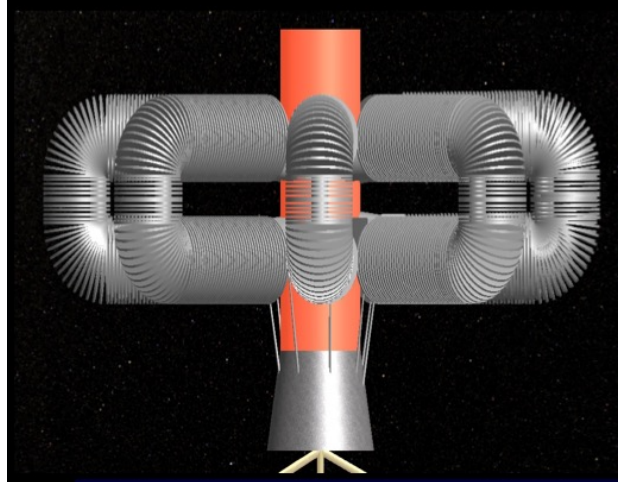
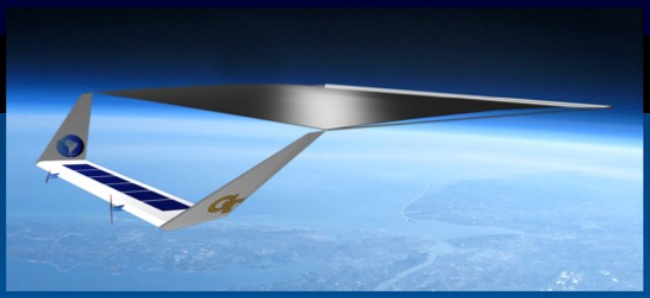
1st Abdul Kalam Conference IITM, Chennai, July 2019



REACHING NEW RESOURCES

Pre Conference Draft Report Working Group 3

The Kalam Conference Team



1st Abdul Kalam Conference
Working Group WG2 Report 20181101

REACHING NEW RESOURCES

Narayanan M. Komerath, Editor for The Kalam Conference Team

July 8, 2019

Contributors

1. Narayanan Komerath
2. Ganapati Myneni
3. Mahendra Sunkara
4. Ganti
5. Arjun Pandit
6. Madhu Thangavelu

Contents

List of Figures

Summary: Reaching New Resources

Note from the Editor: This report is the least 'complete' draft. This does not worry us: for now, we would prefer to keep the conference and discussion from gravitating into speculations on Gee-Whiz technical solutions, and focus instead on all the other aspects. The concepts each will come with extensive referencing, and the document will keep getting refined as technological ideas advance. The pre-conference aspiration is to help people see the various possibilities as they consider the overall problem. An underlying theme of this conference is that we may already have most of the technology to solve many looming and chronic problems - if the nation really decides to do so. The latter part requires interventions and synergy of all the other Working Group areas.

This group's mandate is to look at technological concepts. There is growing recognition that ecological and societal problems which appear intractable, require so-called 'Moonshot' projects with the scale and intensity to achieve solution. The term is inspired by the US initiative with Project Apollo to land and return humans from the Moon, inside a decade from official project start. In this case the project must have not only national initiatives but global buy-in and participation. On the grand cosmic scale, the resources on Earth are only a miniscule fraction of those available even in the Near Solar System. Responsible exploitation requires advancing technology through lunar and Martian bases, asteroid missions, and pursuing Space based solar power: the ultimate dream of harnessing the fusion/fission reactor of the Sun to generate electric power in Space, so that only useful power, not radiation, is delivered to Earth. But there are projects much closer to home that need swift technological solutions. One of the biggest resources from our fantastic ventures beyond Earth, is the knowledge to look at problems differently here on Earth. This comes through in advancing radical solutions that can be scaled up to global size.

Reforestation is an obvious approach to capture carbon dioxide from the lower atmosphere to stop and reverse Global Warming; we can estimate just how much we need to sequester enough carbon dioxide to achieve given levels of temperature decrease. However, converting flat farmlands to forest cannot be justified merely by Carbon Capture or Erosion Control. One approach is through the terrestrial derivatives of technologies proposed for Terraforming, where food is grown within artificially controlled environments. Use of soil is minimized, enabling food-growing to be done in vertical stacks occupying minimal footprint. Obviously this is energy, capital and technology intensive, but it offers some potential relief from the slavery to the vagaries of climate, as well as large savings in the amount of water needed.

Artificial Intelligence technology is coming back in a new round, building on much faster and more distributed computing, Big Data and Machine Learning. Robotics will receive a major boost from these technologies. Self-replicating machines, and mission-adaptable machine and software design technology developed for long-distance space missions, are examples of upcoming capabilities. These will pose threats and opportunities in redefining mass employment. One school of thought is that most repetitive tasks will be automated, eliminating many unskilled and skilled jobs. However, a much greater spectrum of jobs may be created by these changes, that are still beyond our imagination. Competition may intensify to produce ever-smarter and more versatile systems; or perhaps the combined facilities of people worldwide may be focused on much larger ambitions to tap immensely larger resources.

Many applications can already be imagined for Artificial Intelligence. Tele-medicine can be improved tremendously. AI can revolutionize the Justice system, providing the essential conditions for growth of small enterprise.

There are other concepts on the horizon that can stop and reverse climate change and sea-level rise by reducing solar radiation in a controlled manner; however their effects need careful study. Change in public policy will be needed. One example requiring scientific study is the danger of affecting such phenomena as the Monsoons, or ocean currents. Again, Space and atmospheric based sensing is vital to this endeavor.

In the near term, increased self-reliance in energy can hasten an era of clean and quiet transportation, using electric vehicles using battery storage, hybrid hydrocarbon-electric, and hydrogen fuel cell propulsion. As hydrogen becomes available all over the country, its cost will come down (supply is unlimited), and it will become the fuel of choice for air transportation. This could very well start with the advent of supersonic airline flights, for which Indian coastal cities are ideal centers. Domestic air transportation will expand immensely at all levels from UAVs for rural delivery, to nationwide airline and freight access.

Chapter 1

Introduction

Just as there are planetary-scale dangers that capture our attention, there are even larger opportunities that should capture our attention. Dr. Abdul Kalam, whose name inspires this series of conferences, was a strong believer in expanding our minds with the imagination to see such opportunities and pursue them. Those mentored by him report sitting in meetings watching him gently chide the division leaders on his teams for not thinking on sufficiently ambitious scales. The critical need for such ideas and projects is becoming clear even to business/corporate advisors who are usually focused on hardnosed economics. Recent discussions have been citing the critical need to take on *MoonShot* and *Manhattan Project* programs to tackle such problems as Climate Change, as nothing less is having effects that offer much hope of avoiding catastrophe.

1.1 Moonshot and Manhattan

The term *MoonShot* obviously refers to the Apollo program announced by President John F. Kennedy in 1961, just two weeks after the first successful American manned mission to orbit. Inside 8 years, American astronauts had walked on the Moon. The Manhattan Project was the secret project to harness nuclear reactions and develop nuclear weapons and electric power plants. However, one does not have to depend on nostalgia today. The eradication of smallpox and polio are equally if not vastly more significant to most of Humanity. Intercontinental jet airliner travel, the Global Positioning System and the Internet are examples of global coordination that should be hugely inspiring. Many other huge successes came from comparatively tiny

innovations. One little-known example the success against cholera and dysentery by the introduction of the simple black-light ultraviolet water filter, credited to Dr. Ashok Gadgil based on the earlier discovery at General Electric Corporation that ultraviolet light killed most of the *e-coli* bacteria. Other examples are the reductions of child mortality that came from polio, malaria, typhoid, pneumonia, cholera and smallpox immunizations, and screenings for tuberculosis. Megadams have controlled floods and provided irrigation, drinking water and electric power to billions. The Green Revolution and other advances have turned famine nations such as India used to be, into food-exporting powerhouses, in the face of a huge population rise. In every field of human endeavor, there are grand overarching concepts, as well as micro and now nano/pico-level innovations that make an immense difference. In this report we look at a few: the list is neither exhaustive nor claim to be accurately predictive of the future, but it does lay out some paths that can be followed immediately and without closing other options. One theorem of the Concept Developer is that their job is done when they have shown at least one path that is truly viable: they then argue that Humanity is at least smart enough to follow that route if seriously interested in solving the problem. Once people start moving along that route and know that there is one way, others will discover better ways, but later.

1.2 Space Resources as focus of Global Collaboration

We will start with a couple of grand Space concepts, then come down to the even grander ambition: to revolutionize village life in India. The first is that of a Space Based Economy (SBE). One of the great achievements of the United Nations is in the area of Space Law. Resources beyond the atmosphere are considered to be the 'heritage of all humankind' and thus not permitted to be monopolized by any national entity. When it was set up, the primary fear was that of war in Space between the USA and the Soviet Union, but today several nations and consortia have the ability to go into Space and all can benefit from extra-terrestrial resources.

The basic premise is that the resources available on Earth, about which we are so concerned to the point of preparing for wars over them, are all just a tiny fraction of those that are available, within the confines of just the Near Solar System. The Sun is considered a source here, only for energy. However, Venus, Mars and the Near-Earth Objects including the Moon, all have immense resources. With technologies developed to reach these destinations, most of the other planetary systems and comets of the

Solar system become accessible, though with longer travel times. For example, Titan, a large moon of Jupiter, is believed to have oceans of liquid methane. Jupiter and Saturn have atmospheres, indeed much of the entire gas giant planetary mass, of mostly hydrogen. Enceladus, the small moon of Saturn, has oceans of liquid water beneath the surface ice layer. The Near-Earth objects, and their innumerable cousins the Asteroids between Mars and Jupiter orbits, have iron and far more precious metals as well as carbon, in low-gravity stores ripe for exploitation. Our Moon has plenty of iron and other metals, besides silicon and oxygen tied up in the regolith (soil). We are not considering the very scarce and ancient water ice on the Moon as an exploitable resource: it should be protected by international law. The comets that visit the Sun at predictable intervals, are believed to be composed of water ice and other minerals. Thus the concept of an SBE is an economy whose suppliers, markets, customers and production facilities are all located beyond Earth with Earth being just one component. The process to reach the SBE starts with building infrastructure in orbit, which requires global collaboration. President Kalam was a keen proponent of such collaboration.

1.3 Space Solar Power

The first 'product' envisaged as coming from Space, is solar energy. Beyond what we already get as free nuclear fusion power (*too cheap to meter!*) in the form of sunlight, we can also imagine processed electric power delivered directly to Earth-based (and orbit-based) enterprises. This is Space Solar Power (SSP) also now called Space Based Solar Power (SBSP). Given the immense development cost, we postulate that SSP is only relevant if it offers planetary-scale replacement of a significant portion of electric power that is now generated from fossil-burning and nuclear fission. The terrestrial power grid is now designed to handle sources, such as reactors, on a 1-GW scale. Thus full-scale deployment of this concept thus envisages about 4000 to 8000 1-Gigawatt electric power generators in orbit, delivering the power via electromagnetic beams to earth-based collector-converters and into the power grid. Fundamental obstacles remain. Photovoltaic conversion offers no economies of scale; 10 times the power requires 10 times the area, all occupied by relative thick and dense photovoltaic panels and structure. Concentrating sunlight onto solar panels, does not work in Space because there is no conduction or free convection to remove the heat: Beyond about an intensification factor of 2, the mass of the active cooling system needed, outweighs the advantages of intensified conversion.

Consequently, the collision risk with debris negates scaling solar photovoltaic arrays to

the areas needed for utility-scale (thousands of GigaWatt scale units). We have shown that intensified collection of sunlight using ultralight concentrators, and *thermal* conversion can solve this problem . This can achieve high values of Specific Power, the electric power delivered to Earth per unit mass placed in orbit.

The second problem with SSP, which is the main problem as we argue, is the need to develop efficient conversion/transmission/collection/conversion technology that works with high-frequency beams such as millimeter waves or optical radiation. Current Space Law prohibits high-energy lasers beyond Earth, so laser conversion is not being publicly considered; in any event, converting lasers back to useful electric power is still quite inefficient.

The third is the high cost of transporting the needed infrastructure (at least 4 to 8 billion tons of mass) into orbit. Work along all 3 directions will have many spinoffs, known and currently unimaginable.

1.4 Intensified Solar Power

On Earth, intensified solar thermal energy can be used with various reactors. The cost is potentially far below that of solar photovoltaics. This can generate Syngas and liquid petroleum fuel from prairie grass and other waste vegetation.

1.5 Reflecting Sunlight Before It Can Scatter: The Glitter Belt

Much closer to home and in time, is a concept for reversing Climate Change called the Glitter Belt: a constellation of ultralight, reflective sheets floated in the upper atmosphere to reflect sunlight before it can scatter or be absorbed in the atmosphere. The total mass needed for this is on the order of perhaps 100 to 400 Space Shuttle launches, which puts an upper bound on cost by first-cut aerospace cost estimation. The energy needed for these sheets is only a millionth of that required to orbit a spacecraft of the same mass, and the launches can be done worldwide from football fields or beaches, so the cost should be a tiny fraction of the upper bound. This concept is being developed. Meanwhile, there are many gradual and sustainable methods to capture and sequester carbon from the atmosphere or at the industrial source, and reduce its emission.

1.6 Closer to home

These are enumerated below.

1. The technologies to enable rural telemedicine, with the same or better quality as today's best personal-care medicine, pose another frontier where rapid advances are possible. Telerobotic surgery is being demonstrated: if it can be used for precise movements in the complex dynamic interactions of orbital mechanics, it can also be used on Earth. There are technologies to enable on-demand, sustainable transportation from and to the villages. Also, for to-quality rural education.
2. The fast-rising field of Big Data and Artificial Intelligence, offers tremendous potential in and endless array of problem areas. We will briefly look at the issues here, and consider the importance in solving problems that are specific to India.
3. There has been much research put into the idea of Terraforming. Climate-controlled, pressurized environments are created to enable human survival on planets where the natural conditions are hostile to human life. If this can be done on, say, Mars, where we believe that carbon dioxide and water can be converted to methane and oxygen for use as rocket fuel, we ask why similar advances cannot be made in terrestrial agriculture. Vertical farms using little soil, schemes to recycle most of the water that is used in irrigation, and other such ideas come to the fore.
4. India is plagued by what we call the Flood-Drought Curse. We are exploring pilot projects on predicting floods, and on rerouting rising water to parched areas.

1.7 A takeaway: Micro Earth Credits

As much as possible, our strategy draws on current efforts of the government, and on traditional beliefs and history of rural India. Respect for Nature as being central to Creation, and the ancient traditions of distributed rural enterprise, are central elements in this strategy. The native talent for business enterprise and trading will be encouraged. Respect and talent for education will be fostered.

In this spirit, we suggest that consideration be given, to the idea of Micro Earth Credits that anyone can earn, as opposed to the present system of Carbon Credits

which can be earned only by large entities with extreme initial cost threshold. Six billion people participating and doing a little bit each day, may be our best hope to deal with global problems.

Chapter 2

Intensifed Solar Energy

With steerable mirrors, sunlight can be concentrated into small focal volumes, where high temperatures can be reached. Figure 2.2 shows such a device. It is basically a parabolic dish that uses tracking motors to stay aligned with the Sun during the day, allowing a precise and compact focal region to form at the entrance to a reactor vessel. The efficiency of an Ideal Heat engine rises with the temperature difference that can be maintained, between the highest temperature of the fluid going into a heat engine to generate work, and the lowest temperature that can be attained after work extraction, to reject as waste heat.

Thus high temperature implies high thermodynamic efficiency, which means that much more of the solar energy is converted to useful work, than is possible with photovoltaic systems. This technology has come a long way since the 1970s, and is now routinely used in Solar Towers surrounded by large fields of mirrors, as an example, for electric power generation plants. In all cases, if the installation is in a village, the waste heat from heat engine operation is still significant enough to use for cooking or other uses.

While extremely high temperatures of over 2000K can be achieved in the focal volume, the state of the art is limited by the strength and reliability of the vessels that can survive such temperatures. Thus the state of the art, from Professor Jean Davidson of the University of Minnesota, can be summarized as follows:

- At temperatures of 1000K (around 730 degrees Celsius) vegetation such as prairie grass, mixed in a reactor vessel with suitable heat-conducting salts, will decompose in the absence of air, generating syngas. The syngas can further converted into liquid hydrocarbon fuel, suitable for transportation. Such systems

have been working at the laboratory scale, with the output fuel coming at a rate that might fill a 55-gallon drum in a week or so. This is probably enough to bring transportation fuel independence to an Indian village.

- At temperatures of 1500K, if suitable reactors are developed, many more materials can be digested, generating useful products. Electrolysis of water to generate hydrogen and oxygen becomes very efficient, compared to the 2 percent or so that is available at room temperature. Some reactors suitable for such operations are in development.
- At temperatures of 2000K, water (superheated steam) can be directly decomposed into hydrogen and oxygen, thus achieving a system where sunlight and water, with few moving parts, generate fuel for use in the most efficient fuel cells. Reactors for this temperature regime are still some time away in materials development.

A reactor sample is shown in Figure 2.1.

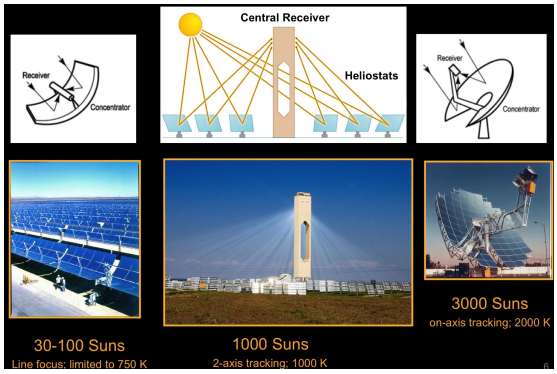


Figure. 2.2: Concentrating Solar Plants. From J. Davidson, by permission.

The implication of the last point is that the route to a hydrogen economy is clear in the longer term. The economics of hydrogen extraction can be vastly boosted if a suitable local market need can be identified for high-purity oxygen. Liquid oxygen can be easily extracted by pressurizing air and cooling it, separating out the oxygen droplets as they condense. It will be difficult to compete with that technology, even though the energy from sunlight is 'free'. On the other hand, today industrial-scale hydrogen production is during the refinement of petroleum. However, a combined hydrogen-oxygen production system could compete on price quite well for both, particularly if done locally. That said, we have no suggestion as yet, why villagers would have a particular market need for purified oxygen. This will be something to bear in mind as rural-based enterprise develops. An interesting side-note is that in India in 2019, canisters of pure oxygen are becoming a fad, claiming benefits of invigoration, helping relieve asthma, and other features. Perhaps the real demand for this product arises from the sad reality of the air quality in major Indian cities.

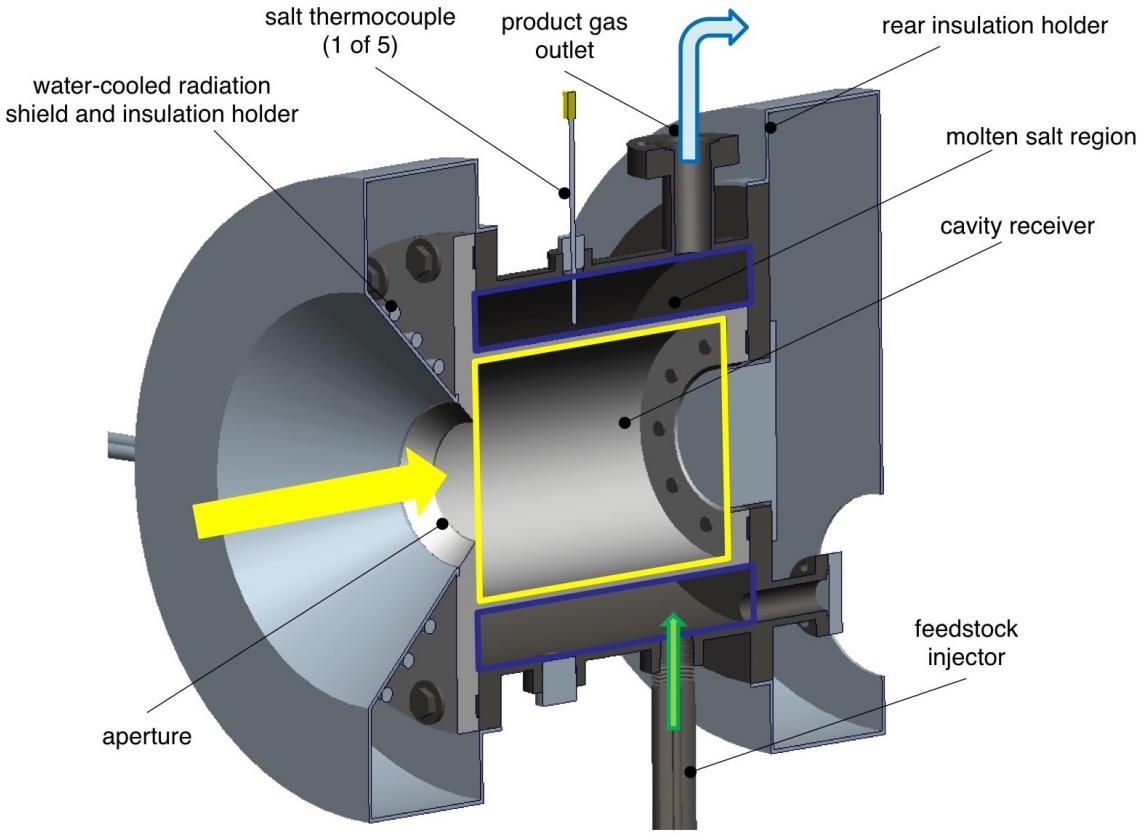


Figure. 2.1: Sample image of a reactor used for fuel generation from solar anaerobic decomposition of vegetation. From J. Davidson, by permission.

However, even today there is a clear route to energy independence at the distributed, local village level, including means of generating hydrogen.

The major disadvantage of the solar tracking intensifier is that is no good on a cloudy day: only direct sunlight can be intensified, not diffused light. As a result, this system may be better suited to dry deserts, or high altitude sites. In addition, if such systems are to be used as primary electric power generators, they must be used in conjunction with other systems that do operate in poor weather. The wider application in India may be to generate storable fuels from vegetation or from water, when the sun is shining, and use those fuels at other times.

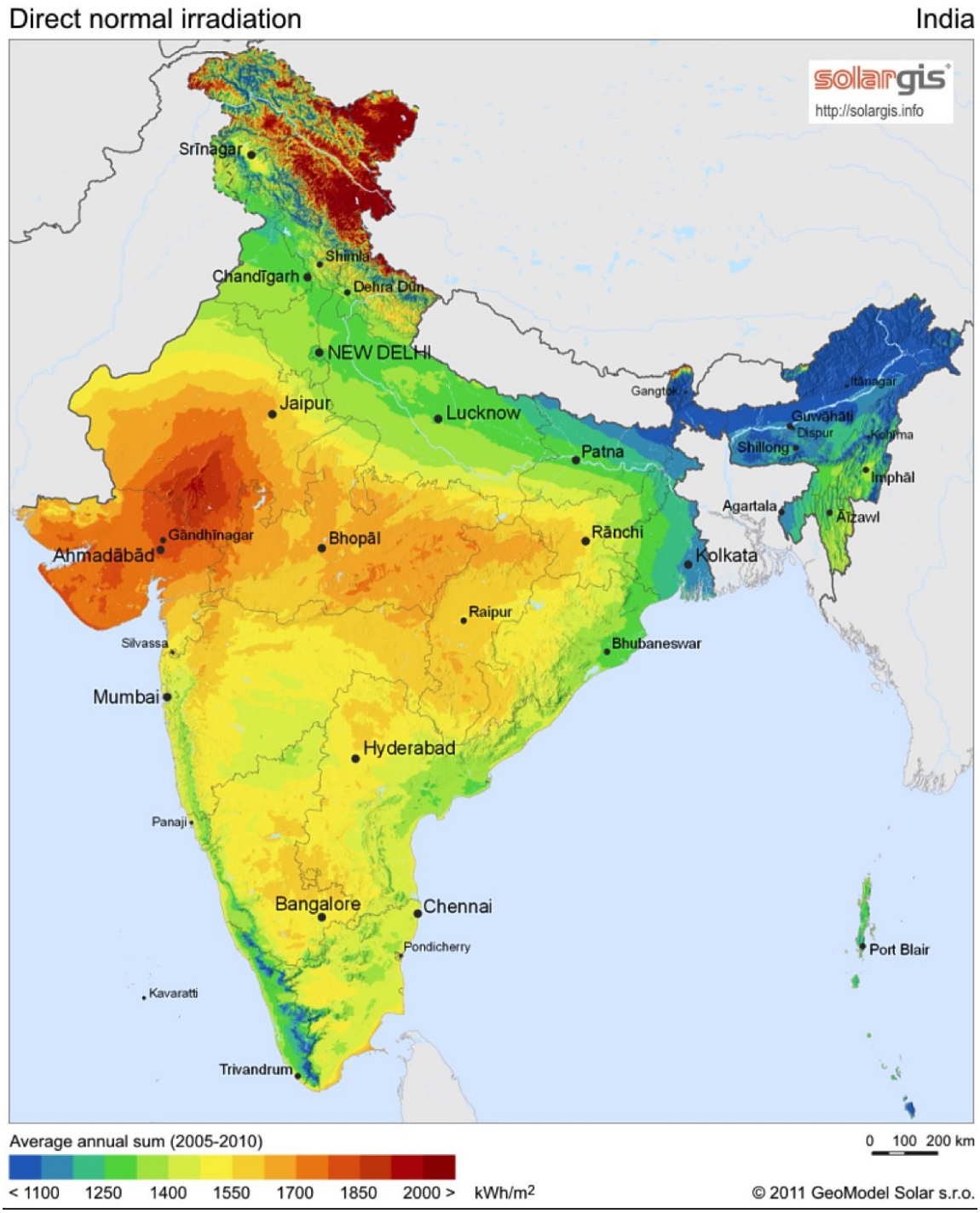


Figure. 2.3: Solar direct normal irradiation in India, showing contours of annual sunlight in kiloWatt hours per square meter. From J. Davidson, by permission.

Chapter 3

Artificial Intelligence: Opportunities and Risks

There is much repetition and duplication between this chapter and one in the Working Group 4 report, because it is relevant in both places and written by the same authors.

3.1 Terminology

3.1.1 Definitions

An experienced corporate leader took the following standard definitions available in public domain for the purpose of this discussion :

- Artificial Intelligence: AI is basically the operation of algorithms, neural networks and statistical analysis which automatically optimize themselves continuously in order to identify the variables to be dealt with to have the desired output. Artificial intelligence does not try to mimic human thought processes. Instead, a good AI system gives the best possible solution for a given problem.
- Cognitive computing: Cognitive computing systems try to simulate human thought processes. They are systems that learn at scale, reason with purpose and interact with humans naturally. Cognitive computing is a mixture of computer science and cognitive science d that is, the understanding of the human brain and how it works. By means of self-teaching algorithms that use

data mining, visual recognition, and natural language processing, the computer is able to solve problems and thereby optimize human processes. Evidently, there is an overlapping with AI systems .

- Internet of Things (IoT): The Internet of Things (IoT) refers to the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects.

NITI Aaayog, India's public organization for strategic planning, released a document on Artificial Intelligence [1] in June 2018. Per practitioners in the field, the term"AI" is too broad. AI does not fit the model of programming languages. AI includes Machine Learning (ML), Natural Language Understanding (NLU), Network Analysis (NL), Mining (Text), etc. ML pertains to systems which learn (supervised or otherwise) over a period of time and get better than humans. AI, on the other hand, is mimicking human intelligence and has a broader or esoteric goal. Both ML and AI attempt to mimic humans. ML (as the name implies) attempts to learn from examples, while other branches of AI need more intervention. The US entrepreneur Elon Musk has recently stated that his ML (using Neural Networks) actually comes up with new algorithms that humans cannot even envisage. There are many areas of interest. Of computer languages used in this field, Python is the most commonly used, R is not too far behind. Based on these two, one must specialize within those languages, in libraries that pertain to a specific field within "AI". Machine Learning uses Statistics a good deal. AI does have a fair amount of coding (Python, etc), but a lot of it is Math. Neural Networks is actually Linear Algebra. Fuzzy Logic is based on Set Theory.

The vast majority of all actually monetizable work is likely to be outsourced or distributed at fairly low level to people who can do some kind of data analysis/ testing. Reading about the problems encountered by large companies building life-critical systems, will give a different view of how the "Real World" at the Top does "testing". Another AI problem is predicting what sorts of disasters to test for, with nonlinear combinations of many System of Systems factors acting on each other.

3.2 Legal System

AI can be the technology that breaks through the convoluted problems of India's Legal System. Think of a case filed: The parties would have to use the AI app (on a seriously powerful computer) to describe their problem/case precisely, but also with the more subjective disputes described. AI digs out the relevant Precedents, laws

etc in a flash. This will take time, as the Precedents are gradually entered into the System, but at the start at least a title search followed by text search is possible soon. The work of Law Clerks taking months can be vastly accelerated by AI to be completed in seconds: the implication being that human operators can do so much more in depth and breadth. The human can step in and clean up what AI cannot. Then the Judge is presented with the AI/clerk based summaries and references to data. The Judgement can be drafted by AI in many cases, for the Judge to review and approve, with a probability-based Certainty Rating (CR) assigned for the Judge to decide how much time to spend. Where the CR is say, below 85%, the Judge has to spend more time reviewing, but the data collection is done very swiftly. The net effect is that the expert human professionals can spend their time far more effectively, achieving a huge improvement in quality.

Hewlett-Packard bought a (British) company by the name of Autonomy, founded around 1995. Their algorithm BTH, is based on Bayesian theorem. It is an excellent tool and widely used in the legal community. It understands natural language usage, in multiple languages.

3.3 Natural Language Processing

AI solutions can and do indeed today deal with multiple Indian languages. This feature must not be lost. An example is if one were to scroll way down on bbc.com, one can see the number of regional languages with which BBC (British Broadcasting Corporation) deals. All of that is Autonomy.

Text summarization (Legal or otherwise) is very much within the grasp of the current NLP. Text understanding(and Translation) is well understood but summary generation with content is still a Work In Process for serious applications. However, there are serious, production-ready applications being developed by ML experts in industry. The scale of the legal application is huge, and so are the numbers and size of documents and text to be processed. Also, first they would have to be digitized, whereas First Information Reports (FIRs) are still handwritten, and then read as text. As of today, no ML framework (TF, Azure, PyTorch) can scale to that level. However, they could be there in 2-3 years.

Scientists are also working to create speech from brain signals [2]

3.4 Medical delivery/ Telemedicine

For every 1,000 people, the number of physicians in India stands at 0.7 (less than 1), compared to the global average of 1.5. There are only 0.7 beds per 1,000 people, compared to the World Health Organisation's (WHO) recommendation of 3.5. The findings from the Deloitte and CII report titled 'Medical Technology, Shaping Healthcare For All In India ' highlights the grim reality of healthcare in the country. India's healthcare space is projected to grow at 23 percent Compounded Annual Growth Rate to a $280 billion market by 2020. With the Digital India initiative, the government has been bolstering all efforts towards bridging the gap in healthtech, an area where Indian startups already have momentum. With cancer patients, early diagnosis or prognosis of the cancer type could prove to be critical. However, with only 500 pathologists specialising in cancer diagnosis according to a NITI Aayog report India faces a backlog, between the number of pathologists available and the number of samples collected.

Here AI has a number of roles to play, from communications to diagnosis. AI started in the medical field. But that AI was very different than what we have today. Unfortunately "diagnosis" is just too wide a term. TODAY AI (seems to) work very well in IDing cancer cells. But it fails when it is consulted for a common cold or fever. A lot of work needs to be done in this area. AI is being used, extensively, in Pharma - to come up with new concoctions.

One growing idea worldwide is the linkage of AI with medical diagnostics - using immense databases that far exceed any one human expert's experience base. For instance, a Pathologist could be empowered immensely by having an AI system work alongside them, usually confirming, but occasionally questioning, the human expert's own observations. Obviously this idea should find a place in Working Group 5, but here it could be applied to other fields as well. Artificial intelligence technology offers a way to break through the communication barriers between many languages of India, by enabling not just translation but understanding of deep meaning, history and context. Note that we emphasize investment in iteration, error checking and constant refinement in such endeavors.

The area of "expert systems" is an old technology and is thoroughly neglected given the focus on Machine Learning. However it has a place in India, where there is so much institutional knowledge. Generations have grown up never taking antibiotics, because what their parents learned from their parents taught them how to treat various common problems faced by small kids. Unless these are written down (not as an expert system) it will be lost. The present generation usually runs to get

antibiotics, and the evolution of antibiotic-resistant bacteria is a real and growing danger.

3.5 Other Applications

There are innumerable and unimaginable other specific applications of course. A recent news article by Sutrishna Ghosh on 8th Apr 2019 summarizes 5 Indian startup companies that are monitoring India's health with AI, machine learning, and smart apps. They work on cancer diagnosis, monitoring diabetes, and digitizing medical records for access. From medical tourism to telemedicine, India's healthcare sector has been expanding at a healthy double-digit rate to include newer and better services powered by new-age technologies. The problem, however, is not availability, but access to these services. The company 'Onward Health' uses predictive analytics and machine learning, with a portfolio of diagnostic tools. They aim to help pathologists diagnose more cases every day with deeper, more accurate insights from available samples. Computer vision techniques and ML algorithms are going into tools for computational pathology and mammography.

The World Health Organization (WHO) predicts that 100 million Indians will be living with diabetes by 2030. The company BeatO developed a smart-phone plug-in glucometer app that was serving around 50,000 diabetes patients across 1,500 cities by 2019. The app also tracks Fitness levels are tracked and guides diet management.

The startup ten3T makes medical grade wearable devices. Its Cicer, palm-sized patch sticker has multiple embedded sensors. This IoT (Internet of Things) technology helps early detection, reducing problems in hospitals, during transport, and even at home.

Ayurveda-inspired AADAR monitors health conditions to proactively head off diseases. It offers herb-based antidotes for lifestyle ailments like protein deficiencies, blood sugar, indigestion, cholesterol, and obesity. The startup company DRiefcase focuses on medical records and record-keeping.

Medical diagnosis using x-rays, CT, MRI images via trained Neural Nets (CNN) are being attempted as well. This is mostly in research labs, yet to be commercialized. A phone picture based glaucoma or other retina anomaly detection etc have been attempted. Given the sensitivity and compliance issues (such as HIPPA) real applications are hard to develop without training data at scale. Hospital Networks, Medical mfg, Pharmaceutical companies with the ability to make big development investments

are working on these. Scalable applications are expected in 2-3 years.

3.6 Voting

AI technologies could be used to make voting much more efficient and convenient: the debate is over security. In particular, let us consider the option of electronic voting for all voters. In India a remarkably high percentage of voters cast their vote in the present system. Voting is above 75% over large areas, generally well above 60% in most areas in the 2019 election. The strict implementation of the "last kilometer" dream now mandates that no voter should have to travel more than 1.3 kilometers *from their registered voting location* to cast their vote: this also means that lines are short. Electronic voting machines (EVM) with a paper trail mean that the official results can be announced within a day of starting the counting.

However, there are substantial hurdles remaining. People who must be out of their registered location must return home to vote: this disenfranchises many. Errors in the electoral rolls are discovered only when voters arrive to vote: in many cases they cannot be resolved on the spot, with the voter being disenfranchised. The emphasis there is necessarily on preventing impostors from voting. Most sadly the vast diaspora of Non-Resident Indians (NRI's), among them some of India's most dedicated, well-informed and productive citizens, are disenfranchised, unless they happen to return home for the election. This not feasible for most people given that they save every vacation hour, and their money, for that annual or biennial or even-less frequent trip home at special times. To make matters worse, if they do arrive, they find far too frequently that their names have been 'struck off the rolls' - or worse, than someone has already voted as them.

AI technology can address the security and privacy issues in enabling voters to vote from anywhere in the world (or from Space!) at times convenient to them, during the announced election season. Note that the 2019 election spanned a whole month, but Polling Days were very specific to each location. It is conceivable that people can be allowed to vote anytime during this month (or hopefully, shorter period in future) via electronic voting. On the other hand, the use of AI technology runs the extreme risk that fraud can become disastrous in consequences, and extremely difficult to detect in time. This requires careful consideration, research, development and testing, with continuous updating.

In voting there are 5 issues:

1. Ensure that one votes IFF (If and only If) one is a registered voter. In the right constituency.
2. Ensure that no one else can see who one votes for.
3. Ensure that the vote that one intended to cast is indeed the vote that was cast.
4. Ensure that the vote that one ended up casting is indeed the vote that ends up being counted.
5. Ensure that the actual vote count is what is announced.

The first item is easy. Aadhar identifies one as a voter. Only 1 vote is allowed per Aadhar. Aadhar is supposed to be updated to remove deceased voters, foreigners etc. When an Aadhar vote is registered the owner is informed that s(he) has voted, just like credit card transactions today.

For the second item, there has to be some randomizer that then guards the entrance to the "polling booth" where one's vote is cast and no one can tell who is voting. This is not any worse than the security issues of BlockChain technology. So it possible to ensure that there is no trace from voting preference to voter. One is not seen going to the polling booth, and in whose car or bus. There is no "black mark" on one's finger that might identify one to the terrorists (a nagging problem in Jammu-Kashmir) as someone who did not boycott the election. Rain or shine, as long as there is electricity and Net connection one can vote.

The third item is the Miami Dade County 2000 election problem: the huge polling sheet was confusing enough that many people of limited attention span voted for someone other than their intended choice - or that was the allegation.

The fourth item is Electronic Voting Machine (EVM) fraud. The fifth item is an Enforcement Directorate problem. India has surmounted that.

The randomizer can be infiltrated: that is another BlockChain type problem. Verifying voter identify (item 3) is the credit card payment problem. If that is secure, why not voting? It is actually much better in the peace and security of one's own computer than on a strange screen in a polling booth. Verifying no. 4 may require innovation. How does one do that with no one seeing WHO cast the vote? What would be the "paper trail" that satisfies the voter, the different candidates and the ED that all is well?

3.7 Military / Security

The Indian Navy recently held a conclave on AI opportunities. This paper talks about AI and ethics in naval operations. The Swarajyamag magazine recently published an article titled 'From War Games To War: It Is A Small Leap For AI, But A Giant Step For Mankind'.

The Indian military for instance, has a window of opportunity to turn India's large numbers of IT-trained workers to gain an edge in the deployment of AI technology in military systems. Perhaps not as early mover/adoptor, but by becoming the biggest, and using that advantage in simulation, deployment and cost savings. Some applications (courtesy of postor Arjun Pandit at the Bharat Rakshak Forum). "The possibilities are endless, but require focussed outcome-oriented support from different organizations and academia.":

1. ISR missions, where a captured SAR Map can be segmented into different regions of interest like hangars, oil dumps, existing deployment of the enemy.
2. Disaster relief : All soldiers doing to avalanche-prone area to have transponder transmit their last location. Based on that, simulation models can be developed to find the estimated location of soldiers in case of avalanche or other accident/incident.
3. Use of AI to improve the automatic identification of mines.
4. Upcoming swarm technologies will involve agent-based modeling and AI to learn from past operations and improve deployment in future missions.
5. Robotics in UGV, UAV, and unmanned naval systems in patrolling.
6. AI can be used as an evaluation tool for different strategies during war gaming.
7. Cybersphere is a domain in itself. Here one will use methods to disable enemy infrastructure. Finding vulnerabilities in their infrastructure and self-protection system involve use of AI. For example, NTRO related work might involve use of AI to cluster social media, finding terror related persons.
8. Deep Learning is a subset of AI, where you simulate using a very large database of inputs. This is primarily used in face recognition and other tasks. for example, face recognition and gait analysis from videos of stone pelters and indexing their profiles in the database.

On the other hand, AI is apparently not doing so well yet in military systems worldwide. One reason is that humans do not trust AI yet. There are two newly

minted areas of interest. The first is "Assured Autonomy", an area pursued by the US Defense Advanced Research Projects Agency (DARPA), where the goal is to incrementally introduce "Automation" via AI (not robotics). What is the difference? While robotics is repetitive (humans see that repetition so often that they trust it), "Autonomy" is actually "decision making", which is why humans do not trust it. This leads to studies in the area of Human-Machine Interface (HMI). These two are closely related and in this step, the human has the option to press a button and take over the task from the machine's AI interface. The US has a great deal of data in this area, especially with respect to aircraft operation.

3.8 Disaster Alleviation

An article titled "How Google Is Using Machine Learning To Predict Floods In India" discusses that initiative. Sella Nevo, the software engineer heading the initiative, is cited as saying that about 20% of fatalities worldwide from flooding occur in India. Google chose Patna, Bihar, as an ideal location due to the incessant rainfall that the city receives, and the number of embankments and other man-made structures. As the country's most flood-prone state, "73% of Bihar's 94,163-sq.km land area gets flooded annually", per the International Water Management Institute (IWMI). The Government of India is providing Google (Alphabet Inc.) with stream gauge measurements as well as forecasts based on their gauge-to-gauge forecasting system. With these and other inputs Google maps areas that are expected to be inundated. Google Machine Language expertise, computational power and other data resources could substantially improve flood forecasting systems. Satellite imagery is used to estimate the amount of water that has gone through a river, and Machine Language is used to integrate the data from the optical and infrared imagery, radar and microwave signal analysis.

One concern expressed by some is that such data are being provided by the government to foreign-based entities. They wonder about the controls on such data, and the potential for their misuse by adversaries. There was some suspicion in 2018 that extreme flooding in Assom and other northeastern states might have been aggravated by anthropogenic means, and perhaps not all of it was unintentional.

The Indian government's Central Water Commission (CWC) estimates that rain and floods have killed 107,487 people and caused 365,860 Crore Indian Rupees of damage across India between 1953 and 2017. Most deaths resulted from the inability of drainage capacity, reservoir regulations and flood control structures to cope with

intense rainfall. An example is the 2018 August flooding in Kerala with over 1000 deaths, destruction of 12,362 houses and a loss of INR 31,000 crores to the State.

3.9 Education and Research

The People's Republic of China has invested significant resources in AI education, starting at the pre-schooler level.

An AI education initiative was launched in July 2018 by the China Education Technology Association Smart Learning Committee and UNESCO. The aim is to democratize AI education in 100 Chinese schools, introduce pre-teens to the basics, strengthen teenagers' capability for using intelligent and applied technologies, and help train hundreds of new AI teachers.

There is a Cloud-based AI e-learning platform that students can access via PC or WeChat. The platform supports major machine learning frameworks including TensorFlow, CNTK, and Caffe; programming environments Scratch 3.0 and Python Integrated Development Environment (IDE); and includes digital copies of the 33 AI textbooks and a broad scope of use cases. Platform development was reportedly led by Google AI experts in Beijing.

In April 40 high schools in Shanghai began using Fundamentals of Artificial Intelligence, a nine-chapter AI textbook compiled by SenseTime, the world's most valuable AI startup. Two months later, Suzhou University published its Primary and Secondary School Artificial intelligence Series.

An expert named Simsirian is quoted as saying: *"With the rise of automation, new skills are emerging as valuable in the age of AI and are often not the focus of K-12 education. These include problem finding, inquiry, flexibility, collaboration, creativity, systems thinking and technological literacy to name the basics'. AI changes what we teach the next generation starting in Kindergarten because the next generation will have jobs that do not exist yet."*

According to he Hindu newspaper there is an initiative by a group of private universities to collect Artificial Intelligence resources. India ranks third in the world in research on artificial intelligence, as gleaned from tracking papers in peer-reviewed journals. This is a long way behind China which leads, and the USA which is second. The application areas seen by present AI researchers in India included healthcare, financial services, monsoon forecasting, retail and education. They felt that the field was 'unlikely to lead' to a destruction of jobs - a key global concern regarding the

field.

One industry insider who works to help organizations in adapting data science/ML, gave his observations baed on many years of interaction with industry people in Bengaluru, Chennai, Hyderabad, Pune and Gurgaon:

1. Big IT companies seem to be finding it difficult to have a strategy to exploit ML/AI. The fast paced nature of most ML/Data Science projects is something that these companies aren't familiar/comfortable with.
2. Consultancies such as McKinsey/EY whose work force is less tech heavy (MBA types) are making it a point that people are able to write SQL queries and do some general python scripting. This seems to be true for teams which were purely into management consulting earlier were doing some sort of excel plus VBA reporting.
3. Some financial companies (foreign banks and market data providers) are focusing on automating some manual processes such as digitizing bank forms, getting relevant financial data from pdf (the ones which are scanned images) using image processing (yes this not purely AI but that's how AI is being used as a term)
4. Automation using RPA is catching up. One big foreign brewery company in Bengaluru has made it a point to impart RPA plus SQL training to people working in functional teams such as Accounts plus Finance
5. Very interesting and innovative work is still being done by startups.
6. Good data culture is an issue with big companies where there are still a lot of technology silos.
7. Very few people appear to be making data-based products. Majority of the people appear to be more focused on doing a consulting assignment.
8. Running SQL queries+general scripting should be skills that every one should learn.

3.10 Steps to enhance the growth of AI in India

Postors commented on this aspect. In summary,

1. Emphasis on mathematics and science right from elementary education. Make

it fun to learn mathematics.

2. Create two streams. Computer "Programming" and Computer "Science". Make people understand the distinction, and grow the "science" stream.
3. People do not become AI engineers just by learning Python.
4. Understand that BI is not ML /AI. We see many resumes that are able to write only SQL Queries and can mention few AI frameworks and call themselves AI engineers
5. RPA is not AI, and is largely an extension of Automated UI testing frameworks like Selenium
6. Machine learning is not writing SQLs.
7. IT organizations should not sell AI skills just to make money. If they want to really create a differentiator, they should stop masquerading SQL Writers as AI/ML Engineers. This is tough call.
8. Educate our oftware workforce. Ask them not to be ugly consumers. For a change, create value and original products.
9. Know your worth as Indian, and work with local problems. Scale is never an Issue in India. If you cant do real ML and AI here in India, where will you do it?

3.11 Concerns About Data Localization

One participant commented that about a year ago he tried to access data for health care (genetic data for autism research). In that case data were owned by NGOs financed by corporate firms like Google. It was a huge disappointment. Even without that effort the data localization requirements from RBI are a good start. We will never have access to proprietary data in public domain. So let us get over that notion. He doubts that data will be publicly available that easily for this application. One must be able to get into the system for this. Google maps/earth data, resolution will have resolution issues. But still there can be some information that can be scraped and figured out. Remember even in private set ups data are not readily available. They has to be collated and processed and a lot of effort goes into this. In his experience 80-90% effort is in getting the data into the right shape and that is when one has the data to begin with. One will have to be resourceful regarding medical data. Westen-owned multinational companies have a stranglehold over internet technologies

and probably China because of hardware manufacturing and data hackings.

3.12 Financial Systems

In financial systems, there has been some evolution/devolution of what is these days called AI. Obviously there is an aspiration to use AI in supporting, and accelerating, human analysts who are trying to make sense of the immense number of variables and factors that contribute to the evolution of the economy at every level.

3.13 Rural Enterprise

A great many of the present workforce trained in India and abroad in Information Technologies, can be re-purposed into Artificial Intelligence system development with relative ease.

Startups in India claim to use AI plus ML in their pitch but when one look beneath the hood of the product, there is very basic level AI work going on. We still are few years behind to do some cutting edge work in AI & ML. Most of the AI work revolves around chatbots and figuring out documentation. The Big - 4 IT companies of India are gearing up but to provide consultancy and offshore any AI+ML+NLP work that originates in the developed world. One hopes that they will also invest heavily in innovation for the domestic market.

3.14 Overall Employment

Economic success of any nation will depend upon its capacity to create wealth and jobs for ensuring a decent life-style to the entire cross section of the population . While GDP is an indicator , it is not necessarily an indicator of the well-being of the people as a whole. A successful nation with respectable societal values considers that wealth creation will have to be associated with job creation. In a knowledge based economy where technology drives the main elements for competitiveness, the required skills undergo continuous transformation and an acceptable equilibrium between job requirement and skill-requirement is essential in order to provide adequate purchasing power for every citizen to have a reasonably comfortable life-style. It is well known that automation will kill certain jobs while it creates certain other jobs of different

skills. If such a change results in large scale unemployment/under employment , it gets translated into a serious societal problem. Several European countries are facing such a situation. We will examine these aspects in the Indian context and see how India can adopt a winning strategy for creation of both wealth and jobs in a competitive environment embracing the enormous potential of AI .

3.14.1 Impact of automation on industrial activities and service activities

Automation techniques were adopted in industrial activities in a big way since the 1970s with the introduction of Numerically controlled (NC) machines and later Computer Numerical Control machines (CNC). The author had the opportunity to witness all the stages of this transformation in a factory in Europe during the period 1970 to 2000. The primary objective of this transformation was to improve competitiveness through automated production lines and increased profitability through better exploitation of manufacturing facilities, so as to have lower direct labour cost. Such changes have resulted in considerable reduction of manpower in all the activities associated with manufacturing: machining, plate working, surface protection, assembly and material-handling. It is true that new jobs were created with other skills. Yet there was a net loss of jobs. No doubt, automation has helped countries with high person-hour cost, to optimize cost in order to be competitive in the global market. This is one of the principal reasons for a high level of unemployment/underemployment in several developed nations. The impact of unemployment in countries covered with a social security net is enormous. The whole system is under strain because the number of persons contributing to the Social security system has come down. In the 1980s, a question was raised by French politician Segolene Royal (Minister in the Mitterand administration) about the possibility of charging a tax on machines which kill jobs. Nothing concrete has been done so far. In the author's view, taxing robots which kill jobs will be inevitable in the near future in order to sustain the social security system.

The adoption of AI-aided CNC machines with auto-correction features will change the job-scenario completely. The political leadership all over the world will have to find solutions adapted to their countries in order to create an equilibrium between work and leisure at reasonable levels of wages, to ensure a decent life-style for all citizens. This is a big challenge.

3.14.2 AI and India's challenges

India's challenges in the job-market are quite different from those of the developed world. Hence it will be a mistake for India to follow the beaten track of the western world, or even China which has followed the West. Any discussion on the impact of AI on jobs in India based on what is happening in the organized sector could be misleading. Let us try to examine the job-scenario in India at present. As per the data published by World bank, India's Labour Force Participation Rate (LFPR) is around 56 % in 2015. This corresponds to a working age population of around 830 million and a labour- force of around 460 million people. Considering the comparatively low median age in India, the LFPR should have been around 65 % (68 % in China, 62 % in USA and 60% in Germany). Out of the 460 million people in the labour force in India, only around 54 million people happen to be in the organized sector (32 million in industrial and service activities and 22 million in Govt service) leaving the vast majority of employees in India in the unorganized sector. By definition, the organized sector is one which is incorporated with appropriate authorities and which follows specific rules and regulations. Any future grand strategy of India for wealth-creation and associated job-creation will have to take into account the following points:

- Take full advantage of the technological evolution for creating wealth and jobs
- Bring the vast majority of the labour force in unorganized sector into organized sector with the required skill development / skill-migration
- Maintain the contribution of agriculture in GDP at the same percentage level as today when GDP gets multiplied by 10 .
- Make the rural India the centre of gravity of wealth-creation and job-creation

In this background, let us try to analyse a scenario on impact of AI on jobs:

AI will kill a considerable number of jobs of today in the organized sector (industrial and commercial activities) unless there is substantial expansion of activities in future. Adoption of AI could kill around two thirds of the present jobs in the organized sector (public and private enterprises) now, i.e. around 21 million jobs. The job-losses in Government service could be around 14 million. This transition will have to be managed very carefully. It India achieves a tenfold increase in GDP in 20 years, it may be possible to keep the number of employees the same as today (evidently with different skills). The Government services should be streamlined in such a way that around 8 million employees should be able to render the required services presently being rendered to the citizens. One has to acknowledge the fact that bulk of Government services are being enjoyed by urban citizens. Rural India is

very badly served by Government services particularly in education, healthcare and administrative services. It will be reasonable to assume that all the six hundred thousand villages should be served by an average of 20 Government servants each. This will work out to 12 million jobs created and paid by local bodies in the villages from taxes collected from wealth generated in the villages.

The political leadership and the bureaucratic leadership will have to accept the simple fact that the responsibility of the Governmentis to create the ambience for wealth-creation and job-creation by entrepreneurs. This also would mean that the Government will not create unwanted jobs simply for the purpose of providing employment. Our educational system should become completely job -oriented and should provide adequate skills for the type of jobs needed in the country. The purpose of university education should not be for manufacturing graduates with degrees/diplomas with no value in the job market. Sadly, that is the case now. In a recent request for applications for 2000 last grade jobs (sweepers) by the Government of Uttar Pradesh, there were around 300,000 applicants, mostly from graduates and some of them post graduates and even candidates with doctorates !!!. We have a problem and we have to recognize the existence of the problem if we are desirous of finding solutions.

In short, the impact of AI will cause a net reduction of jobs in the organized sector even in the best case scenario of job creation both in industrial/commercial activities and Government services. How do we transform Indian villages with the help of AI?

1. Creating wealth and jobs in the rural India in the Agriculture sector with the adoption of AI will be one of the biggest challenges facing in India . The areas where AI could make substantial contributions are:
2. Weather prediction and farming advice based on data-based weather-analysis
3. Precision agriculture : choice of crops including crop rotation , identification of optimal mix of products , plant growth optimization , field management , application of genetics algorithms ,data based yield prediction ,geographical identification
4. Intelligent environment control (soil health evaluation and remedies, identification of field-characteristics, automated irrigation systems , crop health monitoring , protection of delicate items like fruits from change in environment , GPS based system for identifying and removing weeds, disease -detection and optimum use of pesticides/ herbicides, optimum use of fertilizers etc)
5. Driverless intelligent tractors , use of drones, proximity sensing and remote

sensing devices , image based insight generation (3 D mapping and imaging spectroscopy) ,

6. Scientific live stock farming , health monitoring , productivity improvement , traceability and geographical identification .
7. Market analysis, direct market reach through e platforms , customer behavioural change , market influence (natural evolution and through promotion)
8. Optimum logistics- support (storage and transport) for preventing damage to farm products
9. Scientific management of fishing and fish-processing
10. Forestry management for increasing green cover
11. Extending areas for cultivation of commercial crops (cash crops and plantation crops) through data based analysis on soil condition , weather condition, market conditions.

3.15 Conclusions

1. AI will affect all the domains of activities and will kill jobs in a significant manner in almost all the known industrial and service activities. The enormous power of AI should be made use of for creating new activities in physical wealth-creation both in industrial and agricultural sector.
2. Fairness is an important issue to be dealt with in the adoption of AI . Extreme care will have to be taken while creating the algorithms for avoiding bias. This will also mean that certain adaptation will have to be made for adapting to the sensibilities countries/regions
3. Any national economy will have to depend primarily on physical wealth-creation and associated job-creations so as to give purchasing power to the people involved in such activities . Expansion of service activities will have be centered around the wealth-creation activities . Undue emphasis on services in the national GDP based on financial activities particularly on speculative activities is likely to lead to the collapse of the national economies. AI should be capable of forecasting such probable future collapse of the economy so as to trigger the security system for preventing such collapse .
4. Skill -development and skill -migration will have to be a continuous process and an individual may be called upon to undertake skill-migration three or four

times during his professional career of around 40 years . A new equilibrium will have to be developed between work and leisure so that individuals will work less number of hours with increased physical output and higher wages so that leisure activities will create more service-activities .

5. An emerging economy like India will have to use AI for creating new activities in the rural areas so that the centre of gravity of wealth-creation will shift to the rural India with associated increase in service-activities like education , health care and construction etc. The vast majority of jobs in India is under unorganized sector and it will be necessary to bring such jobs under organized sector through effective use of AI in agriculture (including forestry and fishing)
6. AI is the direct consequence of a technology-revolution. No one will be able to stop the adoption of AI in a big way in the wealth-creation process and delivery of services. The impact of this transformation will be considerable on the society. Nations will have to get used to a new way of doing things to take advantage of AI abandoning the attempts to maintain status quo .

Chapter 4

Terraforming Applied To Agriculture

People working on Space Resources have developed many concepts related to Terraforming, which is taken to mean, creating Earth-like conditions beyond Earth using technology. For instance, Mars has about 1/3 the gravity of Earth, about half the sunlight intensity that is experienced on Earth, an atmosphere that should stop most of the UV radiation from the Sun, carbon dioxide, some water ice, and soil with minerals. Enclosed spaces can be created either above or below the surface, inside which livable conditions are achieved. These technologies are seen as far-term solutions if Humanity decides to serious expand, or move away from, Earth.

These technical solutions are similar to those that could transform deserts and frozen areas of Earth. A least we are assured of enough oxygen, nitrogen, atmospheric pressure, gravity and radiation shielding. The main requirements may be water and temperature control, which could be achieved inside enclosures that (for Earth's surface) could be as simple as a transparent, slightly inflated, tent. Given water, hydroponic agriculture (very little soil needed) has been shown to work for many plant species. Developers have advanced these technologies to transform significant areas of the Sahara and other large deserts (whee sunshine is plentiful). The northern tundra poses greater challenges because energy is needed to heat the space.

Vertical farming is another technology that is catching on: this minimizes the land footprint and water needed, but requires intense application of capital and technology. Artificial lighting may prove to be viable in this application, as LED (light emitting diode) technology advances.

We are for now discussing these in the Working Group 2 report where it is essential to discussing the potential of reforestation and making farmers less vulnerable to weather and pests, with alternatives available.

Chapter 5

Robotics

Robotic manufacturing has long-since arrived in the manufacturing of automobiles, electronic components and a host of other products. Consistency, reliability and speed all exceed those of the humans who used to do these tasks before. The investment in development and deployment is seen to be well worth it.

With the revival of Artificial Intelligence technologies, the scope for robotics is vastly greater. Wherever repetitive tasks are identified, robots can be adapted to the application, replacing the human worker. Thus there is a stark prospect that millions of subsistence jobs will disappear in India. The repetitive tasks can become increasingly sophisticated, very quickly: witness the use of robotics in manufacturing.

5.1 The 'IronMan Suit'

An example is the so-called IronMan Suit. This has been developed in the form of a wearable exoskeleton. A human operator climbs into it, and uses its actuators as extensions of his/her own limbs. The result is that the human worker becomes vastly more powerful, strong and has far more endurance. The robot gains the brain of the human worker, as well as the adaptability to a vast variety of tasks. Originally developed for military applications, this technology has now entered the manufacturing floor in South Korea, and soon may break into all other nations' manufacturing.

The next step should be obvious. The actions of the human will be recorded by the robot, generating detailed standard operating procedures for numerous tasks. Once

these are in hand, the human is not really needed inside the exoskeleton.

As costs come down, the IronMan Suit is ideal to replace the farm worker, the artisan, and weaver. Thus India must face the looming prospect that so-called 'casual' or 'unorganized sector' jobs will be lost to robots. What will replace these jobs? The challenge is not to find jobs to soak up the workforce: it is to prepare the workforce for the new higher-value jobs that will be available.

5.2 Exoskeleton competition for grain-field workers

The exoskeleton model can be visualized as enabling an inexpensive version that can do planting, weeding and harvesting in fields through seasonal changes from waterlogged to dry to mud-caked. This will at once encourage small farmers by providing reliable labor, and compete with existing subsistence laborer families. The latter problem could be addressed proactively through alternative farming jobs, such as in vertical farming or skills training for other trades.

The above examples convey the need for careful, proactive planning to introduce technology while respecting the local residents.

Chapter 6

Reversing Atmospheric Heat Retention

Around the world there appears to be a growing sense of hopelessness, punctuated by denial, about rising temperatures. The Inter-governmental panel on climate change (IPCC) estimates that Earth's atmosphere is retaining heat at the rate of between 2.4 and 2.92 Watts per square meter of Earth's surface. So-called Negative Emission Technologies are now agreed to be essential [3], beyond merely reducing emissions. Measures to sequester Carbon, and to reduce emissions, are moving far too slowly to have any perceptible effect on this rate in time to head off the Tipping Point beyond which temperature rise will build on itself. Some drastic measures have been suggested, such as injecting very large amounts of aerosols that create droplets of sulphuric acid in the atmosphere. These droplet clouds are said to reflect solar radiation and keep it from reaching the lower atmosphere. Wigginton [4] cites the dangers of so-called Geo Engineering technologies that take risks with Nature.

Can anything be done, that does not adversely affect the environment in other ways? We believe that the answer is yes. One example is the Glitter Belt concept discussed below. But first the most obvious method: reforestation.

6.0.1 Comparison with Reforestation

As discussed in the WG2 report, unmanaged forest(North American) sequesters roughly 100 metric tons of CO2, containing 27 tons of actual carbon. The low number is because rotting vegetation in unmanaged forests releases methane. Thus

reforestation using orchards where the underbrush is regularly cleared to be converted in reactors, could improve this figure where farmland is converted to trees.

Cumulative emissions since about 1870 add up to 230 Gigatons of Carbon, with half of that since 1990. To absorb all of that would require some 1.7 billion hectares. Growth will take at least 10 years since planting, so that full deployment cannot occur in less than 30 years even if there were immediate worldwide agreement to do this. Shankman [5] argues that pulling CO2 from the air by various means is 'no silver bullet', being extremely difficult to implement.

6.0.2 The Glitter Belt

Sequestration of carbon works because carbon compounds such as methane and CO2 absorb and retain more heat than air. An alternative is to stop and reflect the radiation before it ever gets scattered and absorbed in the atmosphere. Conventional thinking has been to do this either from outer Space, or from the ground. Ground reflectors will catch about 70% of the incoming radiation. Another 30% of the reflected radiation will be absorbed as well, so that 50% of the incoming radiation is absorbed, most of it in the critical lower atmosphere.

Reflection in Space has been considered by various authors [**?**, 6]. It requires that the reflectors be sent into orbit, which requires imparting at least 28 million Joules per kilogram of reflector. The prospect of millions of fast-moving reflectors in orbit is prohibitive, considering collision risks. Pushing the reflectors deeper into Space, requires larger areas of reflectors for the same effectiveness. Space-based reflectors once launched, will be difficult and expensive to de-orbit or re-position.

The Glitter Belt concept is to place ultralight reflectors at the edge of the stratosphere, at roughly 33 kilometers altitude. These will use either aerostatic lift (hydrogen balloons supporting reflector sheets), or aerodynamic lift, using solar-powered propulsion. As discussed in 2 papers from Komerath's group [7, 8], these solutions can be applied in a staged manner with ongoing testing and simulation to detect atmospheric changes. Being always under control, the reflector sheet vehicles can be guided to stay above controlled airspace, avoid areas of strong weather features that cause high atmosphere winds, and to fly in formation over especially crucial areas such as the Arctic and Antarctic coastlines. Swarms of reflectors would be set to follow the Summer Sun, which requires only a continuous drift speed on the order of 1 m/second.

A variation on this system is the Polar Necklace, a ring of reflectors supported by

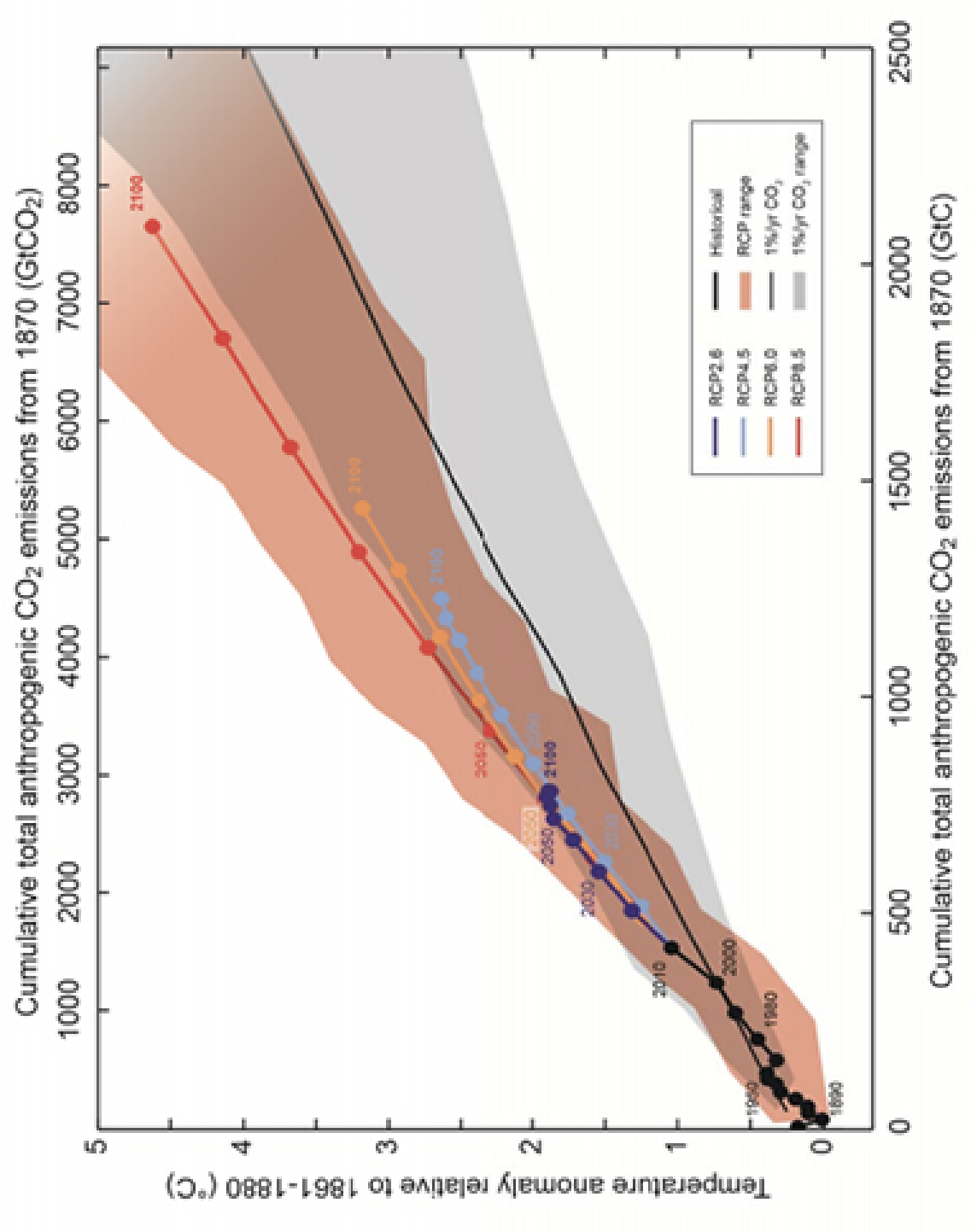


Figure. 6.1: Cumulative anthropogenic carbon dioxide emissions (atmosphere, land and sea) since 1870. Courtesy, IPCC

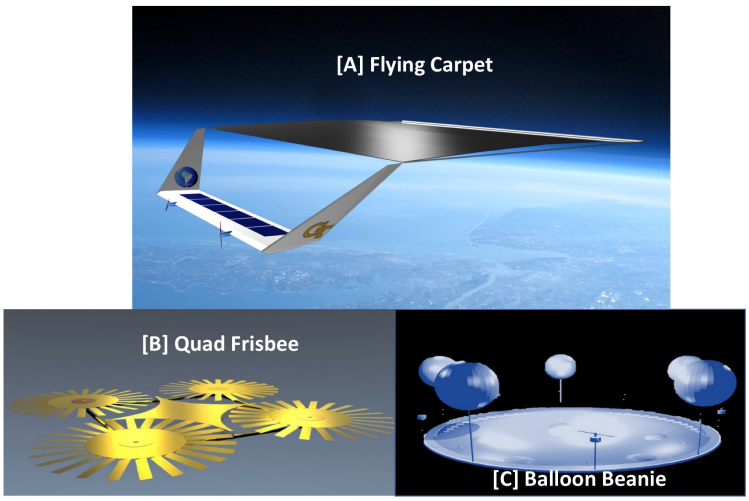


Figure. 6.2: 3 concepts for the Glitter Belt elements. (A) Flying Carpet: Aerodynamically supported reflector. (B)Quad Frisbee: Centrifugally stretched aerodynamic reflector. (C) Balloon Beanie: Aerostatically supported reflector

balloons over the coastline of Antarctica. Komerath's group is studying whether such a system can reduce solar intensity striking the band of Sea Ice adjacent to the coast, enough to alter the balance between summer melting and winter freezing. If this works, the sea ice band can be thickened enough to stabilize it against cracking by wave motion. In turn, the waves can be kept from reaching under the edge of the glacier and causing large chunks to break. Should this work, sea level rise can be continuously reversed. In any event, the reflection of sunlight by the reflector sheets is guaranteed by laws of physics and over time, at a size large enough to more than cancel anthropogenic heat emission, it should cause a reduction in the amount of retained heating.

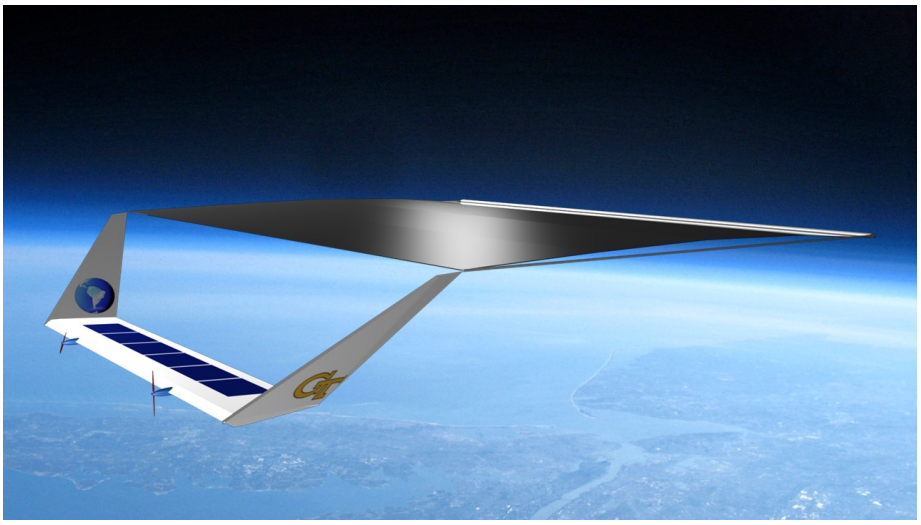


Figure. 6.3: Swarms of such Flying Leaf aerodynamically supported sheets would fly above 33 km where scattering is nearly absent.

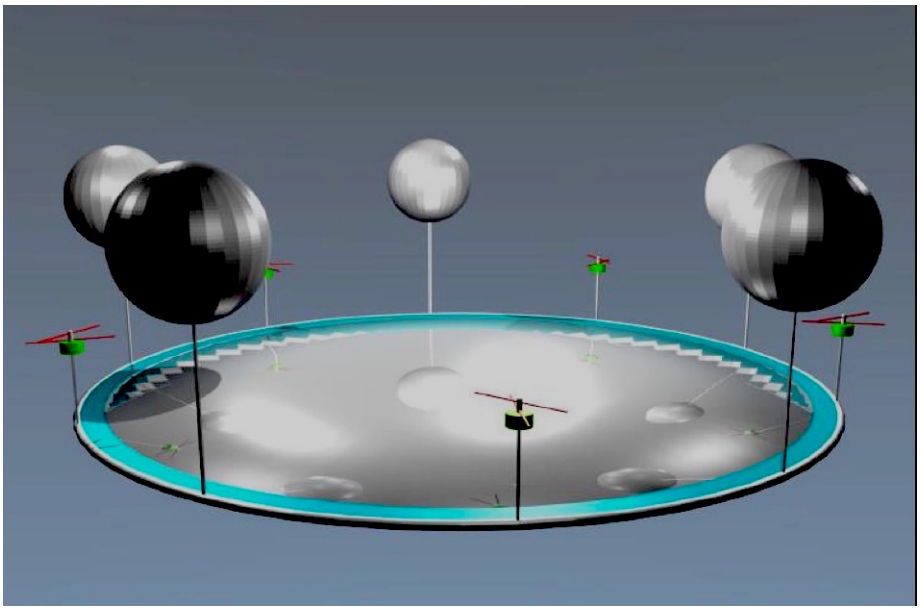


Figure. 6.4: The Balloon Beanie concept for aerostatically supported reflectors to be used in the Polar Necklace around Antarctica to reverse sea level rise.

Chapter 7

Reversing Sea Level Rise

Around the world, sea levels are rising. This is attributed to the melting of the Arctic and Antarctic Ice Caps. The ice shelves at the edge of Antarctica are breaking off. Ice accumulations over the Greenland and Antarctic landmasses are decreasing.

Thus the way to decrease sea level is to reverse the melting at the ice caps. We believe that at least one way exists. In principle, reducing summer sunshine over the ice caps will decrease summer melting so that winter snow and ice accumulation exceeds it. In time, more and more water will accumulate over the ice caps. In practice, this will take an enormous number of reflectors.

Before this is undertaken, it is important to focus on the immediate problem. Evidence from Antactica suggests that the problem is that oscillatory wave motion is reaching the ice shelf overhanging the coast. As this sheet becomes thinner, the wave motion is able to break off pieces from the edge - allowing the wave motion to reach ever more into the ice sheet. Researchers believe that one key to this is the sea ice sheet that surrounds the Antarctic coast, to a distance of a few kilometers. Seawater freezes at a much lower temperature than freshwater. In winter the surface layer of seawater does freeze. Freshwater snow falls on top of this sea ice, making it thicker. In summer, the top layer melts off, more these days because of higher average temperature.

Thus if the sea ice region (the last 1 or 2 kilometers immediately adjacent to the coastline) were shadowed partially in summer, the process could be reversed over a few years' time. The Arctic icecap edge is less well-defined, and sea-ice may be spread over a larger area, so this strategy may be more difficult to implement there.

We suggest that the Polar Necklace version of our Glitter Belt concept could start addressing this problem swiftly, using lighter-than-air hydrogen balloons supporting

large, ultrathin reflective sheets, held perpendicular to the slanted solar radiation at high altitude during the Antarctic summer. For now, experiments and analyses are using the Balloon Beanie version of the vehicle systems. This technology is also very suitable for systematic development in India.

Chapter 8

Beating The Flood-Drought Curse

This is discussed more in Working Group 2. Here we will touch upon a few technical points. India gets rain from two monsoons. The Southwest Monsoon is a widespread phenomenon with winds starting in the Indian Ocean in summer and bringing heavy and prolonged rains to much of India during June to August. The east coast, particularly the southeast coast, is left relatively dry, because the Western Ghats block much of the rain clouds below about 5000 feet.

The Himalayas stop much of the Southwest Monsoon, building some pressure that returns moist air from the northeast down towards the south. This is called the Northeast monsoon, and it brings heavy rain to the east coast in November-December while leaving southwest India dry. Chances of a high-intensity cyclonic storm are highest in the Bay of Bengal during the November-December months, although several killer storms have occurred earlier in the year, particularly in Odisha, on the Bay of Bengal. In 2019 there was a Category 5 equivalent cyclone that struck heavily-populated Odisha, but thanks to space-based weather prediction and communications technology, with over a million people evacuated from the precise area of landfall, there were almost no deaths.

However every year, parts of India experience severe flooding - and other areas, or even the same ones, experience severe droughts. Both destroy crops and cause misery.

The solution is evident to most people: a network of canals and dams that connects all the rivers, balancing their flows to counter both the floods and the droughts.

Implementing this has remained a dream for the most part, despite an entire National Department devoted to the planning of the river interlinking grid.

Power

Chapter 9

Hydrogen Aviation

A modern airliner used for intercontinental flights may have a mass of around 500,000 kilograms. Of this, roughly 40 percent is fuel. Most of the mass of fuel is due to carbon. Since the molecular weight of carbon is only 12, whereas oxygen, O2 is 32, one kilogram of carbon generates 44/12 or 3.67 kilograms of carbon dioxide. Thus, in rough numbers, that airliner dumps 700,000 kilograms, or 700 metric tons of CO2 into the upper atmosphere. Flying 2 trips per day, that adds up to 1400 tons daily, for at least 250 days in a year. A typical large airline operates dozens of such airliners.

Thus it was a big decision by the International Air Transport Association (IATA) that they would bring the airline industry's total carbon footprint down to the same level as it was in 1990. In 1990 the world was a very different place. Travel to and from Southern Africa and Rhodesia was banned by most nations. Overflight of the Soviet Union and the People's Republic of China was not common. The phenomenon of Globalization was still very young. So total air traffic in 1990 was perhaps only 1/3 of what it is today. How are the airlines to achieve such a drastic reduction? They all claim major steps in weight reduction, waste reduction etc, but these add up to a minute fraction. There is some tentative effort to use bio-fuels for cargo flights, and biofuels are argued to be carbon-neutral. Burning bio-fuel still dumps CO2 into the sensitive edge of the troposphere where it absorbs heat and passes it to the weather systems of the troposphere, retaining heat in the atmosphere.

The difference comes from increased ticket prices, used to fund Green Projects that earn Carbon Credits. This has to be kept up every year!

The permanent solution to the airline industry's GHG emissions is to switch to hydrogen fuel. Hydrogen is unlimited in quantity, and ultimately, it is a great leveler:

it is very hard to imagine hydrogen supplies being controlled by any cartel, and its price manipulated. The trouble to-date has been that most industrial-scale generation of hydrogen comes as a by-product during the refining of petroleum, so it is sold by the same entities who control petroleum. An additional source is from certain types of nuclear power plants, but that has not been explored much.

Hydrogen is also hard to transport, since its density is so low. Liquid hydrogen, for instance has a specific gravity of 0.07, compared to 0.8 for petroleum fuels. Liquid hydrogen must be kept at near 6 degrees Kelvin, a task that requires enormous energy input. Hydrogen is also highly corrosive, and hence cannot be transported through the pipelines now used for petroleum. For these reasons, it is hard to visualize hydrogen catching on as a widespread fuel.

Unless it can be generated inexpensively in rural areas.

We now see that the advent of inexpensive and efficient, high-temperature electrolysis driven by intensified solar energy, is a game-changer. As hydrogen storage becomes easy and prevalent in rural areas, transportation will switch increasingly to hydrogen, and prices will come down. Thus the fuel cost for hydrogen-fuelled airliners will drop significantly below today's fuel costs.

We now turn to the interesting area of aircraft design, to see the nonlinear advantages of switching to hydrogen, for the particular case of supersonic intercontinental airliners. Forbes and Komerath showed that with hydrogen fuel, a Mach 1.7 airliner could offer seating as spacious and comfortable as today's Business Class, at ticket prices no higher than today's economy class full fare. The basic reason is easy to see. Consider that airliner mentioned at the start of this chapter. Now consider that hydrogen delivers 3,8 to 4 times as much energy per unit mass as petroleum jet fuel. So the fuel mass goes down by a factor of 4. To carry the same number of passengers the same distance, the mass of fuel needed is thus much smaller. The airplane to carry these passengers also becomes much lighter in structural mass so the gains are nonlinear.

In our analysis of vehicle design for a supersonic point-to-point airliner carrying 250 passengers and a reasonable cargo load (comparable to a Boeing 787) the following conclusions were reached:

1. The initial mission was a point-to-point of around 8000 kilometers, with a cruise Mach number of 1.7 which enabled roughly a 40% reduction in total gate-to-gate time.
2. Because of the heat release per unit mass of hydrogen, the payload fraction can be increased to near 30 percent, versus 10 -11 percent for hydrocarbon-fueled

(HCF) supersonic airliners.

3. Because of the larger volume needed for hydrogen, supersonic wave drag increases, so that the drag coefficient is as much as 50% higher than what can be achieved with HCF. However, the total drag is much lower because of the high payload fraction (smaller, lighter airplane overall for the same payload).
4. These results were encouraging enough that a full 16,000 km range mission was considered. For this mission profile, the uncertainty in drag estimation proved to be too high to claim assurance of success.
5. The higher wave drag due to volume poses interesting questions on the best configuration for such an airliner: deviations from the standard needle-nose thin tube design may be in order. Blended wing-body and perhaps even multiple-fuselage designs may offer advantages.
6. The issue of liquid hydrogen boil-off on the ground, and the risks of refueling, suggest variations where the fuel tank is wheeled in to join the rest of the aircraft configuration only just prior to takeoff, and removed to an enclosure immediately upon reaching the gate after landing. Again this suggests very different configurations.
7. With composite airframes, deviations can be envisaged, from the circular cross-section driven by thin-shell metal properties.

We expect that supersonic airliners (not as cramped as the Concorde, but spacious airliners carrying 250 passengers in business-class comfort) will be the first to use hydrogen. This is for two reasons. Firstly, there will be relatively fewer airports that can operate supersonic flight routes in order to avoid overland supersonic flight. So the fuel infrastructure need be set up only at a relatively few airports. Secondly, hydrogen will be constantly lost due to evaporation. If this happens due to waits on the ground, it will cost much more. Supersonic flights on the other hand will get priority for ground handling.

Chapter 10

Electric and Hybrid Vehicles

Professor Ashok Jhunjhunwala speaks at this conference about Electric Vehicles. We will hold our discussion until after that.

10.1 Ironman Suits and Telepresence

The IEEE Spectrum (North American edition, January 2019, p. 27) presented an article titled 'Ironman suits are coming to factory floors'. An Ironman Suit is a full-body mechanical exoskeleton that is worn by a worker. Robotic actuators in the exoskeleton amplify inputs from the worker's hands and legs, allowing the human worker to perform tasks that are far beyond human strength and endurance. The need for high-precision guidance and control, as well artificial intelligence, are alleviated or eliminated because those are performed by the human. Prototypes have been developed for the US military. For instance a 2010 prototype enabled the wearer to punch through wooden boards, earning the Iron Man suit name. The technology has applications in construction, mining and industrial operations. From an Indian point of view, this equalizes what can be done by workers in countries where average human size and strength may vary significantly. Heavy power tools can be operated by workers who would normally have trouble lifting them for extended periods. The technology may have applications also in emergency/rescue operations in locations where vehicle access may be poor.

Extending this, it may be noted that the human need not be inside the exoskeleton: s(he) may be located a continent away! The IronMan brings a high-power/ high-strength aspect to a technology that is already being used for robotic or telepresence-assisted surgery. Already today in such applications as laser surgery for cataracts of the eye, the entire operation is programmed and made specific to the patient ahead of the surgery, so that at the time of actual surgery the main task is to position the patient's eye properly, with appropriate anasethesia and ability to deal with surprises.

Chapter 11

Survey

Bibliography

[1] National strategy for artificial intelligence - discussion-paper, June 2019.

[2] A prosthetic voice decodes what the brain intends to say, April 24 2019.

[3] EASAC Secretariat. Negative emission technologies: What role in meeting paris agreement targets? Policy Report 35 ISBN 978-3-8047-3841-6, European Academies Science Advisory council, February 2018.

[4] D. Wigington. Geoengineering, a clear and present danger, December 2014.

[5] Sabrina Shankman. We can pull co2 from air, but it's no silver bullet for climate change, scientists warn, February 2018.

[6] Robert Kunzig. A sunshade for planet earth. Scientific American, 299(5):46–55, 2008.

[7] Narayanan Komerath, Shravan Hariharan, Dhwanil Shukla, Sahaj Patel, Vishnu Rajendran, and Emily Hale. The flying carpet: Aerodynamic high-altitude solar reflector design study. Technical report, SAE Technical Paper, 2017.

[8] Narayanan Komerath. The glitter belt. US Patent Pending, September 2017.