Astro Teller X CEO

Dr. Astro Teller currently oversees X, Alphabet's moonshot factory for building magical, audaciously impactful ideas that through science and technology can be brought to reality. Before joining Google / Alphabet, Astro was the co-founding CEO of Cerebellum Capital, Inc, an investment management firm whose investments are continuously designed, executed, and improved by a software system based on techniques from statistical machine learning. Astro was also the co-founding CEO of BodyMedia, Inc, a leading wearable body monitoring company. Prior to starting BodyMedia, Dr. Teller was co-founding CEO of SANDbOX AD, an advanced development technology incubator. Before his tenure as a business executive, Dr. Teller taught at Stanford University and was an engineer and researcher for Phoenix Laser Technologies, Stanford's Center for Integrated Systems, and The Carnegie Group Incorporated. Dr. Teller holds a Bachelor of Science in computer science from Stanford University, Masters of Science in symbolic and heuristic computation, also from Stanford University, and a Ph.D. in artificial intelligence from Carnegie Mellon University, where he was a recipient of the Hertz fellowship. Through his work as a scientist, an inventor, and as an entrepreneur, Teller holds many U.S. and international patents related to his work in hardware and software technology. Astro is also a successful novelist and screenwriter.

Opinion in Detail

The team at X supports the Government of Japan embracing moonshot thinking. The original moonshot - the mission to put astronauts on the moon - was invented by government. There are many problems facing the modern world that would benefit from governments like Japan's embracing moonshot thinking to try to solve them. But - whatever moonshot vision you pick to work on - at X we believe the way you decide to tackle it will be a defining factor in whether or not you succeed. There are lots of big problems that merit attention by government so our advice would be to spend as much - if not more - time thinking about *how* you tackle the problem as you do deciding *what* to work on.

1. **Bold, 10X visions.** Many people endorse using incremental and measurable targets as a tool for managing teams but we do not believe that a moonshot thinking benefits from this approach. A moonshot should have a target that feels incredible because it's a great way to both generate new approaches that haven't been tried before, and it motivates high-achieving talent to join your team. As JFK said of the original moonshot: "We choose to go to the moon in this decade and do the other things not because they are easy, but because they are hard."

2. **Think differently.** A team of high performing yet cognitively diverse people working to solve the moonshot. Moonshots generally have really hard problems at their heart that other people have tried and failed to solve in the past. We believe that you rarely solve your moonshot by being smarter or richer than all the other people that have come before you. Instead, we believe that success is founded in thinking differently about the problem. Coming up with a solution or set of solutions that are different than what's been tried before. This requires moonshot teams to have people that think differently being brought together to challenge each others' expertise and biases. At X we try and bring teams from different disciplines together - physicists and artists, submarine captains and fashion designers - to generate those new ways of thinking that haven't been tried before.

3. **Make real world contact.** Put experimentation and learning at the heart of your approach. Running experiments is the quickest and cheapest way to learn if your ideas might work. Many technologies that work well in the laboratory need to be significantly altered once they make contact with the real world. We ensure all our teams get out of the lab and into a 'real word' environment as quickly as possible - with prototypes and pilots - to test their hypotheses. Our teams have to be ready to have their approaches challenged and changed as a result of that real world feedback. So, as well as running the pilot, teams need to be coached to have a learning mindset, to see how failure is actually a great way to learn and get better (not something to be avoided and scared of).

Peter Gruss CEO and President, Okinawa Institute of Science and Technology Graduate University

He is an internationally renowned researcher in the field of gene control and developmental biology. He received a Ph.D. from Heidelberg University in 1977 (microbiology). He was a professor and a member of the directorate of the Molecular Biology Center of the University and a director at the Max Planck Institute of Biophysical Chemistry from 1986 onwards. He has served as the President of the Max Planck Society in Germany, the a leading research institute in the world from 2002 to 2014, and has been in office at OIST since 2017. During MPS's Presidency , he established and expanded new scientific fields, promoted the internationalization of the Max Planck Institutes, and strengthened research support and training for students and young researchers. He plays a leading role in the field of technology transfer of research results and innovation creation, and is familiar with both science and industry. He serves as the chairman of the Siemens Technology and Innovation Council and has been member of the Board in several companies.

Opinion in Detail

We see an unprecedented pace of innovation in most industries. Unlike a few decades ago, these innovations are not driven by large companies, they are driven by start-ups, at universities and at the intersection of industries with science hubs.
In addition, emerging markets are new innovation hubs on their own, not only for their domestic markets but also for global markets.
Large companies, no matter in which industries, find it increasingly difficult not be outclassed by newer and more agile competitors.
There are a number of reasons to it: their culture and leadership team tends to be risk averse with the aim to deliver on promises, i.e. stay within timeline, budget and specifications. Their leadership team is thus not recruited by people with true entrepreneurial mindsets. Startups require leaders that are able to change their business model on a dime after coming from a customer's meeting, while established businesses need people that are precise and firm in executing their plans (risk averse).
The focus on low risk moves, in reality or just believed, tends to press large companies into a trajectory of incremental innovations, while true market shaping innovations happen elsewhere.
This can be best described as an "inside-out" behavior, well suited for stable markets, but risk to missing out on trends or assessing them incorrectly. This leads to a high risk of being disrupted.
The result: 50% of S&P 500 companies will be replaced over the next 10 years – GE already left the Dow Jones Industrial Average in 2018.

Hence, successful moonshots need a change in culture, a state of mind that tolerates or even seeks risks. Consequently, the following prerequisites are mandatory:

- Reform of the educational system (K-12 school and University)
- Stronger interfaces between Japanese industry and intellectual centers (science hubs)
- Reform of the innovation eco-system (more VC capital, more start-ups)

Without substantial reforms in these areas there will be no sustainable moonshot activity that leads to new creative market contributions (details can and should be discussed).

Additionally, the following suggestions a based on a conversation I had with James Higa (former Apple Vice President) regarding ways to support the innovation of Japan:

- Create a paid gap year program for undergrads to encourage young people to study, intern, perform, get into YC etc., abroad.
- Turn the surge of tourism interest into becoming the most attractive country to emigrate to. OIST like magnets for knowledge workers. Supersede Germany's apprenticeship program.
- Focus on SMB's versus the established large corporations. Become the world's powerhouse exporter of craft, authentic, small cult brands.
- Raise the bar for IPO on Mothers to push companies to bigger ambition than lifestyle companies.
- Mandate circular economy models for all companies.

My hope for a Moonshot of Japan is: to bring back Japan to what it has been many years ago: one of the top creative and innovative countries in the world. Only then can “Society 5.0” be developed.
Japan has excellent infrastructure, efficiency in manufacturing and engineering, and a highly educated and skilled labor force. The 2020 Olympics will turn the eyes of the world toward Japan; thus, it is the perfect opportunity for the country to prove that it should be the destination of choice for bold scientists and engineers from around the globe.
Having creative moonshot goals are an integral part of this. These goals should have defined benefits to society and achieving these goals should catapult Japan into the forefront of global innovation. I have arranged further suggestions for moonshots in the following areas:

1) Automation and digitalization:
Japan is world-renowned for efficient, high-quality manufacturing and engineering. In terms of hardware, Japan has made great progress towards an automated society. However, as the technologies advance, they need more sophisticated software. Transportation systems, delivery systems and logistics, and even healthcare may be automated in the future.
With the influx of international travelers during the upcoming Olympics, a cash-based payment system may not be appropriate. Instead, Japan should aim to become a cashless society through cryptocurrencies and digital wallets, and incorporate fully digital government IDs, signature and contracts into government much like Estonia. This must be coupled with strong cybersecurity programs to protect digital assets.
We are moving towards a society where all elements of our lives (see Saudi Arabia’s to be built smart city) are connected via IoT. It is imperative that highly skilled computer scientists work with social scientists to develop the systems that connect us.

- Go all in on becoming the most automated and roboticized nation in the world. Transportation, retail, delivery, services, health, etc.
- Full digital government ala Estonia. Digital ID, signatures, contracts. Cashless target of 90%, not 40%.

2) Energy:

Japan should invest in sustainable energy sources. Currently, the vast majority of the country's energy needs are being met by imported sources, primarily natural gas, coal and oil, which are expected to increase in cost over time. Thus, Japan needs to become more self-sufficient in meeting its energy demands. My recommendations for moonshots for sustainable energy are: photovoltaics, nuclear fusion, and lignin from wood biomass. Microbiologists have identified enzymes that can break down lignin the subunits of which can subsequently be used as energy rich biomolecules. This would constitute an enormous resource.

Photovoltaics need to be cheap, flexible and efficient. Japan is a leading manufacturer of PVs, but also has some of the highest solar power costs in the world. This industry would benefit from research that would allow for cheaper manufacturing, higher efficiency and higher durability of PVs.

Though Japan has shied away from nuclear energy following the Fukushima Daiichi nuclear disaster, runaway disasters like these would not be possible with nuclear fusion due to the fundamental differences between nuclear fission and fusion. The physics has greatly improved, and the first power plant is expected in the 2040s. Indeed, there are already some start-ups that try to develop creative means to have more economic ways to produce fusion derived power.

Additional activities should be undertaken using tidal wave generators, generate pump reservoirs (to utilize alternative surplus energy; great because of the many mountains and valleys).

- Transform Japan into a leader using sustainable energy.

3) Healthcare:

AI will play a major role in making healthcare more precise and accessible. Patients in remote islands or villages will have reduced need to travel long distances to visit major hospitals, as AI can reconstruct medical images from lower-quality machines and can make diagnoses with higher accuracy than pathologists and radiologists on average.

Biobanks should be utilized to predict vulnerable populations to disease. Genetic analysis will result in the prediction of inherited and complex diseases (multifactorial) that require changes in lifestyle choices. Integrated analysis of clinical and molecular data will result in a shift from therapy to prediction and prevention, which ultimately lowers healthcare costs and leads to longer, healthier lives.

- Genomic scans of everyone. Top 5 largest database in the world. National level behavioral change prevention platforms for chronic diseases. A.I. driven national healthcare system.

4) <u>Mobility:</u>

Japan has been and still is a world leader in mobility. Due to many technological breakthroughs this leading role is jeopardized. Mobility service providers are starting to integrate different modes of transportation. Out-of-the box thinking is required since developments do not happen in a linear manner. Radical concepts are already being realized (e.g. urban air transportation, modular pods, Chicago Express Loop, hyperloop, airships) and a number will disrupt existing mobility solutions. Sales of electric cars are likely to overtake internal combustion engines around mid to end 2020s. Challenges are seen in the distribution of grid infrastructure and charging management. New mobility technologies (full autonomous cars) are explored in controlled environments (eg. closed campuses, innovative city districts) followed by a public roll-out and simultaneous adaption of regulations.

- Transform a Japanese City into a world leading model using latest mobility concepts.

Maurice Conti Chief Innovation Officer, Alpha

He is the Chief Innovation Officer at Alpha which is Europe's first moonshot factory, powered by Telefónica. Conti and his team are responsible for coming up with the ideas, prototypes and proofs of concepts that will go on to become moonshots at Alpha. His projects aim to affect 100 million people or more, be a force for good on the planet and grow into billion-euro businesses. Prior to Alpha, he launched the Applied Research Lab as Director of Applied Research & Innovation at Autodesk. He has been studying Moonshot Thinking, Applied Machine Learning, Advanced Robotics, Augmented Virtual Reality, and the Future of Work, City and Mobility.

Opinion in Detail

- What are the most important things for a successful moonshot?

How do you build and manage research programs? (Especially portfolio design and budget allocation, etc.)

Portfolio design should be driven by the Moonshot Program's overall goals, and by the careful definition of what a successful Moonshot is. In my experience, it is best to manage a diverse portfolio. However, as time goes by, the Program will naturally begin to collect expertise and know-how. The talent and knowledge residing within the program can be valuable for new Moonshots. For instance, if the program develops a successful moonshot in low-cost satellites, then future Moonshots in long-range optics or super-spectral imaging may be able to leverage this expertise to make better progress, faster. This will push portfolio management towards more homogeneity. That is a balance that the Program leadership must manage over time.

It is also important to have a clear process for creating and evaluating early ideas. In your documentation, you mention 2 basic criteria for new Moonshot candidates: technology and social impact. At Alpha we use 4 lenses to evaluate each idea (see image below).

"FOUR LENSES" APPROACH

With respect to budgets, I believe it's important to build a system that gives early Moonshot candidates a chance for life, which means assuring funding to give early ideas enough time to be de-risked before larger investment is required. A gradual increase in funding for candidates as they progress through a well-designed process (with proof-points along the way) has been a successful feature of the processes I've built, at Alpha and other for other teams.

How to evaluate programs although their possibilities to success are difficult to estimate?

This is a critical, and on-going feature of any successful Moonshots program. First of all, evaluation must not only occur at the beginning and end of a Moonshot's development (which could be several years). The Program must have a process that is flexible (so the process doesn't kill good moonshots), yet accurate (so risk is properly assessed), which provides ongoing assessment of every active project.

One of the most valuable things that can be done at the early stages of developing a Moonshots program, as you are, is the design of an effective system for the definition, assessment, measurement and reporting of every project within the program. At Alpha we have realtime visibility into every project. Each project goes through a series of well-defined phases with specific criteria and deliverables that the candidates must meet in order to progress to the next phase, in which they receive more resources and funding. Decision making is also clearly defined for each phase. This is important to make the best decisions on which Moonshot candidates to move forward and which ones to kill, but is also important to maintain team morale as some passionate ideas are killed in favor of others. Please see below some examples from Alpha's process and methodology.

REAL TIME MOONSHOTS DASHBOARD

CRITERIA AND ASSESSMENT

What kinds of people do you assign as program managers? (What skills should they have?)

Because exploration of new Moonshots is by definition a diverse and expansive landscape, my teams have always been very diverse, in as many dimensions as possible. There is no single successful profile. Rather, I've focused on building teams that together could handle the complex and unpredictable challenges of running Moonshots. I always strive for 50/50 balance of male and female team members. I look for a variety of backgrounds in nationality, life experiences, educational and career background, age, language and so forth. A diverse team gives you a head start when considering moonshots that could span different classes of technology, problems they are solving, geographies they will be deployed in, cultures that will use them, etc.

I've sometimes used US Special Forces teams (like the Navy SEALS or Army Delta Force) as a model. These teams are ultra-high performing, they are well equipped for the mission at hand (resources), they bring together a diverse set of skills, yet each of them can operate interchangeably with his teammates on the basics. They are extremely well trained and invest heavily in ongoing training (as do I for my teams). They work exceptionally well as a team, but are also highly functional as individuals. They are consummate problem solvers and independent thinkers, and do not need to be closely managed to achieve exceptional results. Perhaps most importantly, they are ready to succeed at any mission (any kind of Moonshot), even the ones they cannot predict. The ability to thrive in a chaotic and unpredictable environment with very little direction is the single most important quality of a person or team leading Moonshots.

How many researchers do program managers manage?

This depends heavily on your Moonshot development process. At Alpha, our process is progressive, so at the earliest stages, a Moonshot candidate will only have 1 or 2 people working on it. As it progresses and makes its way to higher levels, more resources are added and the program manager will manage more people and more outside collaborators (i.e. researchers). Sometimes a new program manager will be put in place when a candidate reaches a stage where a different management skillset is necessary.

How much money do program managers manage?

As above, this is highly dependent on how the program is designed. I have people on my team who have managed large budgets, and some that have never managed substantial budgets at all (but they have good ideas). The important thing is to match the investment with the risk at any given stage of a project, and to have clear criteria to evaluate whether projects should continue to be funded or not.

○ What do you hope for the Moonshot of Japan?

Put very simply, I hope it succeeds! At this stage, my hope is that the program is able to put in place the structure, process and methodologies that will help the program succeed. There are only a handful of teams focused on building multiple Moonshots ("Moonshot Factories", at present just (Google's) X and Telefonica's Alpha), and so these processes are not widely known or understood. I am very optimistic about your approach so far, as it clearly seeks to understand what has worked for others and to put in place the best practices available. This is an exciting moment in your journey!