EXPONENTIAL TECHNOLOGY IMPACT REPORT

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Singularity University

SPACE

Contents

1 Scope of this Report

The surface of the Earth
is the shore of the cosmic ocean
Recently we've waded a little way up
and the water seems inviting

– **Carl Sagan**, *"A Glorious Dawn"*

Humanity is presently a one-planet species. Although we have sent humans into space, and even to the moon, they have only visited and then returned home to Earth. There are two ways in which this fundamentally limits us: First, it limits the resources available to us, in terms of both matter and energy. Second, it makes us vulnerable to total destruction as a species, should a catastrophe of planetary scale occur.

This report focuses on applications of exponential technologies that may facilitate the eventual establishment of a permanent human presence in space. These steps include the development of technologies to reduce the barriers to entry into space, technologies that may be needed to remain in space indefinitely (while also being useful on Earth), practical strategies to use resources which are off Earth, transformative changes in the business of space science and exploration, and means to educate, excite, and inspire the general public about the possibilities and importance of human space exploration.

1.1 Structure of this Report

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1.1.1 Digraph

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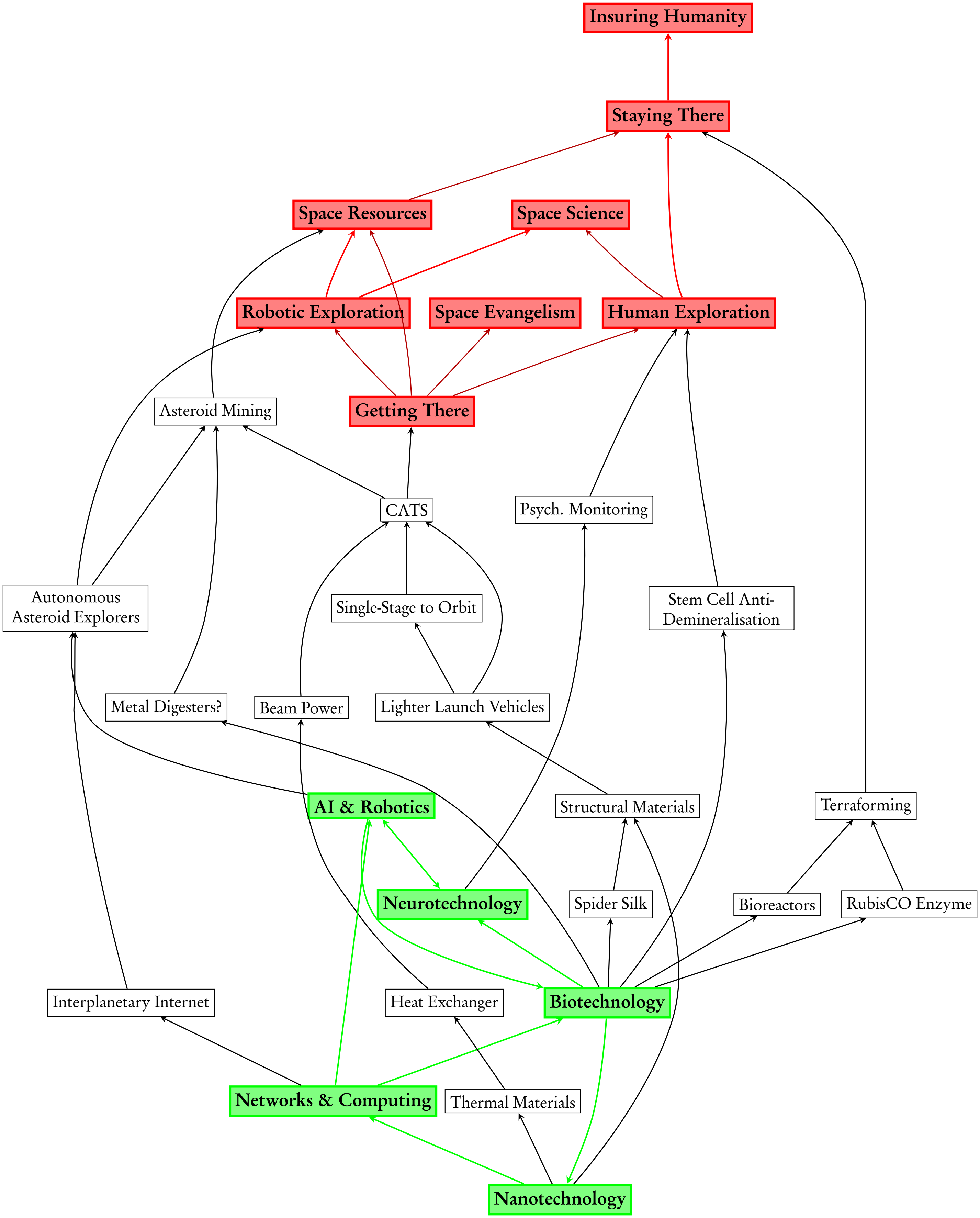
«Example about how to parse this graph—narrative threads run bottom-to-top»


Insuring Humanity
Staying There
Space Resources
Space Science
Robotic Exploration
Space Evangelism
Human Exploration
Asteroid Mining
Getting There
CATS
Psych. Monitoring
Autonomous Asteroid Explorers
Single-Stage to Orbit
Stem Cell Anti-Demineralisation
Metal Digesters?
Beam Power
Lighter Launch Vehicles
AI & Robotics
Structural Materials
Terraforming
Neurotechnology
Spider Silk
Bioreactors
RubisCO Enzyme
Interplanetary Internet
Heat Exchanger
Biotechnology
Networks & Computing
Thermal Materials
Nanotechnology

2 State of the Problem Space

2.1 Overview

Doing business in space should be easy, but it isn't. It's hard to get into space, even sending robots rather than humans. It's hard to stay in space for very long–again, even if you send robots. It's hard to make use of the resources available in space. And it's hard to convince many people that going to space is even a good idea.

2.2 Aspects

We have chosen to focus on the following aspects of the problem space:

2.2.1 Getting There

2.2.2 Staying There

2.2.3 Human Exploration

2.2.4 Robotic Exploration

2.2.5 Space Resources

2.2.6 Space Science

2.2.7 Space Education/Evangelism

A key underlying problem to the limit of humanity's progress in space is that the majority of the human species is uninterested in space. Activities in space today do not inspire the awe that they once did: instead of watching astronauts walk upon the surface of a celestial body for the first time, today, if we're lucky, we get to watch them repair the toilet on the International Space Station. Educational outreach is a good start, but we need to connect humanity to space in a more natural way. Global warming is now perceived as a threat so compelling that most people believe we need to do something about it. But this threat is dwarfed by that of remaining on this planet indefinitely.

NASA's education program attempts to make space and the STEM (Science Technology Engineering and Math) curriculum exciting for students, but they do it without an understanding of the progress exponential technologies will have on the space industry. Students today rarely realize that when they grow older they will have a completely different tool set with which to tackle space. We should teach them what the world will be like in a decade or two and excite them on the possibilities they can create.

In all instances of educating the public on the importance of space, from youth to the elderly, opening the space frontier is never presented as an explicit need—which it is. Space is often considered to be primarily beneficial as an engine for creating technological spin-offs, but even if space exploration paid no technological dividends, it would still be crucially important. People don't appreciate the voyage of Christopher Columbus to the Americas primarily because of the new sextant developed for the journey that was eventually spun off to the private sector and used in merchant shipping.

It is human nature that we need to "see it to believe it," and maybe this is what is holding back humanity from understanding why space exploration is a necessity for survival. Until ordinary people can experience space through their own eyes, the possibilities that it holds will not be fully understood. What will happen when the first child can see our home from space, or when the first ballet dancer experiences weightlessness, or when a paraplegic is given mobility again? Let's not just tell humanity about space, let's give them access to space.

2.2.8 Insuring Humanity

2.3 Exponential Technology Areas

In this report, we will illustrate a number of opportunities to address the above problems with exponential technologies. This section serves as a brief overview to each of the exponential technology areas.

2.3.1 AI and Robotics

In the broadest sense, the fields of AI and robotics strive to make non-human systems able to perform human tasks, or other difficult tasks that are helpful to humans. Robotics focuses on the necessary physical capabilities, while AI focuses on the necessary mental capabilities. At present, AI systems are capable of solving a plethora of individual problems, each of them far more swiftly and accurately than a human could; but no robot is capable of loading a dishwasher yet. This phenomenon is represented by the term "narrow AI": each AI system today is typically helpless outside the situation it was designed for. These systems solve problems such as searching the Internet, routing FedEx packages, military logistics, or playing chess. However, it has been predicted that in the future, we wil develop what is known as "strong AI": an AI system that nears human levels of tolerating uncertainty, and can generate original solutions to problems hitherto unseen and unanticipated by the designers of the AI.

2.3.2 Biotechnology

2.3.3 Nanotechnology and Materials Science

2.3.4 Information Technology and Networking

2.3.5 Neurotechnology and Medicine

2.3.6 Policy, Law, and Ethics

We are not in a position to fully analyze the far-reaching consequences of near-term steps by space agencies and private space entrepreneurs, however we can set about to establish a context for critical evaluation of our motivations and hesitations at the Singularity University during the 2010 GSP. This is a time to develop a culture of intense questioning and reflexivity, weighing up the pros and cons of social and education value, economic and political drivers, scientific benefits, risks, the battle for sovereignty between nation states; time readiness, and the lessons learnt from past human endeavors at each stage of mission planning and undertaking. Particular attention must be paid to our obligations and restrictions, the differences of moral standing and the agents behind them; the intrinsic and instrumental values of global peoples and the core truths of our calling, in order to plan effectively and to garner new insights and knowledge for wider reaching solutions to terrestrial concerns so that we can leverage exponentially advancing technologies for the benefit of humanity, the planet and the future of our activities in space. We have a responsibility to boldly stay to serve legitimate interests as a peaceful, well-meaning people and the opportunity to explore new ways of seeing life, and space, from a whole new perspective.

It is posited that if we are to actually improve standards of living on Earth through space by generating economic opportunity; providing access to new resources (material, intellectual and so on) then we need to bring about the prospect of rapid technological development, the cross-fertilization of ideas, new visions and shared dreams for the benefit of all human-kind and this begins with the power of the questions we ask ourselves, and the declarations we make for our future generations.

2.3.7 Entrepreneurship

2.4 Classification of opportunities

We offer a brief taxonomy of the problems that exponential technologies need to help overcome during the next three decades in order to facilitate the exploration and colonization of space. For each area in this taxonomy, we explore the role that each exponential technology might play.

1. AI and Robotics
2. Biotechnology
3. Nanotechnology and Material Sciences
4. Information Technology and Networking
5. Neurotechnology and Medicine
6. Policy, Law and Ethics
7. Entrepreneurship

The goal of these definitions is twofold: to map for future reference our current understanding of the relative role of each of the exponential technologies and solution domains, and to help us focus our in-depth analysis of conceptual solutions to those areas that appear more fruitful.

3 Exponential Technology Opportunities

…For each of the sections below, we discuss the current state of the art, related exponential technologies, potential benefits, convergences with other technologies, and potential barriers to adoption.

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Glossary

gyrotron a type of high-powered microwave transmitter. 16

specific impulse (I_{sp}) is a metric of rocket (or jet) efficiency; the change in momentum per unit amount of propellant used. (This works out to an SI unit of seconds.) The higher the specific impulse, the less propellant is needed to gain a given amount of momentum. For example, the Space Shuttle Main Engine has an I_{sp} of 453s. 7

Acronyms

CLLSS Closed-Loop Life Support Systems: are life support systems which reuse 100% of their waste resources, with the exception of waste energy. 8

COSPAR Committee on Space Research: COSPAR promotes international scientific research in space, and provides an open forum for the disucssion of problems related to space science (for instance, organizing conferences on planetary protection policy).. 9

EBFF Electron Beam Freeform Fabrication. 14

ISRU In-Situ Resource Utilization: refers to the usage of local resources, especially the local usage of resources found in space, as opposed to the transport of Earth resources into space or vice versa. 7

ITAR International Traffic in Arms Regulations: a set of United States federal regulations that restrict the international trade of items and information which is considered by the federal government to be "munitions," including encryption technology and space technology. 9

LEO Low Earth Orbit. 7

SLS Selective Laser Sintering. 14

SSTO Single Stage to Orbit: refers to a vehicle which reaches orbit without jettisoning hardware, expending only fluids. The term usually, but not exclusively, refers to reusable vehicles. 7

Index