manufacturing: aerospace, automotive, industrial

METAVERSE AND XR (2035 VISION)

By 2035, the Metaverse is a persistent, immersive, and interoperable layer of reality—where we live, learn, work, and play through personalized digital worlds.

OPENING SCENE: IT'S 2035, AND...

In a village in Greece, a teenager named Yiannis attends quantum physics class not through a laptop, but via a neural latency-reduction XR goggles. His classmates—avatars from eight different countries—float around a black hole simulation inside a real-time rendered Einsteinian physics lab. Their instructor is a generative AGI modeled on Feynman's teaching style, who jokes, nudges, and adapts based on each student's learning curve.

Meanwhile, in Paris, an architect walks through three versions of the same building in rapid succession: one optimized for energy, one focused on health and creativity, and one designed for maximizing community and mindset. Each version dynamically updates as her AI design partner tests structural integrity, different materials, and emotional ambiance with crowdsourced feedback from thousands of remote contributors.

In Lagos, a grandmother dons lightweight AR contact lenses to attend her granddaughter's birthday party in New York. She hugs her avatar with near-perfect haptic fidelity, exchanges digital gifts backed by NFT ownership, and watches a custom fireworks show coded by the birthday girl herself. Location is no longer a limitation. Presence is programmable.

All around the world, people move through layers of virtuality that blend with the physical world. Work happens in immersive collaboration domes. Health coaching occurs in gamified mixed-reality gardens. Spiritual retreats take place on memory palaces shaped by each user's subconscious. The Metaverse isn't a destination. It's infrastructure.

A VISION FOR 2035: By 2035, the Metaverse has evolved beyond clunky headsets and cartoonish worlds. It is now a fully immersive, hyper-realistic, always-on dimension of human experience—anchored in physical reality but not constrained by it.

Persistent digital twins of our cities, bodies, and minds exist in synchronized harmony with the real world. Whether you're teaching, learning, building, healing, or exploring, the default interface is spatial, embodied, and emotionally intelligent. We no longer stare at screens. We step into them.

Meta Ray-Ban Display Glasses

Education is now experience-driven. Students explore ancient cities, simulate complex ecosystems, or learn new languages through immersive narratives. Walk through the ancient agora of Athens with Socrates as your guide. Corporate teams collaborate inside fully-synced digital twins of their offices and manufacturing lines, each layer editable in real time, with physics and economics intact.

The shopping experience has transformed as your personal AI knows what you're looking for and highlights any relevant products in the store windows as you walk by. Students desiring to learn can turn on education mode as they walk down the streets and learn physics or history. Toggle on history-mode and you can observe your city as it appeared in 1800, 1900, or 1999. Choose the year and you can travel down memory lane.

The Metaverse economy has overtaken Hollywood. Avatars earn royalties. Digital fashion commands real-world prestige. Creators mint spatial experiences that function as both art and utility. Identity is fluid, verified, and sovereign. This is the spatial internet: the internet we wear, feel, and inhabit.

By 2030, the metaverse could generate $4 trillion to $5 trillion across consumer and enterprise use cases.

Metaverse revenue estimates,
$ trillion

	4–5	(2030)
0.2–0.3		(2022)
2022	**2030**	

McKinsey & Company

Relative 2030 use case potential

	Low	Medium	High
Consumer use cases	• digital media • health and fitness • virtual assets • VR/AR[1] hardware	• ads • education • gaming • live entertainment	• e-commerce
Enterprise use cases	• central government • construction • consumer services • insurance • investment • local government • resource industries • utilities	• education/training • healthcare provider • transportation • wholesale	• banking • discrete manufacturing • media • process manufacturing • professional services • retail • telecommunications

[1]Virtual reality and augmented reality. Source: McKinsey analysis

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Here are the top 10 technological breakthroughs required between now and 2035 to make the Metaverse and XR Metatrend vision a reality:

The Convergence of XR Formats
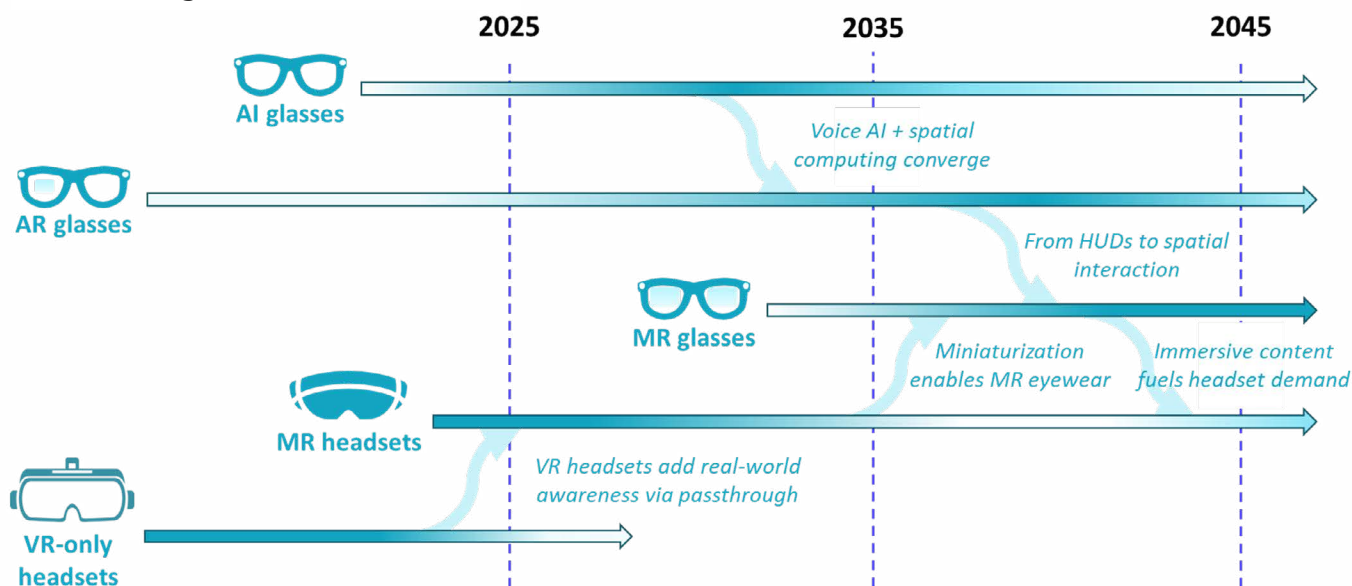
1. Ultra-Light, All-Day Spatial Wearables: Development of featherweight AR/XR glasses or lenses that combine high-res spatial displays, compute power, and all-day battery life. When this occurs, headsets become as ubiquitous—and forgettable—as smartphones are today.

Meta Quest 3 Lenses

2. Non-Invasive Neural Input Interfaces: Commercial-grade BCIs that interpret brain signals, attention, and emotional state without surgery or scalp electrodes. This enables you to control digital environments with thoughts, mood, and focus, and not just gestures.

3. Sub-Millisecond Edge Cloud Infrastructure: Deploy dense edge computing nodes to deliver real-time rendering, physics, and multi-user interaction with virtually zero latency. With this technology, the Metaverse feels more real than Zoom, with no buffering or desync.

4. High-Fidelity Volumetric Capture Systems: Full-body, real-time, photorealistic 3D capture of people and places using compact cameras and AI reconstruction. This will allow you to "beam in" as your true self. Anywhere, anytime.

5. Full-Body Haptics & Force Feedback Wearables: Lightweight haptic suits, gloves, and skin patches with force feedback that simulate touch, temperature, and texture in virtual environments. This enables a hug, a handshake, or a guitar string... felt through code.

6. Real-Time Generative World Engines: Voice- or thought-driven platforms that allow anyone to build interactive environments using natural language, sketches, or emotion. This will enable world-building to become universal with no coding required.

7. Portable Identity & Inventory Layer: Interoperable, decentralized identity protocols that let avatars, achievements, and digital goods move across platforms.With this tech, you are enabled to truly own your persona and assets, regardless of XR vendor.

8. Emotionally Adaptive AI Avatars: Generative AI companions that read your biosignals and respond empathetically: coaching, co-creating, or just keeping you company. With this development, your AI becomes not just useful, but emotionally present.

9. Persistent Spatial Digital Twins: Real-time, dynamic digital twins of cities, campuses, bodies, and factories that sync with XR overlays for interaction and simulation. Now every space and system becomes editable, explorable, and optimizable in XR.

10. Secure, Scalable Metaverse Protocols: Blockchain-backed standards for asset ownership, economy, and governance across immersive environments. This will allow the Metaverse to become a sovereign space, not a corporate silo.

These breakthroughs will make the spatial internet immersive, sovereign, and emotionally resonant—reshaping how we work, learn, play, and connect.

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Dreamscape Worlds: Turn every day into a fun adventure with your family or friends. AI systems link your reality with those of your closest friends enabling you to live out and play photorealistic video games in group-flow. Your dreams and adventures are rendered as explorable, interactive story-worlds and game-worlds.

2. Volumetric Presence-as-a-Service: A subscription that captures your full-body likeness in real time and projects it across the planet via volumetric streaming. Used for business meetings,

birthday parties, or virtual cohabitation. The system updates daily based on cameras in your home or place of work, replicating what you're wearing that day and whether or not you've shaved.

3. City Skins on Demand: See the world around you as you wish, with a layer of super-imposed reality. With a single gesture or thought, you switch your urban overlay: walk through Paris in 1889 or 1999, turn your neighborhood into a jungle temple, or overlay the neuroscience of traffic on your commute.

4. Self-Sovereign ID System and Wallets: The development of verifiable and immutable self-sovereign identification systems and digital wallets will enable individuals globally to have access to bank accounts and hold digital assets.

5. Digital Fashion with Real-World Feedback: Design or buy digital clothes that display mood, status, or affiliations, and earn real-world royalties when others wear or remix your styles across virtual worlds. Or choose a completely different character for today. The world of *Ready Player One*, coming to life.

6. AI-Enabled, Physically Felt Experiences: Users co-create multisensory adventures—like "surfing on Saturn's rings" or "walking through Beethoven's mind"—experienced through haptics, scent, sound, and emotion-synced visuals. Art becomes fully embodied.

7. Time-Travel Education as a Service: Students explore physics with Einstein, learn civil rights from Martin Luther King, Jr., or master Kung Fu from Bruce Lee: AI-powered, interactive historical mentors blended with spatial environments and curriculum gamification.

8. Employment Marketplaces for Digital Beings: A global DAO-run job board where avatars offer services like storytelling, tutoring, UI testing, or performing. Avatars build reputations, earn tokens, and evolve skill trees through feedback and achievements.

9. Spatial AI Retail Assistant: As you walk through cities, stores, or homes, your AI highlights context-aware products through XR overlays: suggesting, comparing, and even negotiating offers in real time across physical and virtual vendors.
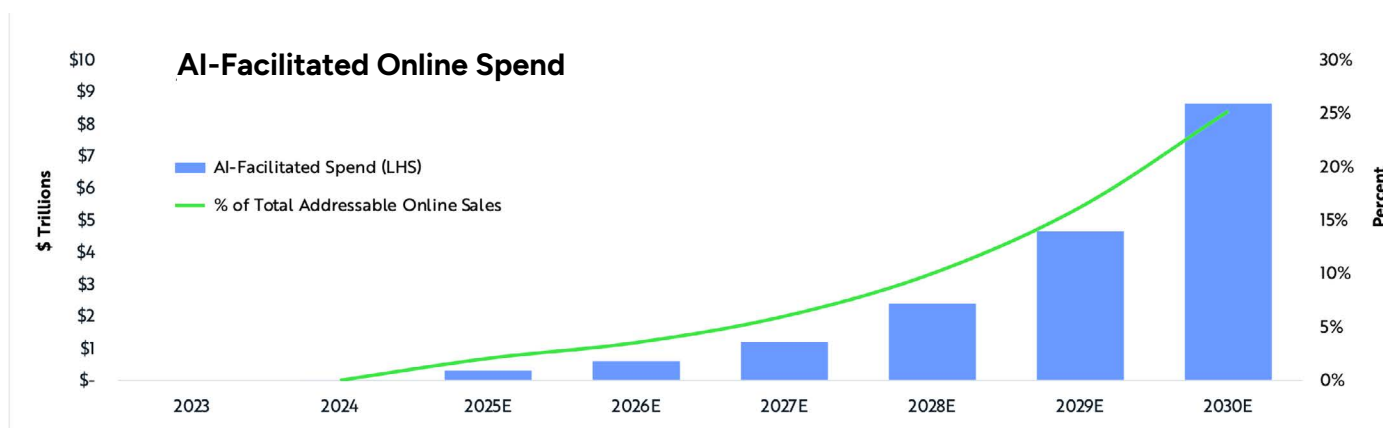
Source: ARK Invest

10. Spatial Workspaces: Teams collaborate in persistent, interactive, 3D environments where documents, dashboards, and simulations float between contributors. Collaborative teams of professionals and AIs work seamlessly in these workspaces.

DARK SIDE OF ABUNDANCE (METAVERSE & XR)

While the upside from Metaverse technologies are massive: supporting education, health, and productivity, there are a number of downsides or dark sides of abundance that must be considered. Here are some of the top ones:

1. **Identity fragmentation:** Constant avatar use may blur self-perception, cause dissociation, or encourage harmful identity manipulation.

2. **Virtual Addiction and Escapism:** Hyper-real worlds may lead to disengagement from physical life and community.

3. **Surveillance Capitalism 2.0:** Every gesture, blink, or neural response may be tracked for monetization unless privacy is hard-coded.

4. **Digital Inequality:** Access to high-fidelity XR may remain gated by geography, income, or bandwidth, thereby widening cognitive and economic divides.

5. **Environmental Footprint of Computation:** Persistent immersive worlds demand massive compute, storage, and cooling resources.

WISDOM FOR AN EXPONENTIAL AGE (METAVERSE & XR):

Following are thoughts worth reflecting up during our decade ahead:

> "The Metaverse is not just a mirror, it is a canvas. We must decide what world we want to reflect, and which we want to invent."

> "Reality is no longer where you are, but how you feel... and what you choose to step into."

> "Presence is no longer constrained by physics; it is now programmed by preference."

> "The avatars we build are not just pixels. They are projections of purpose, play, and possibility."

> "In a world where worlds are infinite, the real challenge is choosing which ones to live in, and why."

Leading Mixed Reality Headset Companies & Models

Company	Product Name	Key Tech Details & Highlights
Apple	Vision Pro	Dual micro-OLED, eye/hand tracking, spatial audio, ultra-high res, $3,499+
Asus	ROG Tarius	QD-LCD/micro-OLED, eye & face tracking, Meta Horizon OS, gamer/performance focus
DPVR	E4 Mixed Reality	Pancake optics, hand/marker tracking, affordable, PC MR gaming
Google/Samsung	Project Moohan	Android XR OS, Samsung design, Gemini AI, gaze and hand tracking
HTC	Vive XR Elite	Detachable battery, Snapdragon XR2 Gen 1, full MR passthrough, diopters, 4-cam inside-out tracking
Lenovo	ThinkReality VRX	Snapdragon XR platform, 6DoF tracking, passthrough, enterprise apps
Magic Leap	Magic Leap 2	Waveguide, spatial sensors, hand tracking, enterprise focus
Meta	Quest 3 / Quest 3S	Snapdragon XR2 Gen 2, LCD (Quest 3 higher res), full-color passthrough, 4MP RGB, hand tracking, $299–$499
Microsoft	HoloLens 2	Waveguide, hand/eye tracking, Azure Spatial Anchors, enterprise
Pico (ByteDance)	Pico 4 Enterprise	Pancake lenses, RGB passthrough, hand tracking, business MR
Sony	PlayStation VR2	OLED, eye tracking, 4K HDR, haptics, PS5 MR spatial apps/games
Varjo	XR-4 Series	Dual miniLED, ultra-high res, LiDAR, eye tracking, industrial/medical focus
Vivo	Vision MR/Discovery	Snapdragon, eye/hand tracking, lighter than Apple Vision, enterprise/consumer China
XREAL (Nreal)	Air 2 Ultra	154" virtual display, micro-OLED, spatial sensors, multi-platform

Sources: TechViz; PCMag; Tom's Guide; CyberNews; Meta; Apple; HTC; Varjo; Lenovo; Microsoft; `Magic Leap; YORD Studio; MixYourReality.com; Treeview Studio; Twin Reality; XR Today; Chinadaily; CNET; Android Central

Leading AR Glasses Companies & Models

Company	Product Name	Key Details/Tech Highlights
Alibaba	Quark AI Glasses	Qwen LLM-powered, hands-free calling, translation, Alipay, Taobao integration
Amazon	Jayhawk	Sleek design; microphones, speakers, camera, full-color display in one eye; Alexa/AI; navigation, hands-free, notifications, photo/video, music. Consumer model targets direct Meta competition
HTC	Vive Eagle	AI glasses, 12MP HDR camera, real-time AI/voice/photo translation, "Hey VIVE" assistant, 4.5h music, 49g, ZEISS sun lenses, privacy focus, Snapdragon AR1 Gen 1, $520, multiple colors
Meta	Oakley Meta Vanguard	Sport design, camera, voice commands, fitness AI, wrap-around sunglasses
Meta	Ray-Ban Meta Display	HUD display (right lens), notifications, apps, Meta AI, EMG wristband, $799
RayNeo (TCL)	Air 3s	1080p per eye, 120Hz, Peacock Optics 2.0, lightweight
RayNeo (TCL)	X3 Pro	Full-color MicroLED waveguide, AI live interaction, ultra-light, spatial sensing
Rokid	AR Spatial	FHD multi-screen, spatial workstation, gesture interaction
Rokid	Rokid Glasses	World's lightest AR smart glasses, green monochrome display, real-time translation
Snap	Spectacles (5th Gen)	Full AR overlay, hand/voice input, dev edition, Snapdragon platform
Solos	AirGo 3	Bluetooth, built-in AI (ChatGPT), translation, ultra-light, $249
Viture	Beast AR	Large FOV, cinema-like display, high immersion
Viture	Luma Pro	152" virtual display, Micro-OLED, 120Hz, portable, immersive, $499+
Xiaomi	Mijia AR Glasses	Display tech, camera, navigation, translation, integration with Xiaomi ecosystem
XREAL (Nreal)	One Pro	Micro-OLED, 171" virtual screen, 120Hz, spatial tracking, modular, $649+

Sources: Mashable; PR Newswire; Yahoo Finance; RADII; XRToday; Reuters; CNBC; Road to VR; Android Central; Rokid; RayNeo; XREAL; Gizmodo; PCMag; Pivot 5; Cognitive Market Research; BrandXR; Statista

SPACE EXPLORATION (2035 VISION)

By 2035, humanity has become a multi-planetary species—building, mining, and thriving in orbit, on the Moon, and on Mars.

OPENING SCENE: IT'S 2035, AND...

The sun rises over Shackleton Crater, but no one sees it directly. Instead, a solar tower perched on the crater rim redirects light via fiber-optic concentrators to a recently founded lunar base. Inside, Yifeng, a Chinese biologist, tends to bioengineered algae designed to convert lunar regolith and CO_2 into oxygen and protein. His lab is housed inside a 3D-printed habitat built from the very dust she now transforms into food and fuel.

In Earth orbit, a dozen autonomous factories hum silently in the vacuum. One assembles solar arrays the size of football fields. Another prints ultralight fiber only manufacturable in microgravity. A third processes space debris into reusable materials. Onboard, robots—guided by edge AI and supervised from Earth—work 24/7 without breaks, oxygen, or error.

Aboard a Starship en route to Mars orbit, a group of 30 settlers and scientists participate in a briefing back to Earth. They are the second mission to the Martian surface, coming to the end of their 9-month transit from Earth.

On Earth, millions tune in to a livestream from the Artemis base: the first major lunar settlement housing over 100 scientists and engineers from 20 nations. Children from around the world ask the astronaut settlers questions about what it's like to live on the Moon. Space is no longer the realm of billionaires and cosmonauts. It is a public good, a laboratory, a workplace, and a new canvas for civilization.
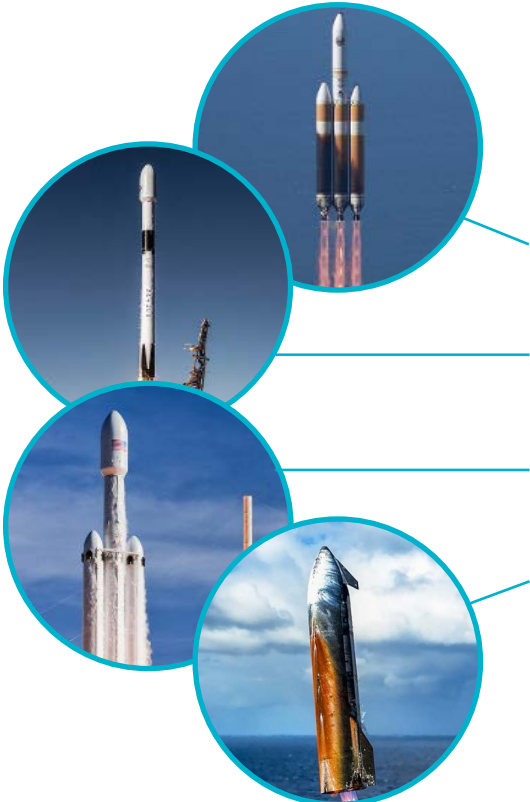
A VISION FOR 2035: By 2035, humanity is firmly established beyond Earth. The Moon hosts three permanent research and industrial bases. Mars has its first orbital station and semi-permanent surface presence. Hundreds of satellites, telescopes, and tugs populate low-Earth and cislunar orbits, forming a dense web of commercial activity, observation, and transportation.

Lunar regolith is mined for oxygen and rare minerals. Water ice is harvested for fuel. Asteroids are surveyed and partially disassembled by robotic probes, their resources primarily oxygen and nickel-iron are refined in zero-g and ferried to factories in the Earth-Moon system. The materials economy has expanded to space, lowering Earth's environmental burden and expanding global supply.

Private space stations host biomanufacturing, microgravity materials research, and luxury zero-G retreats. Space tourism has moved from novelty to niche market, particularly among artists, scientists, and ultra-wealthy explorers. While still somewhat expensive, the 100x reduction made possible by Starship has brought it within reach of many. But more impactful is the birth of orbital industry: new drugs, advanced composites, and clean energy prototypes built where gravity no longer limits design.

On Earth, this off-planet expansion drives a psychological shift. Borders seem smaller. Collaboration grows. The Overview Effect—once rare—is now embedded in education, media, and global culture. We haven't just gone to space. Space has come home.

| Rocket Model	2020 (USD/kg)	2025 (USD/kg)	2030 (USD/kg)	2035 (USD/kg)
Delta IV Heavy	$13,000–$16,000	$13,000–$16,000	N/A	N/A
Falcon 9	$2,720	$1,600–$2,000	$2,000	$2,000
Falcon Heavy	$1,400–$2,200	$1,400	$1,400.00	N/A
Starship	N/A	$94	<$100	$15

Sources: NASA Technical Reports; Our World in Data; PayloadSpace; Metaculus; NextBigFuture; PatentPC; Netizen; Wikipedia

10 TECHNOLOGY BREAKTHROUGHS REQUIRED TO IMPLEMENT THIS METATREND:

Projected Size of the Global Space Economy (USD Billions)
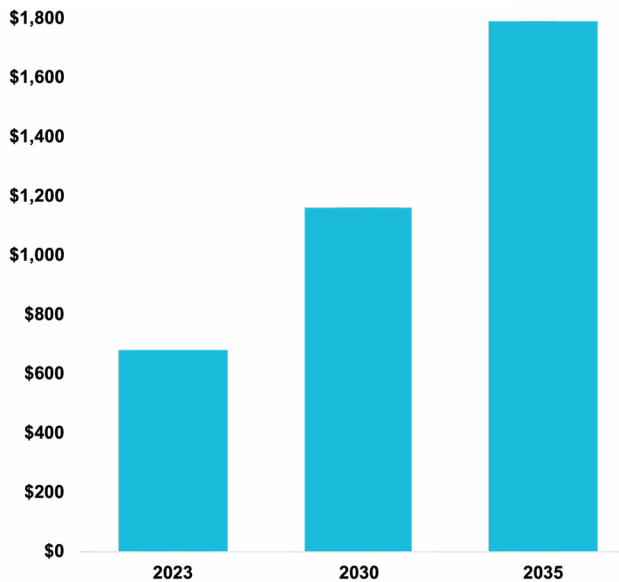
Source: McKinsey
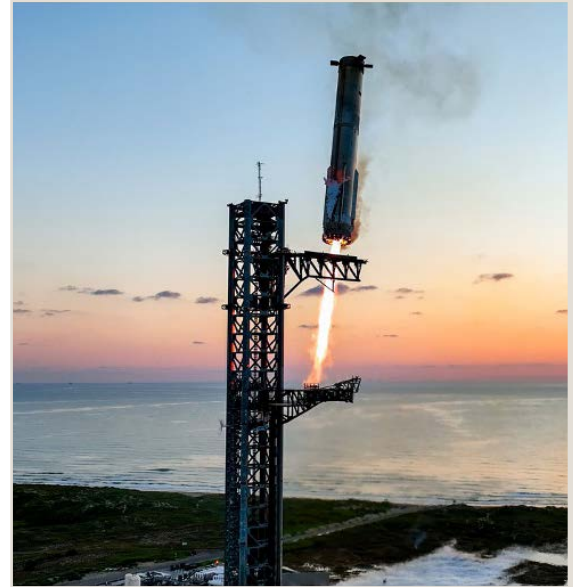
Catching the SpaceX Super Heavy Booster

Here are the top 10 technological breakthroughs required between now and 2035 to make the Space Exploration Metatrend vision a reality:

1. **Fully-Reusable Heavy-Lift Launch Systems:** Fully reusable rockets (e.g., SpaceX's Starship) to reduce cost-to-orbit by 100x and enable mass cargo and crew transport to Moon, Mars, and LEO.

2. **In-Situ Resource Utilization (ISRU):** Tech to extract water, oxygen, and minerals from lunar regolith and Martian soil for life support, fuel, and construction.

3. **Autonomous Off-World Construction:** Robotic systems to 3D-print habitats and infrastructure using local materials under extreme environmental conditions.

4. **Radiation Protection Systems:** Lightweight, efficient shielding (materials + biotech) to protect humans from solar and cosmic radiation in deep space and on planetary surfaces.

5. **Advanced Closed-Loop Life Support:** Bioengineered ecosystems and systems (e.g., algae bioreactors) that recycle CO_2, waste, and water to support long-term habitation.

6. **Microgravity Manufacturing Platforms:** Functional orbital factories that exploit zero-G to produce next-gen materials (e.g., perfect fiber optics, protein crystals, novel alloys).

7. **Space-Based Solar Power & Energy Transmission:** High-efficiency space solar arrays with wireless power beaming to provide reliable energy for lunar and orbital infrastructure.

8. **AI-Driven Robotic Autonomy for the Space Environment:** Edge AI systems to operate spacecraft, mining bots, and orbital factories with minimal Earth oversight due to long communication delays.

9. **Interplanetary Navigation & Communication Networks:** Robust infrastructure (e.g., laser comms, delay-tolerant networks) linking Earth, Moon, Mars, and spacecraft in real-time or near-real-time.

10. **Orbital Debris Recycling & Resource Recovery:** Technology to capture and repurpose orbital junk into valuable materials for construction, shielding, and manufacturing.

Together, these trends bootstrap a multiplanetary civilization where Earth is no longer a single point of failure.

## Tracked Objects in Low Earth Orbit, by Type

Objects are subtracted from the time series after they have reentered the Earth's atmosphere. Not all objects are tracked: in 2021, the European Space Agency estimated there were more than 130 million space debris objects larger than 1 millimeter.
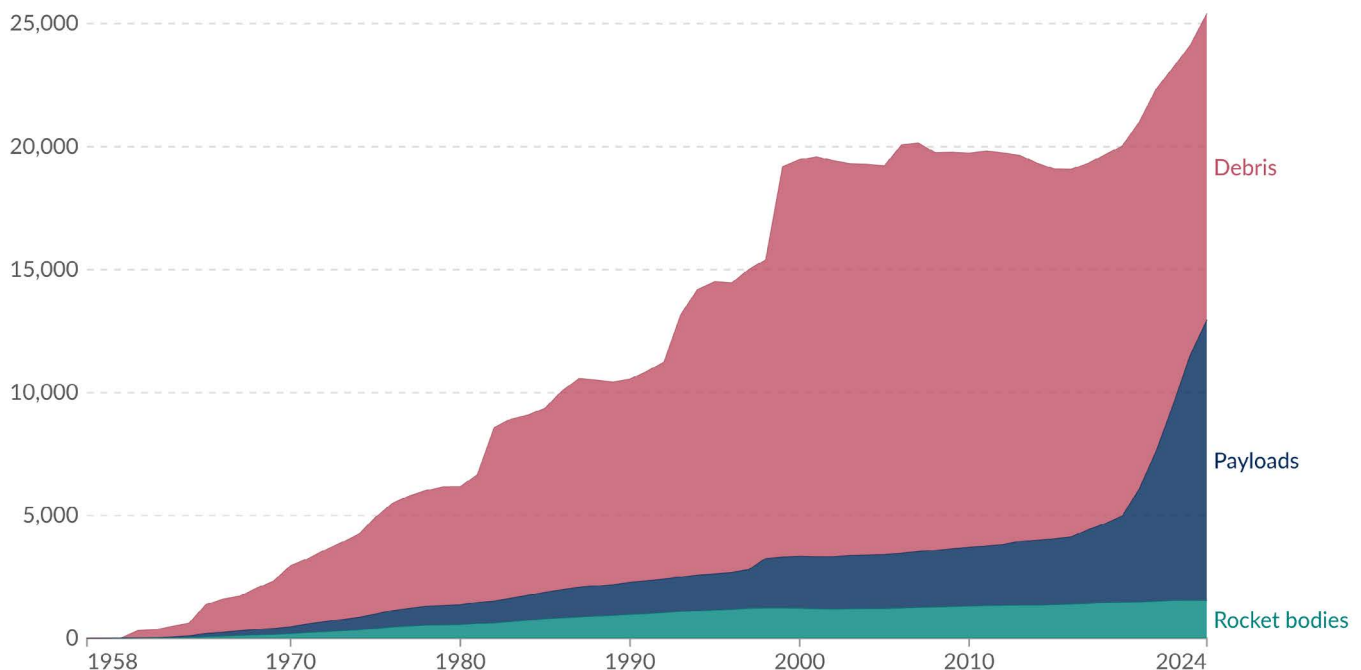
Source: Our World In Data

Cumulative Number of Exoplanets Discovered, by Method

Cumulative number of planets discovered outside the Solar System, broken down by their first identification method: transit[1], radial velocity[2], microlensing[3], or other.
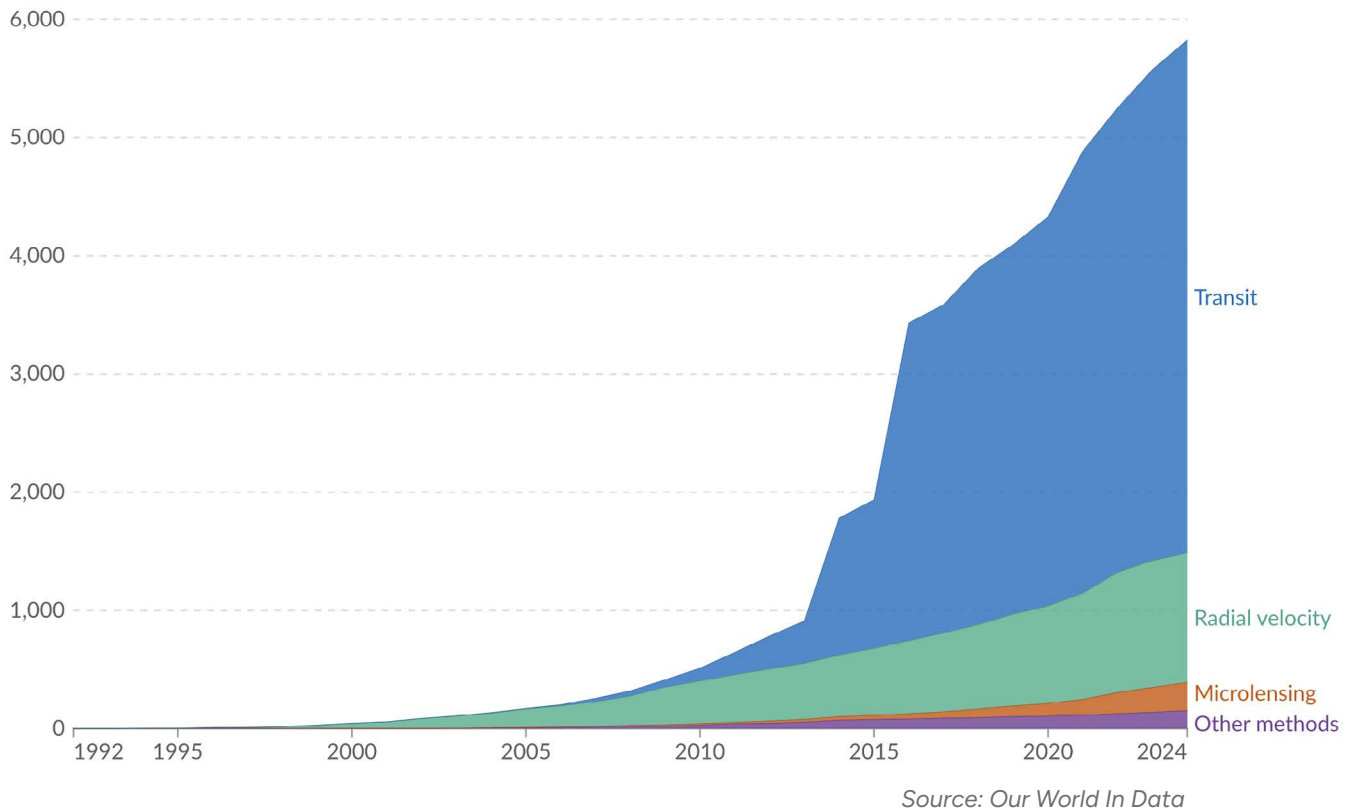
Source: Our World In Data

10 PREDICTIONS FOR 2035:
NEW PRODUCTS & SERVICES

As this Metatrend materializes in 2035, what are the new products and services that enterprising Moonshot entrepreneurs might create? Here's a list of 10 to consider:

1. Orbital Habitats & Hotels: Low-Earth orbit accommodations with panoramic views, artificial gravity modules, and roundtrip transport via Starship. Designed for ultra-high-net-worth tourism, scientific retreats, and media production. This is the successor to the ISS designed as a commercial destination, with concierge service.

2. Interplanetary Internet/Laser Mesh: The development of a network of laser-linked communication satellites between low-Earth orbit, the Moon, Mars and the asteroid belt enabling constant communications. The birth of the interplanetary internet.

3. Asteroid Mining Missions and Liquid Oxygen Refueling: Autonomous robotic missions retrieve water (i.e., oxygen) from near-Earth asteroids to refuel spacecraft in Earth-Moon orbit. First step toward a space-based supply chain, fueling the new economy.

SPACE RESOURCES: TRILLION DOLLAR ASSETS

Carbonaceous Chondrites
162173 Ryugu Asteroid
Near-Earth Approaching (Earth-Mars)
1 Km in diameter

Metallic Chondrites
16 Psyche Asteroid
224 Km (diameter) / Asteroid Belt

One **75-meter Carbonaceous Asteroid** contains enough Hydrogen & Oxygen to have launched all 135 Space Shuttle Missions (these are the Saudi oil-fields of space).

Composition: Iron & Platinum-group metals (e.g. Platinum, Palladium, Iridium, Osmium).

Value: $100,000 Quadrillion (10^20)

4. Martian Founders Network: A platform and DAO for future Mars settlers to co-develop governance frameworks, fund missions, and design initial settlements. A legal and cultural sandbox for off-world civilization design.

5. 3D Printing Tech Using In-Situ Space Materials: The development of new 3D printing and robotic technology that utilizes lunar regolith to create concrete, alloys, and solar panels enabling settlers and scientists to build on the Moon reducing dependence on Earth-launched materials.

6. Cislunar Flight & Lunar Landings: Regular Earth-to-Moon transport services for scientists, engineers, and tourists. Initial lunar surface excursions feature short-stay pressurized rovers and mobile habitats. A new class of "Lunanauts" emerges: commercial, not just government.

7. Orbital Manufacturing as a Platform: Space-based foundries producing next-gen materials, ultralight alloys, and perfect crystal substrates impossible to make on Earth.

The platform offers microgravity as a manufacturing differentiator.

8. Orbital Rapid Deployment to Earth: On-orbit storage of critical infrastructure pods (medical stations, shelters, power units, drones) that can be de-orbited and land globally within 45 minutes, anywhere at any time. Emergency relief or military logistics deployment. Space-based, just-in-time delivery.

9. Lunar Surface Infrastructure Kits: Prefab power, comms, and life-support modules dropped to the Moon and assembled autonomously to expand settlements and industrial zones. Shipping containers for the Moon: robot-assembled, plug-and-play.

10. The Space Games: Development of a new category of zero gravity and lunar gravity Olympic Games for entertainment purposes.

DARK SIDE OF ABUNDANCE (SPACE EXPLORATION):

While a future of Space Exploration offers profound benefits, it also brings potential dark sides: unintended consequences and societal risks that must be managed. Here are the top dark sides likely to emerge:

1. **Orbital Militarization & Space Conflict**: As nations and corporations compete for strategic positions in orbit and on the Moon, we risk triggering a new arms race. Satellite-killer weapons, laser defense systems, and lunar military outposts could destabilize geopolitical power structures—turning space into the next theater of war.

2. **Space Colonialism & Resource Inequity**: Early access to off-world resources (like lunar water or asteroid metals) may be monopolized by a handful of corporations or nations, repeating the patterns of colonial extraction. Instead of a commons, space may become a privatized frontier dominated by the ultra-wealthy and technologically elite.

3. **Biosecurity & Planetary Contamination**: Cross-contamination between Earth microbes and extraterrestrial environments could irreversibly damage alien ecosystems, or introduce unknown pathogens back to Earth. Poor biosecurity could destroy decades of astrobiological research and pose existential risks.

4. **Environmental Neglect of Earth**: As attention and capital shift toward space, there's a risk of deprioritizing climate restoration, biodiversity, and environmental repair on Earth. A "space escape fantasy" could reduce urgency for solving our planetary crises.

5. **Mental Health Crisis Among Space Workers**: Long-duration isolation, confinement, and exposure to radiation may produce profound psychological strain among off-world settlers. Without robust support systems, space workers may experience depression, detachment, or even suicide in environments with limited intervention capacity.

6. **Orbital congestion and debris risk:** Without strict coordination, collisions and Kessler Syndrome could jeopardize entire orbits.

7. **Economic inequality in access:** Early space industry profits could consolidate wealth and power among a few nations or corporations.

WISDOM FOR AN EXPONENTIAL AGE (SPACE EXPLORATION):

Following are thoughts worth reflecting up during our decade ahead:

"We are not limited by our resources, but by our imagination and our will to act."

"As we become a multi-planetary species, we must export not just our technologies, but the best of our values: empathy, cooperation, and stewardship. The stars must reflect our higher nature, not our darker instincts."

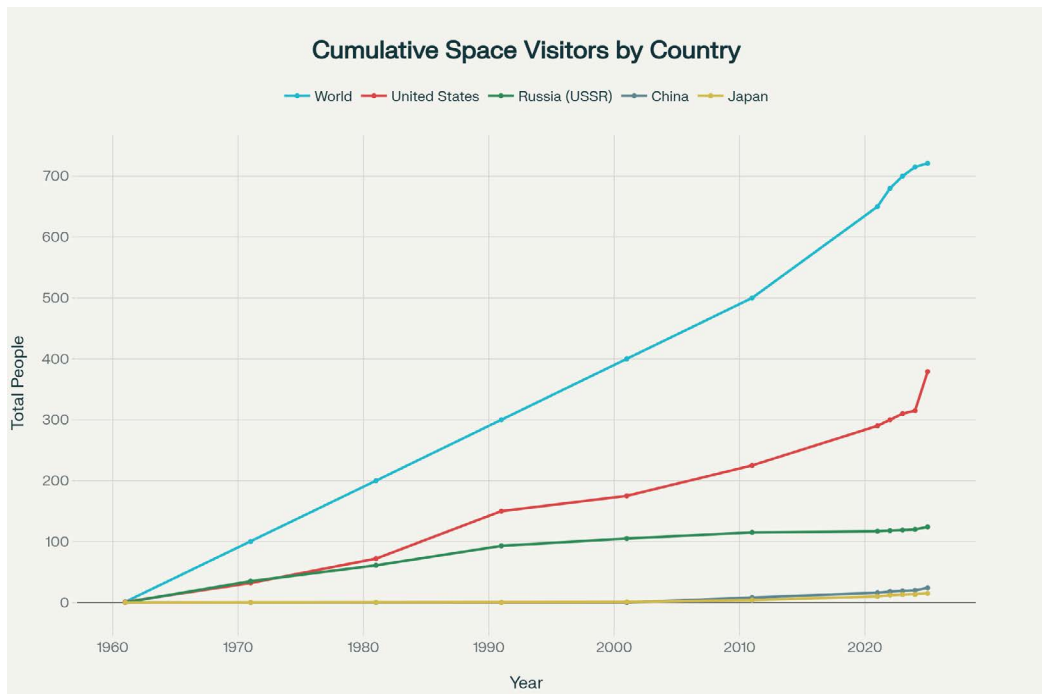"When Earth is no longer our only home, we must learn to be better guests across the cosmos."

"The stars will not save us from ourselves—but they will reflect back what we bring with us. Space therefore doesn't erase our nature, it amplifies it. What we export to the stars reveals who we truly are."
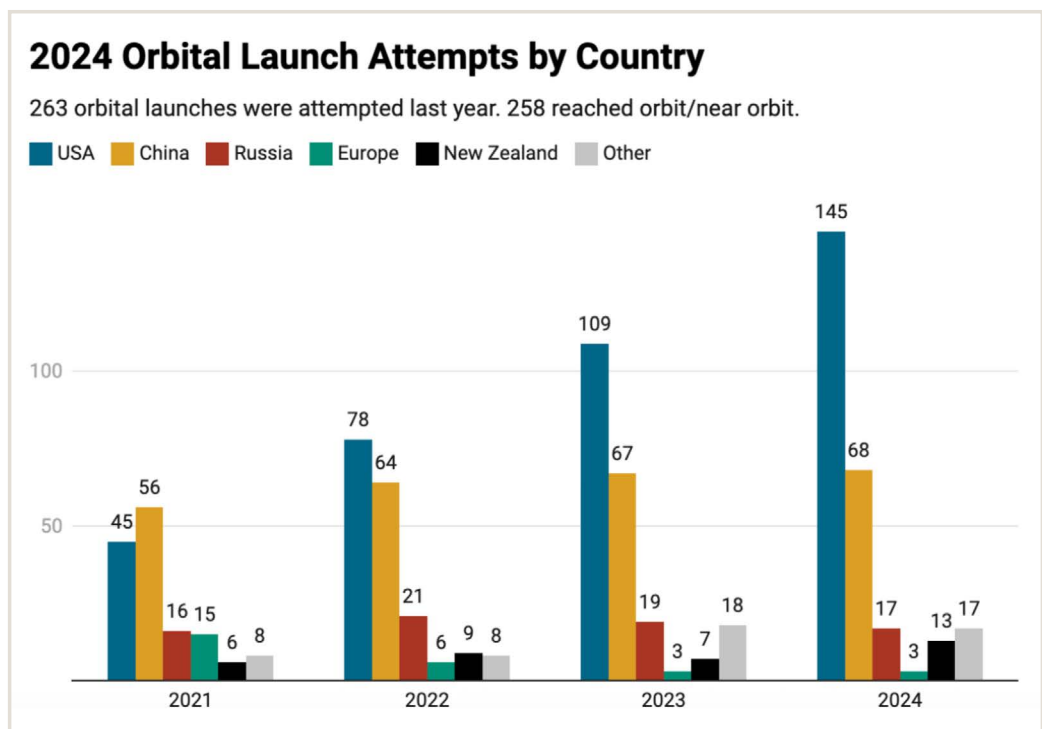
"Exploration without ethics risks repeating Earth's mistakes on a cosmic scale."

Cumulative Space Visitors by Country
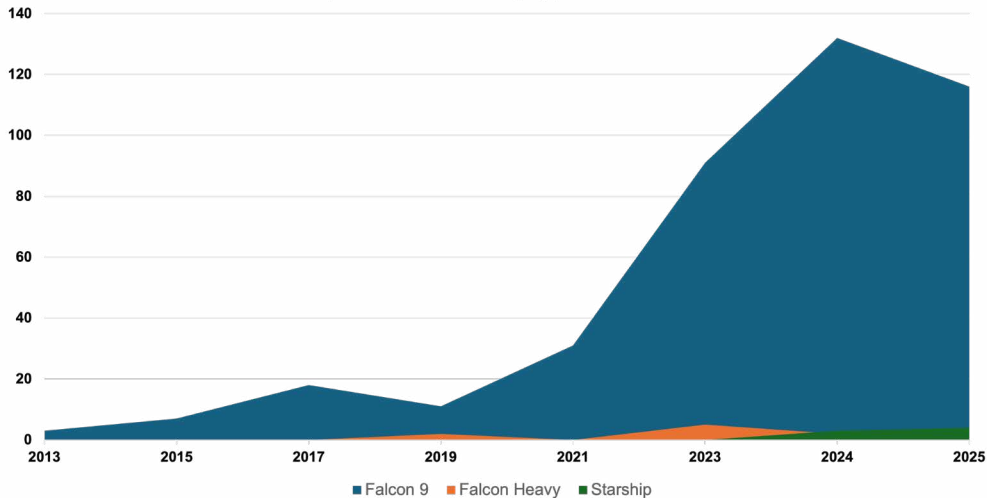
Sources: Our World in Data; Scientific American; Wikipedia

2024 Orbital Launch Attempts by Country

263 orbital launches were attempted last year. 258 reached orbit/near orbit.

Source: Payload Space

SpaceX Launches By Type Over Time

Legend: Falcon 9, Falcon Heavy, Starship

Source: Impulso.Space

APOLLO = ~$36B/TON TO THE MOON vs.
SPACEX = ~$70M/TON TO THE MOON

500X Cheaper

Cost per ton of payload to the moon: Apollo vs. Space X starship HLS

$36 B — Apollo
$70 M — SpaceX Starship HLS

Starship HLS
Apollo Lunar Lander

Component	Mass (MT)	$/kg ($)	Cost $
Methane (CH4)	1,012	0.50	$506,000
Liquid Oxygen (LOX)	3,588	0.15	$538,200
Total	4,600		$1,044,200

1X
Starship
SpaceX

=

6X
Falcon 9
SpaceX

Source: UP.Partners research of publicly available information.

CLOSING THOUGHTS: YOUR ROLE IN SHAPING THE AGE OF ABUNDANCE

We've arrived at the most extraordinary decade in human history. The years leading to 2035 are not just our near-term future, they are the inflection point where we, humanity, decide what kind of civilization we desire for the centuries ahead.

THE CONVERGENCE IS HERE.

Artificial intelligence, quantum computing, robotics, biotechnology, space systems, and clean energy are not advancing in isolation. They are colliding, amplifying one another, and accelerating at a pace that defies precedent. This convergence is multiplicative. It's the shift from addition to exponentiation, from slow evolution to explosive transformation.

FROM SCARCITY TO ABUNDANCE.

Again and again, we've seen the same trajectory: what begins as rare, expensive, and elite becomes cheap, universal, and embedded in everyday life. Computing power, global communication, and genomic sequencing have already made this leap. Now, the same arc is unfolding—simultaneously—across food, energy, education, longevity, mobility, manufacturing, and even our access to space. By 2035, the fundamental building blocks of human dignity—nutrition, learning, energy, and health—can be abundant for every man, woman, and child on Earth.

THE CHOICE BEFORE US.

Technology is neutral. It will not, on its own, choose justice over exploitation, empowerment over control, or unity over division. That choice is ours. We can use these exponential tools to uplift every human being, or we can allow them to concentrate power in the hands of a few. The difference will be measured in the decisions we make. Now.

THE HUMAN IMPERATIVE.

This is our generation's Moonshot: to ensure that the Age of Abundance benefits all of humanity. That means designing systems with inclusion baked in. It means aligning AI with human values. It means measuring success not by GDP, but by the number of lives elevated, the opportunities unlocked, and the futures preserved.

THE CALL TO ACTION.

If you are an entrepreneur, build Moonshots that matter. If you are an investor, fund the bold ideas that can bend the arc of history toward abundance. If you are a policymaker, legislate for a future where opportunity is a birthright, not a privilege. And if you are a citizen, stay informed, stay engaged, and help shape the narrative toward hope, possibility, and shared prosperity.

By 2035, we can live in a world where aging is optional, space is accessible, every child learns from a personalized AI tutor, every home produces its own clean energy, and scarcity is an artifact of history.

The future is arriving faster than most realize. It will not wait for us to be ready. We must decide—today—to be its architects, not its passengers.

The exponential age is here. **The question is not whether change will come, but whether you will help steer it.** Both the choice and the responsibility are yours.