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Space Abundance for Humankind's Needs: A Proposal for US Leadership

Recursive Distinctioning: The 2016 Conference

KEPLER SPACE INSTITUTE

DEDICATION

By the Kepler Space Institute Board of Directors

We dedicate this Fall 2016 issue of the *Journal of Space Philosophy* to the scholars, researchers, authors, and students who dedicate their talents to improving humankind's future.

The previously published issues of the *Journal of Space Philosophy* have captured a large spectrum of examples, including this one. Your search of the internet for *futures, forecasting*, or *humanity* will expose a huge library of references. We would like to recognize just a few currently getting attention from the Kepler Space Institute:

1. The Millennium Project, Jerome C. Glenn, Founder & Director: CEO, The Millennium Project (www.millennium-project.org); Global Futures Intelligence System (www.millennium-project.org/millennium/GFIS.html); 2015-16 State of the Future (www.millennium-project.org/millennium/201516SOF.html).

2. The career publications of Yehezkel Dror, Professor Emeritus of Political Science and Wolfson Chair of Public Administration, The Hebrew University of Jerusalem; specifically, his latest book publication, *Avant-Garde Politician: Leaders for a New Epoch*.[1]

3. The work of professionals focusing on transitionalism (www.transitionalism.org). Transitionalism is a non-theistic spiritual worldview and social movement that frames individuals, society, and the environment within the question of the meaning of human existence as it relates to humanity's present and future in our striving to become more human. David J. Kelley, Artificial General Intelligence, Inc., and associates, have been conducting bi-monthly workshops in American cities with the goal of publishing the *Extreme Futures and Technology Forecasting Journal*. See the article in this issue by Dr. Bob Krone and Salena-Gregory Krone on their participation in the most current workshop in San Francisco, October 22, 2016, title: *Extreme Futures Technology and Forecasting*.

[1] (Washington, DC: Westphalia Press, 2014).

Preface

By Bob Krone and Gordon Arthur

We wish to advise readers that this issue of the *Journal of Space Philosophy* completes five years of its publication for the Global Space Community. We acknowledge the excellent continuous professional work of Kepler Space Institute (KSI) officers and staff, and the Journal's Board of Editors (see the last article in every issue) since 2012, for the creation of this valuable resource reference. We intend to continue its publication in perpetuity.

It will be useful to review for readers the long-term vision of KSI and the major policies for article publication that have not changed through those five years.

KSI's Long-Term Vision

Our umbrella and long-term vision is simple in statement, but precedent breaking for humanity. *We believe that Space offers humanity the potential for historic achievement of peace insuring survival*. The first issue of this journal, Fall 2012, published the KSI philosophy. Abbreviated, the aim is *reverence for life within ethical civilizations implemented by the Policy Sciences*. Although never achieved, and extremely complex, we believe that humanity can achieve this vision in Space where there is no history of human conflict or war. As that vision successfully evolves, it will be a model for replication on Earth.

This journal is dedicated to documenting Space research, education, presentations, conferences, and publications leading to that vision. It is designed to be a scholarly, universal reference for Space knowledge. Authors hold the copyright for their publications. The KSI Board of Directors does not take positions on developing or controversial Space concepts, theories, or programs. Authors are responsible for the positions, arguments, and forecasting in their articles. We published our KSI space philosophy in the first issue, Fall 2012. Over the past five years, we have found no reason to change those fundamentals, which are fundamental to the long-term vision. Many of the articles published since 2012 provide sub-system details of that philosophy.

The original cover for this Issue was designed by Haroon B. Oqab, Professional Engineer and National Technical Program Manager of the Canadian Space Society. He is a valuable member of Kepler Space Institute.

Bob Krone, PhD, Editor-in-Chief
Gordon Arthur, PhD, Associate Editor

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Access to the Journal of Space Philosophy and free downloading of its articles is available at www.keplerspaceinstitute.com/jsp. Anyone on Earth or in Space may submit an article or Letter to the Editor to BobKrone@aol.com.

PRESS RELEASE

December 13, 2016

By Gordon Arthur

Kepler Space Institute has released the latest edition of the *Journal of Space Philosophy*. This issue is dedicated to all those who use their talents in the cause of improving humankind's future. It also completes the fifth year of publication of the journal. All the issues and all the articles are available from our recently relaunched website, keplerspaceinstitute.com.

The Preface in this issue reviews the KSI Board's visions, goals and policies for Journal publication. We continue our publication on Recursive Distinctioning, specifically with articles on the September 2016 Convention in Clayton, MO and an article by Martin Hay article on Recursive Distinctioning, Tetracoding and the Symmetry Properties of Chiral Tetrahedral Molecules.

We include two papers on Space Programs: one by distinguished Space scientists, Paul Werbos and Edward McCullough, and another by Space Virtual Systems Founder, Kim Peart. Jay Rollins provides a paper on Tailoring Airlines for Space Operations. Holly Melear offers a paper on New Worlds of Education for Space.

There are reports on important conventions: by Naté Sushereba on IAC Guadalajara, and by Bob Krone and Selena Gregory-Krone on ISDC Puerto Rico and the Extreme Futures and Technology Forecasting convention in San Francisco.

A last-minute addition to this issue is the Bob Krone and Leo Thorsness article, "Space Abundance for Humankind's Needs." It is a proposal to US leadership for a 21st-century project which would use the Marshall Plan after WWII as a precedent, but have the goal of solving resource needs for all of humanity on Earth and/or as humans settle in Space. Naté Sushereba, Haroon Oqab, Sherry Bell, and Bob Krone will also present this case to the ISDC 2017 in St Louis in May

This issue illustrates KSI's continuing goal for the journal to document, and make available to readers, all aspects of the emerging Space Epoch

NOTES FROM THE CHAIR

By Gordon Holder, VADM, US Navy (Ret.), Kepler Space Institute Chairman of the Board

Reflecting on our past five years of publishing this *Journal of Space Philosophy* (see Bob Krone and Gordon Arthur's Preface) gives the Board of Directors both satisfaction and confidence for important future contributions that Kepler Space Institute (KSI) can make.

Note the dedication of this issue to the scholars, researchers, authors, and students who use their talents to improve humankind's future. KSI leaders has devoted their time and resources to KSI over eight years of volunteer work since Dr. Richard Kirby, our first president, announced its formation on January 1, 2009, for one fundamental reason. We believe that the philosophy, goals, products, research, and education we have sponsored, and will sponsor, are critically important for the progress – and even survival – of humanity on Earth and as humans expand their presence into the Solar System and beyond.

Also, note in this issue the report of the September 2016 Conference on Recursive Distinctioning (RD), which was the sole focus of our Special Science Issue published in Spring 2016. KSI will continue to support the documentation of knowledge and research into RD, which Dr. Joel Isaacson, who discovered this natural cosmic intelligence phenomenon in 1964, has described as being a fundamental part of perception, cognition and intelligence and suggested that "it is a law of nature, perhaps on a par with gravity" (e-mail to Bob Krone, April 20,2011).

Readers will also note in this issue the wide diversity of subjects addressing *Resurrecting the US Space Program*, *Recursive Distinctioning*, *Building in Space with 3D Printers*, *Future Crew Culture for Space Flights*, *New Worlds of Education*, and the *Dawn of a Space Revolution*.

In our view, Space exploration, Space development, and human settlement offers people of all cultures, nationalities, ages, politics, and races the most exciting breakthrough thinking – and hoping – possible today.

Letters to the Editor

We invite readers of the *Journal of Space Philosophy* to send us letters referencing any past publication, to suggest subjects for future publication, or to submit information from anywhere in the Global Space Community. ***Bob Krone and Gordon Arthur***.

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From Dr. Kim Kee Young, December 9, 2015

Dear Editor,

I really appreciate your mind-wrenching vision and philosophy of Space and Earth, which Salena Gregory has documented well. I am much clearer now about what you seek from the study of Space from a philosophical perspective and the academic value of the *Journal of Space Philosophy*. Your venture is so valuable, and in time may lead to a breakthrough, with a brand new concept of ethical civilization for humankind on earth to influence future human history.

Kee Young Kim, PhD

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From Kim Peart, September 11, 2016

Dear Editor,

"What do you want to create?" is an excellent question presented in the story, "How Do You Train for a Job That Doesn't Exist Yet?"[1]

Born in 1952 and raised in Howrah, I really did get to experience the best that civilisation has to offer, from making sand castles as a kid, learning solid life and bush skills in Scouts,

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[1] Alexandra Carlton, "How Do You Train for a Job That Doesn't Exist Yet?" *The Mercury*, September 11, 2016, www.themercury.com.au/news/training-for-jobs-that-dont-yet-exist/news-story/1b8abbd9bb4d03fe49caa79bfb1b6b6a

finding opportunities with art, and discovering those very advanced minds at Princeton working out how to build cities in space.

Stung by the space bug in 1976, I waited for the future, but the future forgot to arrive, as automation delivered a growth economy that relies on around 5% unemployment to keep the wheels of growth turning, and we now gaze, mesmerised, into the robot revolution that is set to eliminate half of current paid work over the next couple of decades.

Why do we tolerate under-employment, unemployment, poverty, and homelessness in this nation of the once upon a time fair go? We have every opportunity under the sun, but we choose to deliver nightmare life to a large number of Australian citizens. We have become a mean and silly society dizzy on money. We have allowed politicians to rip us off, so we can blame the poor for their poverty, as we siphon the wealth of the nation from the bottom to the top gamblers, to send away on the winds of the global economy, instead of investing in the future of this nation.

We can do better, if we decide to transcend greed and invest in a sustainable industrial presence beyond Earth. We can create a stellar economy that will give us access to the level of wealth that will allow us to create a life opportunity for all, and deliver a healthy and creative life for all Earth's children.

That is the way to get peace on Earth, and we can do it, if we give a damn about a fair go future.

We have to create that future, and each of us can help do it. Go into Second Life and send an instant message to my avatar there, Starfarer, and I will show you our virtual space program, where we connect globally to create a new future on Earth and in space. If everyone joined us, anything would be possible.

Or write to me in Ross. We are getting our hands dirty there too, creating a better future with art, land, technology and imagineering.

Yours sincerely,

Kim Peart

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From Mike Snead, November 16, 2016

Dear Editor,

At every presidential election, many wish, as I once did, for a candidate that will "save" NASA and America's space program. As the last 40 years have shown, the real American political system does not work that way. Opening new frontiers has always been very expensive. To transform America from an occasional human space exploring nation into a true commercial human spacefaring nation requires profits from substantial new markets and customers. Just wanting to be a spacefaring nation is not enough.

The election of Donald Trump to be America's next president holds the best prospect in recent decades for a president to be open to sound proposals that will transform America into a true commercial human spacefaring nation. The opportunity that now presents itself is very similar to that of commercial aviation at the end of World War II. Under post-WWII military contracts, the aviation industry developed the key enabling technologies for jet aviation. As the technology maturity of jet aviation improved in the early 1950s, this led to the rapid creation of the American commercial jet airline industry by the late 1950s. Only jet aviation provided the practical means to span the continental United States and the world's oceans in hours instead of days. Jet aviation's travel time compression opened the entire world to commerce and affordable leisure travel.

The market opening opportunity that will drive America's transformation into a true commercial human spacefaring nation is the unavoidable transition from fossil fuels to space-based sustainable energy. A typical coal or nuclear power plant provides 1 gigawatt (GW) of baseload electrical power. By 2100, the 10 billion humans populating the world will need roughly 50,000 GW of continuous baseload electrical power to have a fossil-fuel-free standard of living comparable to Europe and Japan. There are no practical terrestrial renewable or nuclear energy options to provide 50,000 GW of baseload power. Only space-based sustainable energy, such as GEO space solar power, can do this.

Here are the key calculations. The current American wholesale price of electrical power is about $0.08 per kilowatt-hour (kWh).

> 50,000 GW = 50,000,000 megawatts (MW)
>
> 50,000,000 MW = 50,000,000,000 kilowatts (kW)
>
> 50,000,000,000 kW x 365 days/year x 24 hours/day = 438 trillion kWh/year
>
> 438 trillion kWh/year x $0.08/kWh = $35 trillion/year in revenue

To transition from fossil fuels by 2100 and provide the world with a middle-class standard of living, a space solar power industry with ANNUAL revenues of roughly $35 trillion will be needed by 2100. This is roughly twice the total current US gross domestic product. Of this total, roughly $2.8 trillion/year will come from providing the 4,000 GW needed by the United States in 2100 to replace fossil fuels.

President-elect Trump is looking for ways to achieve real, private sector economic growth over the long term. For America, the world's need for space-based sustainable energy is a long-term, market-opening opportunity ideal for exploiting America's aerospace industrial mastery. This is the gleaming American spacefaring future vision to "sell" to the new president – not human Mars missions.

Bottom line: Stop worrying about saving NASA and focus on creating a great American commercial human spacefaring future for President-elect Trump to champion. This opportunity is now knocking quite loudly!

Mike Snead
President
Spacefaring Institute™
http://spacefaringinstitute.com

Space Abundance for Humankind's Needs: A Proposal for US Leadership

By Bob Krone, PhD and Leo Thorsness

Proposed as *The Trump 21st-Century Plan* by: Bob Krone, PhD, President, Kepler Space Institute, Emeritus Professor of Systems Management, University of Southern California, Colonel, USAF (Ret.); Fellow Member, American Society for Quality; and Leo K. Thorsness, Colonel, USAF (Ret.), Former President, Medal of Honor Society; and Endorsed by The Board of Directors, Kepler Space Institute (www.keplerspaceinstitute.com).

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We are in a new century with a new US Administration with visions to inspire, improve and preserve all humanity.

The United States will lead Earth's International Community in a long-term vision of solving humankind's resource requirements. All the resources humans will ever need are waiting in Space. America has led in two massive successful models that were historic precedents in the 20th Century. First was its design of the Marshall Plan and Japan's post-WWII recovery. Second was avoiding World War III through the peaceful resolution of the Cold War. Science, technology, and brainpower have reached the point in the 21st Century where achieving universal peaceful human communities and Space settlements is no longer a dream.

The Law of Space Abundance, which states that Space has the resources to meet human needs, has been proven valid. Limited resources have always been the cause of human conflict and catastrophe. The major motives for those in society to terrorize or kill others will be removed. There will remain human pathologies that need additional brainpower to cure.

This plan has the vision to focus Earth's brainpower on accomplishing the means to satisfy humankind's needs for energy, water, food, housing, health care, the arts, and spiritual needs wherever humans live on Earth and wherever they settle in the Solar System and beyond.

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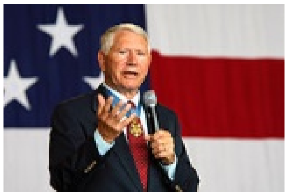
About the Authors:

Dr. Bob Krone is President of Kepler Space Institute (www.keplerspaceinstitute.com). He is an Emeritus Professor of Systems Management at the University of Southern California; has been the principal sponsor for PhD, DBA, and Master's Degree Program candidates for forty years; and is a USAF Colonel (Ret). BobKrone@aol.com.

Colonel Leo K. Thorsness, USAF (retired) had a distinguished career as a jet fighter pilot when he was selected in 1967 to be the commander of the F-105F Wild Weasel Squadron flying over North Vietnam. The Wild Weasels were tasked with attacking the North Vietnamese Air Defense system – the most sophisticated one since Allied airpower fought in World War II. He and his backseat Electronic Warfare Officer, Captain Harry Johnson, was shot down on his 93rd mission a week after flying a dramatic mission that earned him the Medal of Honor. They survived six and a half years in North Vietnamese prisons. See his Surviving Hell: A POW's Journey (New York: Encounter Books, 2008). In 2010 he was elected to be the President of the Medal of Honor Society. For his bio and the story of his Medal of Honor Mission go to en.wikipedia.org/wiki/Leo_K._Thorsness.



Resurrecting the US Space Program by Focusing on New Advanced Technology for Human Presence and Profit

By Paul J. Werbos and Edward D. McCullough

"Who needs humans in space?"
"Who needs humans on Earth?"
Humans, that's us.

Recommendations

For the last 10 to 20 years, civilian space policy has been driven by questions such as: "What should our next ten-year grand challenge be? Should we put flags and footprints on the moon again, this time leaving behind a few structures? Or should we try to get to Mars in ten years, perhaps by flybys or one-way trips? What about building a new big expendable rocket like the Saturn V, but more impressive and more expensive?"

We agree with those commentators[1] who say that there is an urgent need to restructure the entire mission. The United States needs to focus on more meaningful longer term goals, and to restructure the enterprise to achieve longer term goals more efficiently. In particular:

- We do not take a fixed position on what the NASA budget should be. In a decade of budget pressures and sequestration, we now see many activities at NASA that could be cut back without major loss to the nation as a whole, but we would prefer those changes to be made that would justify including NASA in the list of truly cutting-edge, innovative R&D agencies for which a 7% annual growth in real dollars would be appropriate, considering the impact of advanced R&D on productivity and economic growth.

- Instead of a 10-year core focus on moon, asteroids, cis-lunar space, or Mars, we recommend shifting the core focus to a longer term tangible goal: economic sustainability of permanent human settlement and expansion in space. This should be instituted as the permanent core mission of NASA until such time as it is fully achieved. Shorter term subgoals should be pursued in a more adaptive way, only as part of a rational strategy to reach the larger goal.

- At the present time, the most promising and urgent subgoals to reach that goal are the development of reusable launch vehicles which would reduce the unit cost of getting to low Earth orbit (LEO) to $500/kg or less,[2] and the development of space solar power (SSP) at a cost of

[1] Eric Sterner, ed., *America's Space Futures* (Raleigh, NC: Marshall Institute, 2013).
[2] IEEE USA, *Low Cost Access to Space*, www.ieeeusa.org/policy/positions/SpaceAccess0214.pdf.

10¢ per kwh of electricity delivered to the earth,[3] conditional on such launch costs.

- To transition to this new approach, NASA should immediately restructure the Space Launch System program to take more time to do it right, and to use it as a platform for saving and enhancing reentry technologies developed for both the space shuttle and earlier military programs such as TAV and RASV.

- We support the new trends towards competitive, market-based activities in space, which will be crucial to economic sustainability and independence in the long term. Market economics says very clearly that the proper role of the government is to support activities that are too risky or too far in the future for industry to handle on its own; therefore, throughout NASA, we recommend a radical shift away from low-risk, proven technology to the development of the most advanced technology, to aim for the long-term goal of doing things right.

- We also recommend reinvigorating the important noncore, leverage activities of NASA, in order to take advantage of capabilities unique to NASA to address exciting new opportunities in areas such as global Internet education, environmental and military defense, new directions in physics, and imaging the universe.

Guiding Principles: The Basis for the Recommendations

Decades ago, the historian Oswald Spengler[4] described how civilizations on a path to collapse often go through periods of nostalgia, when people try to relive their collective childhood in a way that blocks them from facing up to new challenges and seals their doom. There is reason to worry that the US space program is falling into that same kind of trap, due in part to the power of groups hoping to revive public excitement through ever more boring reruns of the Apollo program, aimed at planting flags and footprints on the moon or Mars for their own sake. But is this really what would excite the new generation the most, in any case? The Star Trek generation and the Neil de Grasse generation understand that space has great potential, but are wisely skeptical on the whole about the present directions at NASA. This position paper calls for a radical change in priorities, to focus more directly on the larger goal of economically sustainable human settlement of space, and to revive the true original spirit of Apollo.

The original Apollo program was a fantastic success, and we can learn a lot from its lessons. The period of Apollo coincided with the fastest growth in overall productivity in the US economy in the twentieth century, related to the great slate of high-risk advanced technology R&D that NASA initiated under President Kennedy. Kennedy said: "We go to the moon, not because it is easy, but because it is hard." The current

[3] Paul Werbos, "Reviewing Space Solar Power Policy, *Ad Astra* 26, no. 2 (2013), www.nss.org/adastra/volume26/ssppolicy.html; John C. Mankins, *The Case for Space Solar Power* (Houston: Virginia Edition, 2014).

[4] Oswald Spengler, *The Decline of the West* (Oxford: Oxford University Press, 1991).

emphasis on proven technology, old pathways, and things that are less demanding on the skills of the workforce reverses the one aspect of Apollo that we really need to revive. Above all, we need to go back to dedicating a larger portion of the NASA budget to more aggressive, high-risk, advanced technology, and building the infrastructure – both human and material – necessary to improve productivity in space enough to achieve economic sustainability and independence. This will be more difficult now than it would have been ten years ago, because of retirements and changes in corporate culture,[5] but there is a serious possibility of success, if we apply enough determination and foresight. If it is not done, risk is avoided by guaranteeing failure. The same applies to the two important subgoals of reducing access costs to LEO to $500/kg or less, and of deploying SSP to supply electricity to Earth at 10¢ per kwh – subgoals that could have an immense impact on the feasibility of the larger goal.

Many critics of space have asked: "Who needs humans in space at all?" Others have sometimes asked: "Who needs humans on Earth either?" Our support for human growth on Earth and in space is based on the fact that we *are* humans, and care about humans for their own sake, as a fundamental value. Certainly there are great risks in trying to improve productivity, markets, and infrastructure in space enough to create a growing human economy there[6] – but there are also risks of human extinction on the Earth itself. The challenge is to create a strategy to maximize the probability that we achieve the core goal here, facing up to all the many uncertainties, and regularly asking ourselves how to adapt that strategy, focusing on the larger goals themselves. This position paper gives a sketch of such a strategy.

The hopes for human economic development in space, and for larger benefits to Earth, do not rest on NASA alone. The DoD, other nations and the commercial private sector all have crucial roles to play, which are part of any optimal strategy for NASA. None of these other space programs are enough, on their present course, to bring us to the human settlement of space, without additional, catalytic efforts through NASA and Congress. New directions for collaboration and enhancing the activities of those partners is a crucial opportunity in making the hope of success ever more real.

Market economics says clearly that the government can have a proper role in this kind of venture, which some call "the moral equivalent of war." Success in the human settlement of space will require investment in technologies too high-risk, too long-term in payoff, and with benefits too hard to limit to just one company for normal market mechanisms. Government investment is justified only if it focuses on those aspects of what is needed, and on general-use infrastructure, and it continues to try to download as much as possible to the commercial market sector. A strong system of universities and small businesses, making use of high-quality, apolitical, competitive review systems, is also crucial, to enable success in this kind of high-risk R&D, and it also

[5] William S. Bainbridge, ed. *Leadership in Science and Technology: A Reference Handbook* (Thousand Oaks, CA: Sage, 2011).
[6] Walt W. Rostow, *The Stages of Economic Growth: A Non-Communist Manifesto* (Cambridge: Cambridge University Press, 1990).

needs some reinvigoration at this time in the United States.[7] When government spending tilts towards large, low-risk jobs programs, it strongly violates the basic principles of free market economics.

Proposed New Structure and Operation of NASA

High productivity in any organization (or research project) depends critically on having a very clear and ambitious long-term target, not only to focus effort within the organization, but also to inspire people and to overcome the petty distractions that can cause stagnation in any aspect of human life.

For NASA, we propose that there should be a core focus on achieving the target suggested above: to achieve technology, new markets, infrastructure, and life support for humans in space (whether NASA or non-NASA) great enough to initiate self-sustaining human presence and growth in space – a "tradeoff economy"[8] for humans in space. How to do that is an optimization problem – how to maximize the probability that humans someday do get to that point, and how to minimize the time between now and then. The mathematics of this kind of optimization should have absolute priority over the myopic kinds of bean counting that have often led to grossly suboptimal policies and policy analysis reports in the past. For example, the cost per pound of getting to LEO is one crucial metric of progress towards these goals, but the requirement is for costs that are low enough ($500/kg or less) under conditions of multiple launches, after the initial R&D is complete; the selection between options for the space shuttle, at the start of that program, put heavy emphasis on short-term variables. It is conceivable that we would already be at $500/kg-LEO today, supporting a much larger volume of activities in space at a lower cost, if we had selected the original, more aggressive proposal from Mueller of NASA, which better reflected the spirit of the Apollo era.[9]

In order to do justice to this optimization problem in real time, year after year, there should be greater use of an open, analytic process of revisiting the "decision trees"[10] involved in achieving the core long-term goal subject to budget constraints, decision trees that will change every year if we develop new technology and new knowledge as fast as we should. A well-constructed process should naturally reflect concepts like technology readiness levels, like "build a little and test a little," and like the value of buying information.[11] Not only strategic plans, but also actual budgets, at the highest level, should be continuously adapted in accord with the shifting needs of the larger goal of human settlement of space, and other values to society. Key information should also

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[7] Norman R. Augustine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 1997).

[8] Rostow, *Stages of Economic Growth*.

[9] George E. Mueller, "The New Future for Manned Spacecraft Developments (Manned Spacecraft Developments, Considering Apollo Applications Program, Space Station Establishment, Space Shuttle Operations and Payload Cost)," *Astronautics and Aeronautics* 7 (1969): 24-32.

[10] Howard Raiffa, *Decision Analysis: Introductory Lectures on Choices Under Uncertainty* (Reading, MA: Addison-Wesley, 1968); Frank Lewis and Derong Liu, eds. *Reinforcement Learning and Approximate Dynamic Programming for Feedback Control,* Vol. 17 (Hoboken, NJ: John Wiley & Sons, 2013).

[11] Raiffa, *Decision Analysis*.

be digitized in an organized fashion, as it is developed, with a kind of succession plan, so that we never face the risk of technology loss that we face today.

Given constraints on resources, the goal of not losing technology that may be crucial in the future is perhaps the most urgent task now before us. There are many, many cases of this concern; for example, as of 2009, only one full-scale test article had ever passed the stringent requirements of the unique test lab at Wright Patterson for a structure able to survive all the shocks of repeated re-entry; that test article, developed under RASV and classified programs, has since been lost, and the engineers who knew how to build it have retired. Active thermal protection systems using slush hydrogen are an article of faith in some communities, but even on paper, they never met the weight requirements for use in a re-entry vehicle, when they were actively pursued as part of the National Aerospace Plane program.

Having a strong core mission/target is essential, but there is also a compelling need for NASA to support other activities that leverage its capabilities. Studies of defense spending[12] have shown how gross inefficiencies and gaps can arise when policy is carved up into separate organizations or stovepipes that focus only on their core mission to the exclusion of all else. Therefore, we propose that all NASA funding decisions be based on a kind of cost-benefit analysis (accounting for uncertainties[13]), where benefit is the sum of two benefits:

1. (CORE MERIT) impact on the core mission, the accomplishment of a takeoff economy for humans in space; and

2. (BROADER IMPACT) the extra benefit to other important national goals that results from leveraging the use of unique NASA capabilities developed as a benefit of the core mission.

These are the two foundations of the NASA we would like to see. The remainder of this paper describes the new opportunities in these two areas in more detail.

Strategy for Achieving the Core Mission

To achieve a takeoff economy for humans in space, NASA should support activities aimed at building the four pillars upon which our hopes here rest:

1. NEW MARKETS from space to earth, large enough and tricky enough to create multiplier effects beyond what the existing applications in space provide. Energy from space is now the most promising hope for a very large new market, addressing core economic needs both on earth and in space, thanks to recent advances in power beaming technology and new design approaches.[14] Space tourism has also generated much excitement and interest in the private sector worthy of

[12] Charles J. Hitch, *Economics of Defense in the Nuclear Age* (Ann Arbor: University of Michigan Press, 1967).
[13] Raiffa, *Decision Analysis*; Lewis and Liu, *Reinforcement Learning*.
[14] Mankins, *The Case for Space Solar Power*; Werbos, "Reviewing Space Solar Power Policy."

support, especially as it calls for support to achieve lower travel tickets and support for forms of tourism that are actually independent, productive activities. We also need to be vigilant in looking for new opportunities with substantial economic potential, such as geoengineering, or higher levels of communication capabilities to bring better Internet capabilities to the poorest people on earth. Whatever the risks in these markets, we need to do the best we can to open up the full potential of the new markets, through both changed regulation and technology development. That is a top priority. There is also a need for NASA to work with other partners to help to smooth the transition of the new technologies to the commercial sectors.[15]

2 ADVANCED TECHNOLOGY will also be crucial to making space activities sustainable, affordable, and profitable on a larger scale. Most urgent is the development of new technology to allow reusable access to space at minimum marginal cost, no more than $500/kg-LEO, designed with foresight, looking ahead to the hope of large launch volumes to serve new markets.[16] DARPA's XS-1 project is a unique shining light in this space, but earlier projects at the height of the cold war (like Science Dawn, RASV, and TAV) developed low-cost technology that is still essential to the possibilities before us. XS-1 does not currently have enough funding to fill this crucial gap. We do not actually take a position on who develops this technology – new space, old space, or governments. Rather, we will try to provide encouragement and support to any player ready to do the serious advanced technology work. In addition to access to space, better technology for transportation beyond LEO is also essential, as are other elements of crucial economic infrastructure to improve cost-effectiveness of all efforts in space, even to the end of the solar system and beyond. Among the most important options in this area would be:

a restructuring and extension of the Space Launch System program (without reducing spending per year) to move as soon as possible and as completely as possible away from government-developed expendable rockets to at least partially reusable concepts, such as shuttle-derived vehicles, using passive hot structures to withstand re-entry; or

b a reusable booster to be a companion to the X37B, in a joint NASA-DoD effort organized like NASP, but based on rocket technologies ready for full-scale development and testing here and now.[17] Air-breathing, hypersonic technologies offer real hope of even lower costs in the future, but the long-term success of such efforts will be

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[15] See, for example, www.nss.org/legislative/positions/tarrifs.html.
[16] IEEE USA, *Low Cost Access to Space*.
[17] Ibid.

strongly endangered if we do not begin full-scale development and testing now of technologies that will also be needed for such air breathers.

3 NONTERRESTRIAL materials are another basic pillar of humanity's hope for self-sustaining economic growth in space. This will take more time than the initial development of new markets, but it is an essential requirement that we must meet sooner or later. We have no interest in putting flags and footprints on the moon for their own sake – but we do have an interest in rational steps as part of a strategy to get real economic value from the moon and from the asteroids, and eventually Mars. There is also major potential for public excitement and support for subgoals in this area.[18] The economic history of Earth tells us that the best strategy is to develop not just one source of materials, but all of them, starting with what is easiest to get to, and planning to transition the key decisions about priorities into market systems as soon as they become able to take over. It is important that our decision trees account for a variety of materials and production technologies,[19] and that key capabilities not be lost. There should be a new push for cross-disciplinary research, cutting across lunar chemical engineering, manufacturing, and propulsion, and accounting for the new findings from the LCROSS satellite, to try to develop new, higher performance options in this sector.

4 HUMAN ABILITY to live and work in space at an affordable cost, in the long term, is the fourth and final fundamental pillar of human settlement, and another basic commitment. To make this real, we agree, at a minimum, that human presence in space should remain continuous and permanent, initially through the International Space Station, but also through larger, expanded systems in the future, without any retreat. All-robotic assembly of large structures in space is possible in principle, but optimal management of such systems is far in the future,[20] and it poses several risks of global instability including possibilities for "Terminator modes." It is better and more realistic to focus on the use of teleautonomy,[21] as in the robotic mining operations pioneered by Baiden, based on cooperative networks of humans and robots with humans firmly in charge. We should improve automation

[18] Gerard K. O'Neill, *The High Frontier: Human Colonies in Space* (New York: William Morrow and Company, 1977).

[19] See Planetary and Terrestrial Mining Sciences Symposium (PTMSS), www.deltion.ca/ptmss/Home.php. See also www.isruinfo.com/, www.lpi.usra.edu/leag/LER-Version-1-3-2013.pdf, and www.planetaryresources.com/ .

[20] Paul Werbos, "From ADP to the Brain: Foundations, Roadmap, Challenges and Research Priorities," in *2014 International Joint Conference on Neural Networks (IJCNN)* (New York: IEEE, 2014), 107-111. arxiv.org/abs/1404.0554.

[21] Greg Baiden, "Telerobotic Lunar Habitat Construction and Mining." Paper given at the 2008 International Symposium of Artificial Intelligence, Robotics and Automation in Space, Hollywood, CA.

and efficiency in an incremental way by making use of new technology for vector intelligence.[22]

Important New Noncore Opportunities Leveraging Core NASA Capabilities
Among the most important new broader benefits possible from NASA and from its partnerships are:

1 Better understanding and imaging of the Earth, measuring new variables and improving predictions, so as to achieve better early warning and prediction for the worst-case possibilities for changes in the global environment. Perhaps the most serious worst case possibility is the risk that emissions of H_2S gas from the oceans could reach levels fatal to humans, and cause fatal destruction of the stratospheric ozone layer, as they have done five to ten times in the previous history of the earth.[23] Warning and better prediction are important, because it is equally possible that we will somehow escape, and that a major tipping point will occur 40 years in the future as the oxygen levels in the deep far south of the Pacific Ocean will reach zero, at present rates of change. Monitoring oxygen levels and nutrition levels which drive the growth of H_2S-producing microbes, at depth in the ocean, will require expansion in the partnerships with NOAA, the Navy, and the European Space Agency.

2 Combining low-cost launch and massive new communications satellites, and related work, reaching out to provide K-12 education by Internet to the "other three billion" (O3B), in public-private partnerships. Efforts to reach the O3B are already a major priority for several major Internet companies, but with larger new satellites using higher levels of solar power, and new educational materials, this effort could move faster. There is an opportunity here to leapfrog education (and female education) in the poorest parts of the world; those variables, in turn, are crucial to stability and economic growth in those areas, essential to US national security.

3 Technological breakthroughs in imaging of objects in space (asteroids, sun, astrophysics) using new quantum and/or constellation technologies to improve resolution massively and to create other new capabilities.[24] If we can actually see planets in other solar systems with

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[22] Werbos, "From ADP to the Brain."

[23] Peter Douglas Ward, *Under a Green Sky: Global Warming, the Mass Extinctions of the Past, and What They Can Tell Us About Our Future* (New York: Harper Perennial, 2008). Available in Kindle format from Amazon.com; Lee R. Kump, Alexander Pavlov, and Michael A. Arthur, "Massive Release of Hydrogen Sulfide to the Surface Ocean and Atmosphere During Intervals of Oceanic Anoxia," *Geology* 33 (2005): 397-400.

[24] David C. Hyland, Jon Winkeller, Robert Mosher, Anif Momin, Gerardo Iglesias, Quentin Donnellan, Jerry Stanley, et al. "A conceptual design for an exoplanet imager," in *Optical Engineering + Applications*, (Bellingham, WA: International Society for Optics and Photonics, 2007), 66930K; Jianbin Liu, Yu Zhou, and Fuli Li, "Changing Two-Photon Correlation into Anticorrelation by Superposing Thermal and Laser

enough resolution to see the chemical traces of life in earth-sized planets, the cultural benefits will be enormous, and we will develop a better understanding of the future possibilities for humans in the galaxy, which are currently extremely hard to guess in a rational way.[25] There is also some hope that new forms of quantum ghost imaging, using three entangled photons instead of just two, might allow imaging without a sensor on the detector channel, and thus allow some form of predictive imaging for distant objects.[26]

4 Space-based missile defense … where a factor of 10 reduction in $/kg-LEO equates to having ten times as much mass in orbit for the same launch cost. The need for better, more complete defense against missiles has become greater and greater, as events in North Korea and in the Middle East remind us, but at present launch costs it is not really feasible. At $500/kg-LEO, the game changes. As Ronald Reagan once asserted, the greatest security for developed nations may occur if there is sharing of this technology with Russia, and also with emerging powers willing to cooperate on behalf of humanity as a whole, under balanced arrangements. There have been cases where US efforts to avoid technology loss to China have actually resulted in superiority of the Chinese technology as the US players suffer, such as the vector intelligence technology used in hit-to-kill applications.[27]

5 Advanced physics experiments in space, exploiting either the unique observation platform or the safety benefit of doing some things off the surface of the Earth. For example, there may be ways to extend the classic B factory experiments related to the Lisa experiment in space, to help us understand better how nuclear forces really work, or experiments to test and extend the new work of Alfred Leitenstorfer of Konstanz, who has measured field fluctuations in free space at a level of 10 MW per cubic meter. It is possible that a better working understanding of strong nuclear forces may suggest experiments with possible energy release high enough that it is safer to do the work in Earth orbit at the early stages, when we do not yet really know how things will work out. Because of the high cost of pumping lasers for the National Inertial Fusion facility at Livermore, it would make sense to

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Light," www.paper.edu.cn/en_releasepaper/downPaper/201401-713.html (see also Ruifeng Liu and Fuli Li, "Effects of Photon Bunching on Ghost Imagining and Interference," paper presented at the Princeton-TAMU Workshop on Classical-Quantum Interface, Princeton University, Princeton, NJ, May 2015; Dmitry V. Strekalov, Baris I. Erkmen, and Nan Yu, "Ghost Imaging of Space Objects," *Journal of Physics: Conference Series* 414, no. 1 (2013): 012037, iopscience.iop.org/1742-6596/414/1/012037/pdf/1742-6596_414_1_012037.pdf.

[25] David Brin, *Existence* (New York: Macmillan, 2012).

[26] Paul Werbos, "Analog Quantum Computing and the Need for Time-Symmetric Physics," *Quantum Information Processing*, submitted 2015, extension of a paper published at SPIE/DSS 2015.

[27] Lewis and Liu, *Reinforcement Learning*; Werbos, "From ADP to the Brain."

experiment with lightweight, optically pumped lasers instead, using lightweight mirrors to focus light on lasers used for fusion experiments.

6 Developing geoengineering capabilities, such as low-cost mirrors, which are strongly advocated by Abdul Kalam,[28] the popular past president of India, as another option for energy from space. If we reduce the cost of bringing these mirrors into earth orbit, there is at least some hope that we could use them to reflect enough light away from the Antarctic to stop the ongoing melting, which has already injected fresh water and ice into the waters near the Antarctic, interrupting the thermohaline currents that previously replenished the oxygen in the deep waters of the Pacific Ocean.

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About the Authors:

Paul Werbos has had major program responsibilities in the U.S. Government, scientific and engineering research organizations, and the National Science Foundation (NSF) since his graduation from Harvard University with a PhD in 1974. His NSF responsibilities, beginning in 1988, have been in Domestic Nuclear Detection, Energy, Power, Adaptive Systems, Robotics, and Science-Engineering and Society. His broad background in science, technology, and engineering has propelled him into a leading professional role as a Fellow in IEEE and an award winner within the International Neural Network Society (INNS). His research and writings have made important contributions to energy, to learning, to sustainability and to study of the Universe and Space.

Edward D. McCullough is a retired principal scientist at Boeing and a former member of the NSS Board of Directors. He received his professional training in nuclear engineering through the US Navy and Bettis and Knowles Atomic Power Laboratories (gaining his Certification for Nuclear Engineering at Pearl Harbor Naval Shipyard in 1975).

He focused on concept development, experimental chemistry, and advanced technology at Rockwell Space Systems Advanced Engineering and at the Boeing divisions of Phantom Works and Integrated Defense Systems. He has researched innovative methods to reduce the development time of technologies and systems from

[28] See www.nss.org/news/releases/Kalam_Address_ISDC2013.pdf.

10 to 20 years down to five years. He has experienced successes in chemistry and chemical engineering for extraterrestrial processing and photonics for vehicle management systems, and integrated vehicle health management and communications. He has led efforts for biologically inspired multi parallax geometric situational awareness for advanced autonomous mobility and space manufacturing. He has developed several patents, including patents for an angular sensing system; a method for enhancing digestion reaction rates of chemical systems; and a system for mechanically stabilizing a bed of particulate media.

He is Chair Emeritus of the AIAA Space Colonization Technical Committee, a member of the Board of Trustees for the University Space Research Association, a member of the Science Council for Research Institute for Advanced Computer Science, and a charter member of the AIAA Space Exploration Program Committee. He previously served on the NRC Committee to Review NASA's Exploration Technology Development Programs, and the Planning Committee for the Workshop on Research Enabled by the Lunar Environment.

Editors' Notes: This paper advocates a return to first principles for NASA, focusing on what one might call applied blue-sky research, however much that might sound like an oxymoron. It recalls the pioneer spirit that built America, and it also echoes a comment from *Star Trek*'s Captain Kirk in 1968: "Gentlemen, risk is our business."[29] It is also thoroughly forward-looking, in that it encourages NASA to do what only it can do, and to leave things that others can do as well or better to other organizations. It is a welcome addition to the *Journal of Space Philosophy*. ***Bob Krone and Gordon Arthur.***

[29] "Return to Tomorrow," an episode of *Star Trek*, created by Gene Roddenberry (Paramount Pictures, 1968).

Recursive Distinctioning: The 2016 Clayton, Missouri Conference

By Bob Krone

The *Recursive Distinctioning Team* met for its 2016 Convention at the residence of Dr. and Mrs. Joel Isaacson, 20 Crestwood Drive, Clayton Missouri, 63105, USA, 16-18 September 2016.

Participating were Dr. Joel D. Isaacson, Mrs. Leora Isaacson, Ms. Orna Isaacson, Dr. Louis H. Kauffman, Ms. Diane Slaviero, Dr. Robert M. Krone, Mrs. Salena Gregory-Krone, Dr. John Barker, Mr. Martin Hay, Mrs. Frances Hay, Professor Moshe Klein (via Skype from Tel Aviv University, Israel), and Mr. Joe Sobodowski (via telephone from Florida, USA).

1. Bob Krone introduced the Conference with a three-minute video. The script of the video was:

   I am Dr. Robert M. Krone, president of Kepler Space Institute. The date is September 17th in the year 2016. The location is Clayton, Missouri, USA, where a small group of professionals have met at the residence of Dr. Joel and Mrs. Leora Isaacson.

   Dr. Joel D. Isaacson discovered Recursive Distinctioning in 1964. He has defined Recursive Distinctioning as a natural principle of nature that occurs across all types of perception and intelligence, and is independent of the particular sensory modalities deployed. The purpose of this meeting is to identify future research, applications and academics for Recursive Distinctioning – which has the short acronym of RD. Those applications will have profound future impacts on many sciences, technologies, industries, and disciplines.

   Dr. Isaacson's life research in RD has been given a huge impetus by Dr. Louis H. Kauffman, Professor of mathematics at the University of Illinois in Chicago, who has worked intensively with Dr. Isaacson over the past year. Dr. Kauffman has stated; "the principle of distinction/description in recursive process applies at all levels of biology, cognition, information science and computing." Drs. Isaacson and Kauffman published a major paper on the theory, definition, and description of RD in the spring 2016 issue of the *Journal of Space Philosophy* (www.keplerspaceinstitute.com/jsp)….

   This event has special meaning for me, personally, because I have been a colleague of Dr. Isaacson since we first met at a NASA summer research session in 1980.

2. *Convention Achievements*. All participants judged the conference a success and predicted that it will lead to future RD research and applications that will be additions to current science and technology knowledge across multiple industries, while also impacting all levels of education.

3. During Saturday, September 17 and Sunday, September 18, there were presentations by Dr. Kauffman, Dr. Barker, Dr. Isaacson, Mr. Hay, and Professor Klein (via Skype). Documentation for those presentations has been retained in the RD Team Archives. Summaries of those presentations follow:

   A. *Dr. Joel D. Isaacson*. Joel Isaacson made a short presentation on a tetrahedral molecule that may represent two XOR operations that are required for generating representations of RD icons. In the Fischer projection for such a molecule, the central atom is carbon, or in the alternative, silicon or germanium. The four ligands need to be determined. The two vertical are input terminals and have two states.

The two horizontal are output terminals. A chain of these molecules can be assembled. Depending on chemical signals inputs, the molecule as a whole assumes a state that represents one of four RD icons. The four ligands need not be exotic and are most likely common chemical groups in organic chemistry. However, interpretation of the computational aspects of this kind of molecule requires understanding of polarity strings and quaternions and also four-icon theories as developed by Isaacson and Kauffman and by Schmeikal. It is unlikely that at present organic chemists are familiar with these concepts.

B. *Dr. Louis H. Kauffman*. Louis H. Kauffman talked about the basics of RD and the structure of the mathematical definition of RD due to Joel Isaacson and himself.

He then explained about iconic alphabets, including a 16-letter alphabet for two-dimensional RD and its relationships with the quaternions. In a second talk, Kauffman described a number of points of view, algebraic and geometric, about the quaternions and the octonions. Kauffman raised numerous questions about the practical applicability of RD, and he described how the simplest RD patterns in one dimension are related to patterns of mitosis and patterns of DNA replication in biology.

C. *Dr. John Barker*. John Barker provided some philosophical reflections on the ubiquity of recursive processes in the biological, cognitive, metacognitive, and linguistic realms, and demonstrated how his computational model of mental processes, ProtoThinker, makes extensive use of recursion in simulating some of these processes. (Prof. Barker's work is supplementary to RD theory and applications).

D. *Mr. Martin Hay*. Referring to Joel Isaacson's pioneering patent on RD and to iterant/polarity string quaternion models described by Lou Kauffman and Bernd Schmeikal, Martin Hay presented his invention of chiralkine systems for coding and processing information about social relationships based on the symmetry properties of chiral tetrahedral molecules. He demonstrated how two interpenetrating, mutually exclusive enantiomeric forms of a chiral tetrahedral molecule can constitute a basis for coding and processing information about relationships in four kinds of state, which states can be described by iterants/polarity strings and interpreted geometrically as the corners and faces of a cube consisting of the two interpenetrating enantiomers. State changes in the system can be interpreted as coupled polarity flips and geometrically as rotations of the cube. Attendees were shown code written to support a new kind of economic system that could function without money, including voting/decision making/dispute resolution and exchange of goods and services/taxation. A new kind of game was also demonstrated, which game could be used to teach children how rights and obligations are interrelated, and could also potentially be developed for the treatment of brain injury and stroke.

E. *Prof. Moshe Klein and Prof. Oded Maimon* (via Skype from Tel Aviv University, Israel) described soft logic that develops a new monordinate system that makes a distinction between -0 and +0. Any line that is passing through 0 intersects the monordinate system at four points that create a Klein group. This group is analogue to the Klein group that is generated by the four letters SA in RD. **Theorem:** There is an isomorphism between RD and soft logic.

4. Dr. Joel D. Isaacson and Dr. Louis H. Kauffman tentatively agreed to make themselves available for the International Space Development Conference, sponsored by the National Space Society, at St. Louis, on the date of Saturday, May 27, 2017.

5. Dr. Kauffman recommended the title of *Recursive Distinctioning Dynamics* for the RD academics being designed by Dr. Bob Krone, for the Kepler Space Institute's forthcoming PhD in Space Sciences Degree Program (the PhD/DSS).

6. Mr. Joe Sobodowski is the KSI VP for Finance.

7. Scheduling of a third RD Team meeting in 2017 was left for the future.

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About the Author: Dr. Bob Krone is President of Kepler Space Institute (www.keplerspaceinstitute.com). He is an Emeritus Professor of Systems Management at the University of Southern California; has been the principal sponsor for PhD, DBA, and Master's Degree Program candidates for forty years; and is a USAF Colonel (Ret). BobKrone@aol.com.

Editor's Notes: We are grateful to the team for keeping us updated on recent developments. ***Gordon Arthur*.**

Recursive Distinctioning, Tetracoding and the Symmetry Properties of Chiral Tetrahedral Molecules

By Martin A. Hay

Abstract
This paper describes the material I presented at the Convention on Recursive Distinctioning (RD) in Clayton MO on September 16-18, 2016. It is in several parts. The first part seeks to teach how to build control systems for coding and processing information about relationships in the four relationship states (00), (01), (11) and (10) described in Joel Isaacson's US patent number 4,286,330 on tetracoding and RD. It takes as its starting point the work of Joel Isaacson on RD, of Louis Kauffman on quaternions and iterants and Bernd Schmeikal on polarity strings, and it integrates this with my own work based on an analysis of the symmetry properties of chiral tetrahedral molecules.[1] It also relates to work of Moshe Klein and Yale Landsberg, who, like me, seek to draw a distinction between different zeroes. The subsequent parts of the paper describe applications of such systems that have already been prototyped or could be, including a new kind of game embodying rights and obligations that can be played under control of left and right musculature and may potentially be useful in the treatment of brain injury or stroke, a new kind of voting system and a new kind of system for controlling the exchange of goods and services that does not involve the use of an imaginary store of value of any kind (money or credit).

Relationship States

We teach our children to construct their world view based on the principle of a balance (weighing scales). A balance can be tipped to the left, balanced or tipped to the right. An object can be positioned to the left, in the middle or to the right. A number can be negative, zero or positive. Socially a person can be in debt (owe money), in balance or in credit (own money). However, the building blocks of all our constructs are distinctions:[2] the same or different. The three possible positions of a balance and the three different kinds of number: positive, zero and negative, are all constructed out of combinations of same and different. A way to do this was worked out a long time ago,[3] but is very little known. The same and different are coded as 0 and 1. The three positions of a balance are treated as left, right ordered pairs of 1s and 0s. -1 is treated as (10); balance as (00) and +1 as (01). The addition of +1 (01) to -1 (10) affords (11), which cancels down to (00). The 1s are tallied as in 1 + 1 = 2, but the 0s are not, as in 0 + 0 = 0 and 0 + 1 = 1. Thus, our models of the world are constructed out of three relationship states: (10) – different on the left, not the right; (00) = (11) – no difference between the left and the right; and (01) – different on the right, not the left.

[1] *Journal of Space Philosophy* 5, No. 1 (2016); Terry Marks-Tarlow, Martin A. Hay, and Herb Klitzner, "Quaternions, Chirality, Exchange Interactions: A New Tool for Neuroscience?" *Society for Chaos Theory in Psychology & Life Sciences* 23, No. 1. (2015): 8-14; Bernd Schmeikal, "Four Forms Make a Universe," *Advances in Applied Clifford Algebras* 25, No. 1 (2015): 1-23; Joel Isaacson and Louis H. Kauffman, "Recursive Distinctioning" (2016), arXiv:1606.06965 [physics.gen-ph].

[2] G. Spencer-Brown, *Laws of Form* (London: George Allen and Unwin, 1969).

[3] D. E. Littlewood, *The Skeleton Key of Mathematics: A Simple Account of Complex Algebraic Theories* (New York: Harper Torchbooks, 1960).

This number coding based on the principle of a balance (+1, 0, -1) is ubiquitous in science and technology, as well as in the coding and processing of information about economic relationships. Voting systems in effect weigh the votes for one candidate against those for another, such that voting for no candidate (00) has the same effect as a vote for every candidate (11). In the exchange of goods and services and taxation, an individual may be in a state of debt (owes money), credit (owns money) or balance (neither owns nor owes money). The three states encode mutual relations between two individuals and a resource. For every credit there is a counterpart debt. Every time a good or service is provided without another good or service being provided in return, the receiving party goes into a state of debt and the providing party into a state of credit.

Human societies have been coding and processing information based on the principle of a balance for hundreds if not thousands of years, but biology does not actually work this way. The perception of presence and absence are both active constructs. A neuron can fire in response to the presence or the absence of a stimulus. It follows that biology does not distinguish presence and absence in the same way that numbers that can be tallied, 1s, are distinguished from numbers that cannot, 0s. Each kind can be encoded in the firing of one or more neurons. Accordingly, instead of representing the same and different in terms of 0 (which cannot be tallied) and 1 (which can be tallied), it appears more appropriate to use + and -. This issue of when the same or different can be tallied is important and is revisited later.

Joel Isaacson's US patent number 4,286,330[4] discloses tetracoding: a way of encoding mutual relationships in four relationship states, A (00), B (01), D (11) and C (10), each of which is defined in terms of its relations to its two neighbours.

A (00): both neighbours are distinct (0) from the state;

B (01): the left neighbour is distinct (0) and the right neighbour is indistinct (1) from the state;

D (11): both neighbours are indistinct (1) from the state; and

C (10): the left neighbour is indistinct (1) and the right neighbour is distinct (0) from the state.

This way of encoding mutual relationships works on a principle fundamentally different from that of a balance. It draws a distinction not only between two antisymmetric states (10) and (01) as in voting for one candidate, not another or debt and credit, but also between two symmetric relationship states (11) and (00), as in active and passive abstention in voting, or an object that belongs to neither or both members of a relationship. It works on the principle of order, as I will explain later.

My own international patent application, publication number WO2012/069776 discloses a chiralkine system.[5] The system is encoded in four relationship states: two

[4] Joel D. Isaacson, "Autonomic String-Manipulation System," US Patent 4,286,330, August 25, 1981, www.isss.org/2001meet/2001paper/4286330.pdf.

antisymmetric: A (↑↓ or + -) and C (↓↑ or - +) and two symmetric: D (↑↑ or + +) and L (↓↓ or - -). These can be mapped to the four states disclosed in US Patent Number 4,286,330.

D (↑↑ or + +) → A (00): both neighbours are distinct (0) from the state;

A (↑↓ or + -) → B (01): the left neighbour is distinct (0) and the right neighbour is indistinct (1) from the state;

L (↓↓ or - -) → D (11): both neighbours are indistinct (1) from the state; and

C (↓↑ or - +) → C (10): the left neighbour is indistinct (1) and the right neighbour is distinct (0) from the state.

In a chiralkine system, relationship states are manipulated pairwise based on the principle of order: A turns C into L and C turns A into D.

Coding in Biological Systems, Chirality

In the genetic code of living systems, information is coded in a polymer of four bases known as DNA. Each polymer is an ordered combination of four bases: adenine (A), thymine (T), guanine (G) and cytosine (C). These bases can pair up as in A to T and G to C such that each strand of DNA can pair up with its complement. Each polymer of DNA encodes for the production of a polymer of amino acids, in particular a peptide of protein. Each amino acid is encoded by a particular sequence of three bases (triplet) in the DNA polymer.

An amino acid can be represented by the general chemical formula (Figure 1):

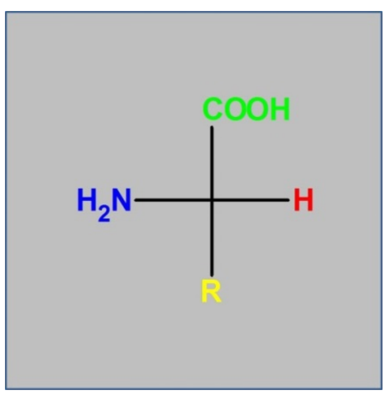

Figure 1. The formula of an amino acid.

in which R represents a general group. Each molecule of an amino acid has a tetrahedral shape. The central carbon atom (not shown) is bonded to four different

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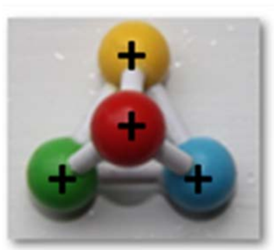
[5] Martin A. Hay, "Chiralkine," US Patent Applications, Publication Nos. 2013/0221616 (2013), 2016/0199725 (2016); Martin A. Hay and Frances G. Boul Hay, "Technology Alternative to Money for Enabling Equitable Trade," US Patent Application, Publication No. 2014/0195379.

atoms or groups: a hydrogen atom, an amino group (NH_2), a carboxyl group (COOH) and a group R (other than glycine, where R is itself a hydrogen atom). For example, when R represents a methyl group, the amino acid is alanine.

Amino acids can form chains in which the carboxyl group of one amino acid forms a peptide bond (CONH) with an amino group of an adjacent amino acid. In this way, amino acids can form peptides and proteins, which have many different functions in living organisms. It is worth noting that an amino acid can be in one of four states: unbound on the amino and carboxyl groups; bound on the amino and carboxyl groups; bound on the amino, not the carboxyl group and bound on the carboxyl, not the amino group. However, this paper focuses on another property of amino acids: their handedness, or chirality.

The word "chiral" comes from the Greek word for hand. Amino acids are chiral molecules. Four different objects can be arranged in 3D space in two mirror-opposite ways, like the wrist, thumb, first finger and second finger of the hands (Figure 2).



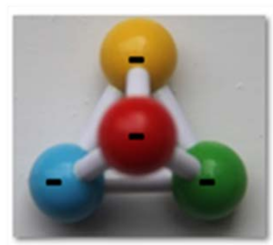


Figure 2. Mirror-image models of chiral tetrahedral molecules.

In an amino acid, the four different objects are the hydrogen atom, R group, amino group and carboxyl group bonded to a central carbon atom. They point towards the corners of a tetrahedron. All the amino acids in the human body are of one handedness.

Most people find it very difficult to visualise shapes in 3D space, and even more difficult to visualise how the components of a shape move as the shape is rotated. Chemists use a technique known as the Fischer projection[6] to distinguish between the two forms of a chiral tetrahedral molecule. A Fischer projection sets out the four components of a tetrahedral molecule as if they lie at the ends of a cross. The two components positioned horizontally are deemed to project towards (+) the viewer and those positioned vertically are deemed to project away (-) from the viewer. By convention, the carboxyl group of an amino acid is positioned above and the R group below (Figure 3).

[6] S. Capozziello and A. Lattanzi, "Chiral Tetrahedrons as Unitary Quaternions: Molecules and Particles Under the Same Standard," *International Journal of Quantum Chemistry* 104 (2005): 885-39; Francisco M. Fernández, "On the Algebraic Structure of Central Molecular Chirality," Journal of Mathematical Chemistry 54 (2016): 552-58.

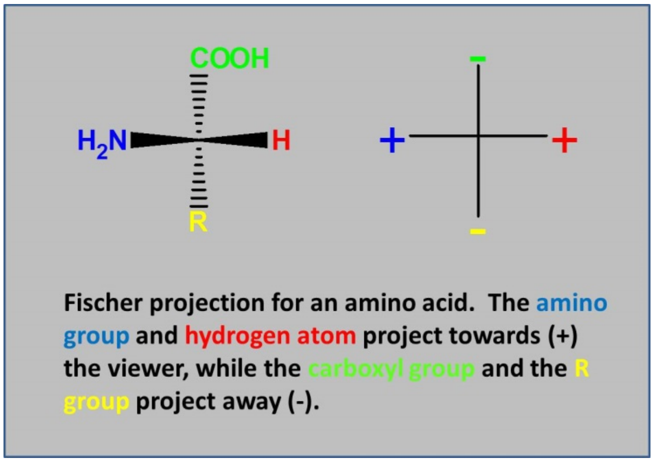


Figure 3. Fischer projection for an amino acid.

When the amino group is positioned on the left and the hydrogen is positioned on the right, the amino acid is said to be in the L configuration. When the amino group is positioned on the right and the hydrogen is positioned on the left, the amino acid is said to be in the D configuration. All amino acids in the human body are in the L configuration (Figure 4).

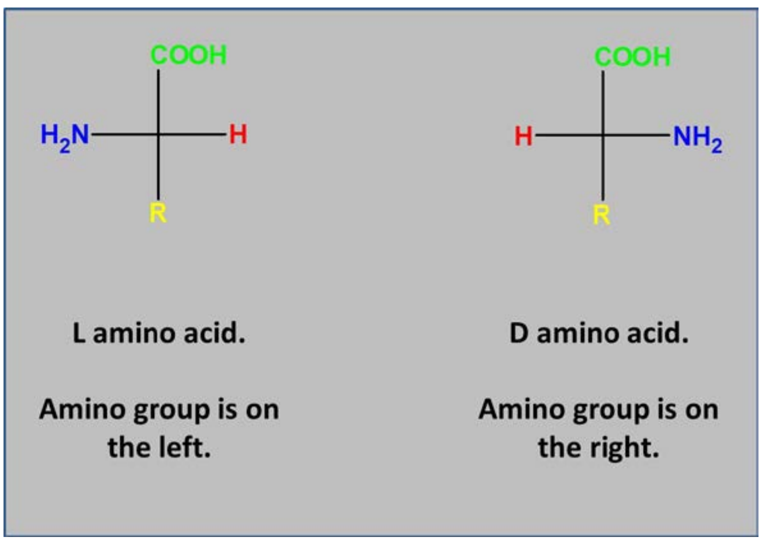


Figure 4. L and D amino acids.

Instead of viewing an amino acid with both the amino group and hydrogen atom projecting towards (+) the viewer, we can also look at the amino acid with just the hydrogen atom projecting towards (+) the viewer and the other three groups projecting away (-). The order of the R group, amino group and carboxyl group is clockwise for the L amino acid and anticlockwise for the D amino acid. However, if the D amino acid is viewed from the opposite side (in effect reversing all the signs), then the order of the R group, amino group and carboxyl group is the same as that for the L amino acid viewed from the opposite side (Figure 5).

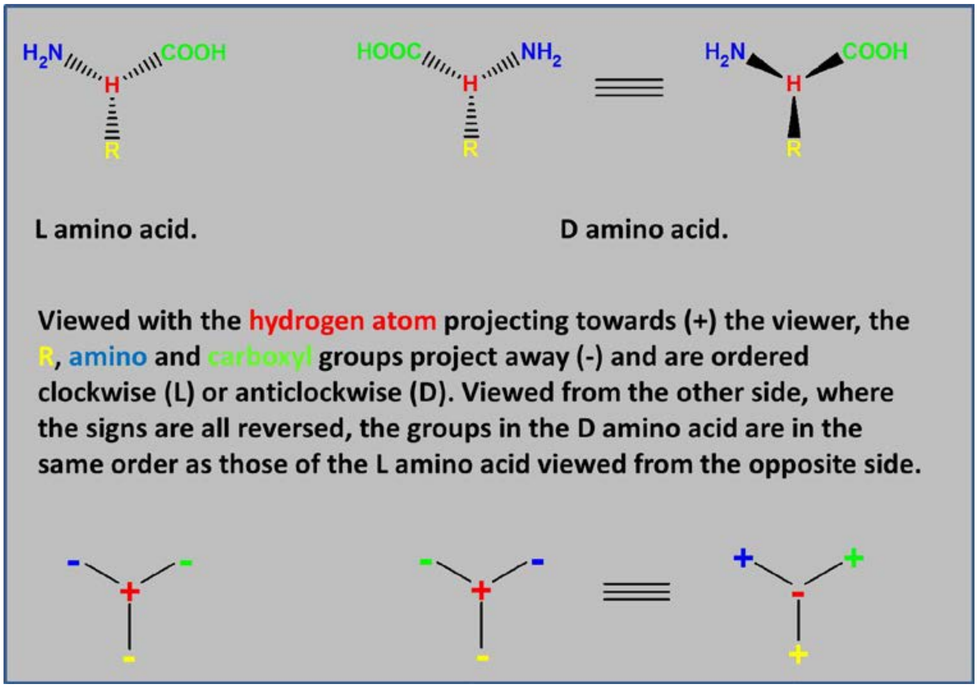


Figure 5. The effect of viewing amino acids with the hydrogen atom projecting towards the observer.

The significance of the signs and their utility in the coding of relationships will become clear below.

The two different forms of an amino acid, L and D, are called enantiomers. It is not possible to superimpose the four groups of one enantiomeric form on those of the other, no matter how you rotate the molecule. This can be imagined by taking a disc having a black side and a white side and marked to match up with three of the four objects of one enantiomer on one side and three of the four objects of the other enantiomer on the reverse side (Figure 6).

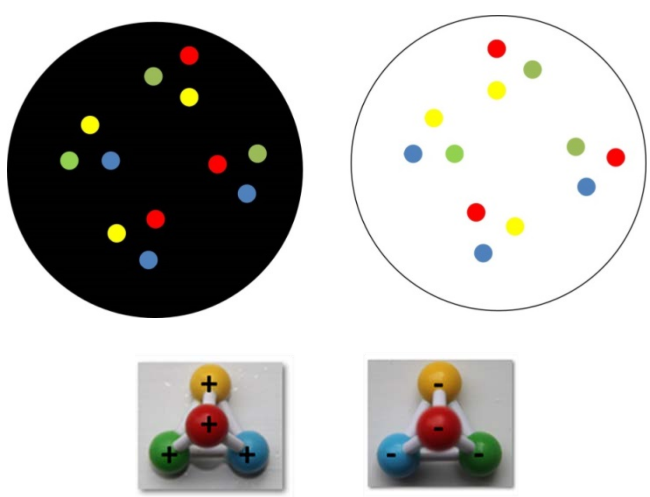


Figure 6. Enantiomers of L and D amino acids.

The two enantiomers are mutually exclusive (XOR). The eight objects of the two enantiomers if taken together (interpenetrating) would point to the corners of a cube (Figure 7).

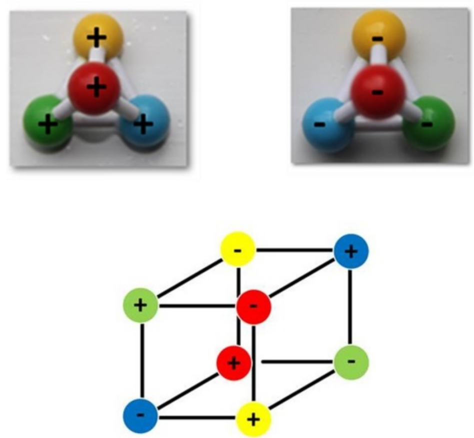


Figure 7. Forming a cube from the enantiomers of a chiral tetrahedral molecule.

Each face of a cube corresponds with a Fischer projection of a chiral tetrahedral molecule, i.e., with two groups projecting towards (+) and two away (-) from the viewer. There are 24 such projections: four for each of the six faces, and they correspond with the 24 different ways in which four different objects can be permuted (4 x 3 x 2 x 1). Each corner corresponds with a view of a chiral tetrahedral molecule with one or three groups projecting towards (+) the viewer and three or one groups projecting away (-).

The cube can be combined with quaternion mathematics to code relationships. The quaternions were invented by William Rowan Hamilton.[7] They are composed of four ordered elements 1, i, j and k, each of which can be positive or negative, and each of which conforms to the following multiplication rules (Figure 8):

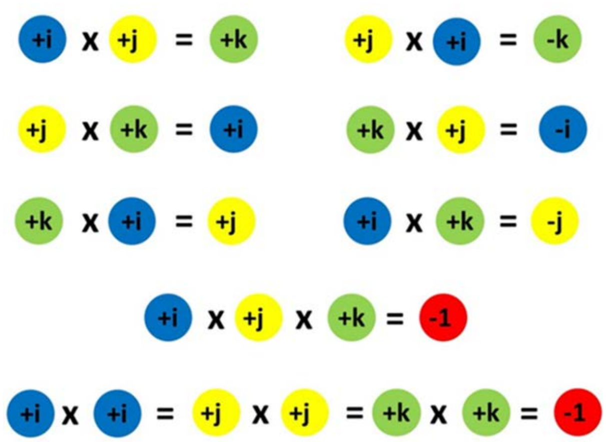
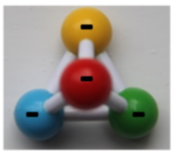
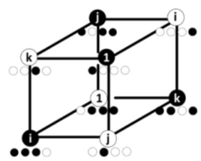
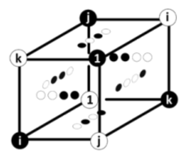
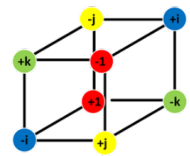


Figure 8. Quaternion multiplication rules.

[7] Herb Klitzner, "Quaternion Connections to Social Robotics, Compassion and Aesthetics," Presentation to the New York Academy of Sciences, June 2016.

We interpret each face of a cube as a quaternion, sorting the four vertices of the face into the order red, blue, yellow, green and noting the sign of each. All the faces and corners of the cube then conform to the quaternion multiplication rules. For example, if we start with the code +1 -i -j -k and multiply each element by +i we get +1 +i +j –k, which is +i. We can call a sequence of polarities, such as + + + -, an iterant or a polarity string (Table 1).

Table 1. Polarity Strings for Quaternions

Quaternion 	Corner 	Face 	Cube 
+1	+1 -i -j -k		+1 +i +j +k
-1	-1 +i +j +k		-1 -i -j -k
+i	+1 +i +j -k	-1 +i -j +k	
-i	-1 -i -j +k	+1 -i +j -k	
+j	+1 -i +j +k	-1 +i +j -k	
-j	-1 +i -j -k	+1 -i -j +k	
+k	+1 +i -j +k	-1 -i +j +k	
-k	-1 -i +j -k	+1 +i -j -k	

Each of the signed quaternions ±1; ±i; ±j and ±k has two associated iterants. These can be sorted into two complementary tables as shown below (Table 2). Imagine that each polarity is one side of a two-sided coin (+ and -). One table is the other table viewed in a mirror, as if a mirror is being used to enable both sides of the coins to be seen at the same time.

Table 2. Iterants for Quaternions

Face →, Corner ↓

	1	i	j	k
1	+	-	-	-
i	+	+	+	-
j	+	-	+	+
k	+	+	-	+

Face →, Corner ↓

	-1	-i	-j	-k
-1	-	+	+	+
-i	-	-	-	+
-j	-	+	-	-
-k	-	-	+	-

The diagonals, top left to bottom right, identify each quaternion (±1; ±i; ±j or ±k) coded by the two iterants in its respective row and column. The eight rows constitute the corners of a cube and the columns ±i; ±j and ±k constitute the faces. Each polarity in a table that is not in a diagonal changes sign with the exchange of row and column co-ordinates, but each polarity in a diagonal (shown in colour) does not. For example, +i corner, +j face is +, and +j corner, +i face is -, but +i corner and +i face is +.

We can assign the letter coding from Recursive Distinctioning (RD) to pairs of polarities in the iterants: A (+ +); B (+ -), C (- +) and D (- -). In all rows and two of the four columns, the four letters run in sequence A, B, D, C read in a clockwise or an anticlockwise ring. B and C are never adjacent, nor are A and D. It is as if B (+ -) turns into D (- -) and C (- +) turns into A (+ +). The letters are paired A with D and B with C, like A with T and G with C in DNA. For example, we have D B A C and its complement A C D B (Table 3).

Table 3. Pairings of Letter Codes

Corner ↓ / Face →	1	i	j	k
1	B		D	
i	A		B	
j	B		A	
k	A		C	

Corner ↓ / Face →	-1	-i	-j	-k
-1	C		A	
-i	D		C	
-j	C		D	
-k	D		B	

We can also create a second pair of tables by exchanging the corner and face axes (Table 4). This gives us:

Table 4. Iterants for Corner and Face Axes

Face ↓ / Corner →	1	i	j	k
1	+	+	+	+
i	-	+	-	+
j	-	+	+	-
k	-	-	+	+

Face ↓ / Corner →	-1	-i	-j	-k
-1	-	-	-	-
-i	+	-	+	-
-j	+	-	-	+
-k	+	+	-	-

The face representations (±i; ±j or ±k) constitute a group of six iterants: a pair of triplets. Chiralkine systems are coded in these triplet pairs. The members of a triplet exhibit an interesting property. In any column, the sign of any two polarities indicates the sign of the third polarity. On the table on the left, - signifies same and + signifies different. For example, if the iterant for +i (- + - +) is compared with that for +j (- + + -), comparison of the signs produces (- - + +), which is +j. Comparison of any of the iterants with itself produces (- - - -), which is -1. On the table on the right, + signifies the same and - signifies different. For example, if the iterant for -i (+ - + -) is compared with that for -j (+ - - +), comparison of the signs produces (+ + - -), which is -j. Comparison of any of the iterants with itself produces (+ + + +), which is +1. Thus, each triplet combined with the code for its "opposite missing face" constitutes a quaternion group in which + and - have a consistent "same" or "different" meaning. States in a family can be tallied (add the polarities for each "same" sign in a column, not those of the "different" sign, to determine quantities of each state present). This is illustrated below (Table 5).

Table 5. Tallying Polarities of Quaternions

Corner →
Face ↓

	1	i	j	k
1	+	+	+	+
i	-	+	-	+
j	-	+	+	-
k	-	-	+	+
Σ	3-	1-	1-	1-

Corner →
Face ↓

	-1	-i	-j	-k
-1	-	-	-	-
-i	+	-	+	-
-j	+	-	-	+
-k	+	+	-	-
Σ	3+	1+	1+	1+

For example, +1i +3j +7k is 11, 1, 3, 7. On this side, we do not tally the +. We can work with just two symbols: + and -: we do not need a third symbol, 0. This can be exploited to construct quantitative systems, as is described later. The pattern also calls to mind human colour vision.[8] I do not possess any specialist knowledge of human colour vision, but offer the following thoughts. The modern theory of human colour perception is based on an understanding that there are three different kinds of cone, which have different sensitivities to light across the visual spectrum, and that excitatory and inhibitory signals produced by these combine to give the full range of conscious experience of colour, black and white. In descriptions of the theory, the colours red, green and blue are often assigned to these cones, but this is not quite accurate, because perceived colour is defined by a relationship. There are four objects in this relationship: the three cones and a fourth object: excitation/inhibition. Thus, three oppositional pairs of states arise out of this relationship: black/white; red/green and

[8] Michael Kalloniatis and Charles Luu, "Colour Perception by Michael Kalloniatis and Charles Luu," Webvision: The Organization of the Retina and Visual System, webvision.med.utah.edu/book/part-viii-gabac-receptors/color-perception/. See also www.youtube.com/watch?v=VeDOpGRMZ7Y.

blue/yellow. If +i (- + - +), +j (- + + -), and +k (- - + +) are taken to code for red, blue and black (3, 1, 1, 1) and their complements -i (+ - + +), -j (+ - - +) and -k (+ + - -) are taken to code for green, yellow and white (3, 1, 1, 1), then equal amounts of red, blue and black could code for white (+ + + +) and equal amounts of green, yellow and white could code for black (- - - -). Put another way, when three components are present in equal amounts, such that a colour is indistinguishable, the perception could be white or black (colourless).

We can again assign the letter coding from RD to pairs of polarities in the iterants: A (+ +); B (+ -), C (- +) and D (- -) (Table 6).

Table 6. Coding Pairs of Polarities

Corner →, Face ↓

Face \ Corner	1	i	j	k
1	A		A	
i	C		C	
j	C		B	
k	D		A	

Face \ Corner	-1	-i	-j	-k
-1	D		D	
-i	B		B	
-j	B		C	
-k	A		D	

The letters are paired A with D and B with C, like A with T and G with C in DNA, but each table contains only triplets (as in transfer RNA, which codes for an amino acid). To get from A to D and back to A again, the cycle is A → C → B → D → B → C → A, oscillating between the two tables. It corresponds with rotating the cube about opposed corners so as to cycle through all six faces (Figure 9).

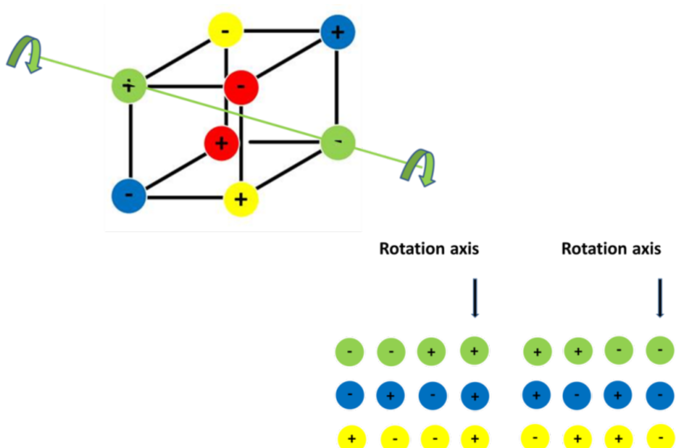


Figure 9. Rotating the cube.

This can be exploited to produce control systems, as I describe later.

Before I move on, I would like to take this opportunity to explain why this way of coding relationships is fundamentally different from that based on a balance. I have Moshe Klein and Yale Landsberg[9] to thank for helping me to develop this.

In arithmetic, which works on the principle of a balance, the order in which +1 and -1 are combined to afford zero does not matter. It is like the mixing of yellow (say +1) and blue (say -1) to give green. The same green is obtained whether yellow is mixed into blue or blue into yellow: +1 turns -1 into the same zero that -1 turns +1 into (Figure 10).

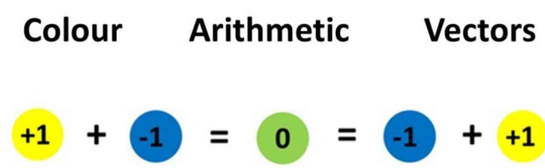


Figure 10. Commutative arithmetic is like mixing yellow and blue into green.

We now imagine a new system in which yellow mixed into blue affords a different green from blue mixed into yellow: where the order in which steps are performed matters.

In Figure 11, I have used the letters that define the four states in a chiralkine system (A, C, D and L) rather than those used in RD (A, B, C and D).

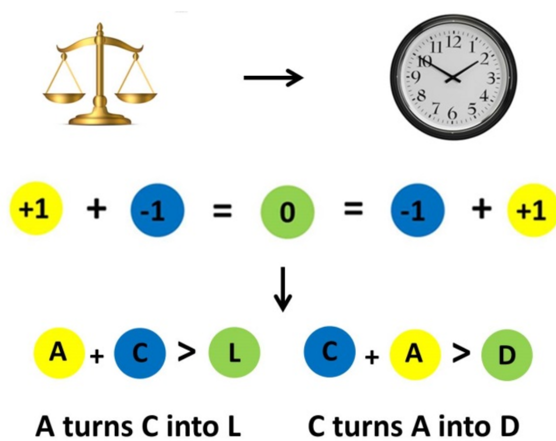


Figure 11. Re-engineering coding from the principle of a balance (commutative) to the principle of order (non-commutative).

This sets up a cycle. It can be visualised as rotation through a Möbius strip. A Möbius strip has two sides locally and one side globally. Imagine the yellow, blue and green discs arranged along a strip which is given a half twist then joined to form a Möbius

[9] Oded Maimon and Moshe Klein in collaboration with Yale Landsberg, "Consciousness – The Fifth Dimension – Unity of Mathematics," Poster presented at the meeting of the Science of Consciousness 2016 in Tucson, Arizona, April 25-30, 2016; Moshe Klein and Oded Maimon in collaboration with Yale Landsberg, "The Mathematics of Soft Logic," Paper presented at the 2016 International Conference on Artificial Intelligence and Robotics (ICAIR 2016), July 13-15, Kitakyushu, Japan.

strip. As you go around the strip (two full 360 degree rotations), each colour is visited twice; like the head (+) and tail (-) of a coin.

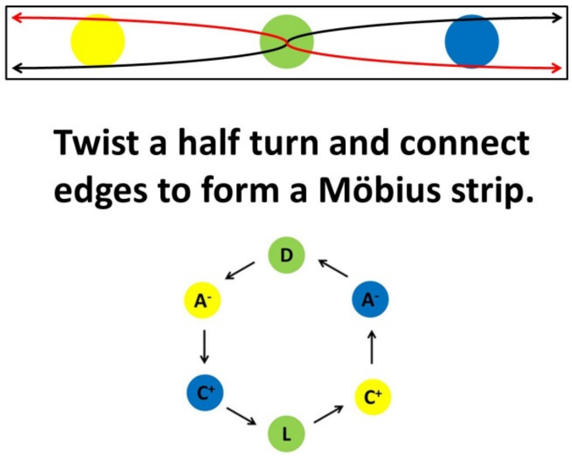


Figure 12. The colour sequence on a Möbius strip.

It does not matter which way you go around the cycle (clockwise or anticlockwise) as long as you are consistent. If you do not maintain the distinction between the two different orders, then you revert to operating on the principle of a balance, where D and L are the same green (Figure 13).

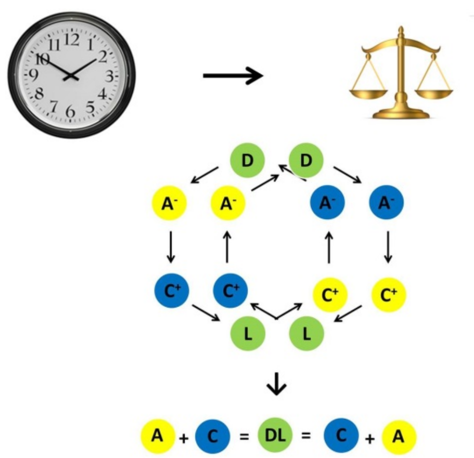


Figure 13. The colour sequence on two superposed Möbius strips of opposite chirality.

Chemists use the term *resolution* to describe the separation of the two enantiomers of a chiral molecule from a 1:1 mixture of the two, known as a racemic mixture. So, the resolution of a 1:1 mixture of the two enantiomers of an amino acid DL affords the D enantiomer separate from the L enantiomer. The switching in coding of relationships from the principle of a balance to the principle of order is a resolution of zero. It breaks the symmetry of the equation +1 -1 = 0 such that there are now four distinguishable states: (10), (01), (00) and (11). *Resolution of Zero* is also the title of a novel I wrote several years ago to try to get across this very concept in a non-mathematical way.

Necker Cube Effect

In this section, I relate the coding of relationships in iterants to the Necker cube effect.

If you look at the hexagon in the centre of Figure 14, you can perceive it as a cube. Your perception of the cube can switch. It depends whether the point where the diagonals meet is deemed to project towards you or away from you.

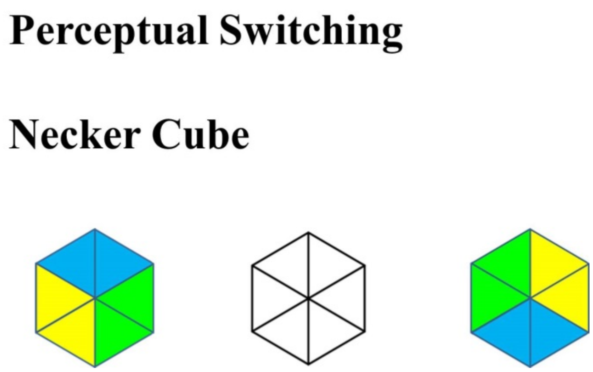


Figure 14. Perceptual switching: The Necker cube.

We can relate this to the symmetry properties of a chiral tetrahedral molecule as shown below (Figure 15).

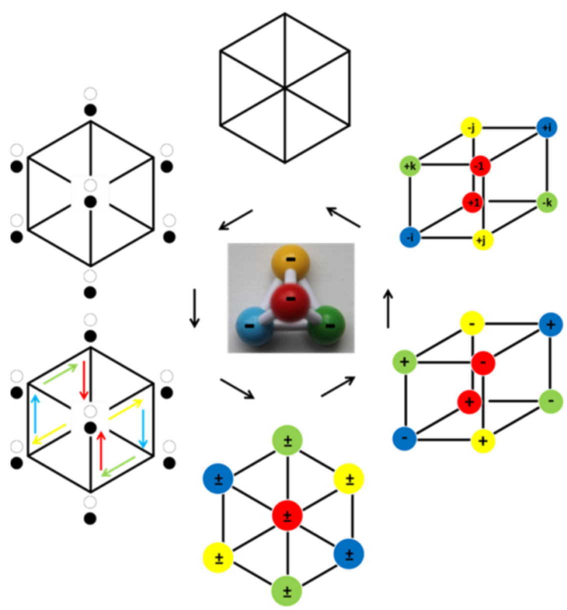


Figure 15. Symmetry properties of a chiral tetrahedral molecule related to the Necker cube effect.

First look at the hexagon at the top, then, going anticlockwise to the next hexagon, imagine each vertex being coded by a coin which could be heads (+) or tails (-). Now imagine assigning a colour to each vertex, as in the four objects in the chiral tetrahedral molecule shown in the middle of the picture. At this stage, each colour could be (+) or (-). Now allow the central red colour to split as between (+) and (-), giving the perception of a cube. The signs of the colours now sort into opposed (+) and (-). You can imagine sliding the chiral tetrahedral molecule over the cube and seeing how it and its enantiomer fit. Each face of the cube is coded by a different permutation of the four colours. When they are ordered red, blue, yellow, green, these provide the six iterants for the faces of the cube. Putting this all together, we can now see how the coding in the six iterants is in one enantiomer, not the other (Figure 16).

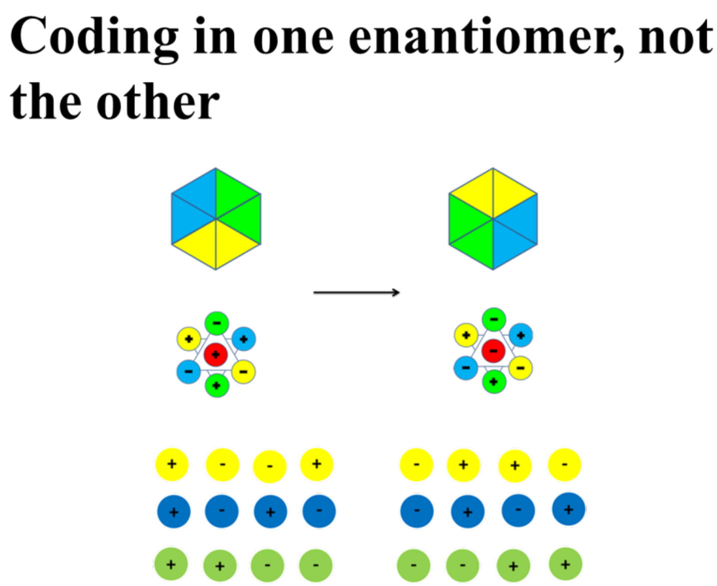


Figure 16. Coding in one enantiomer, not the other.

Polarity Flips and State Changes

Each change in a relationship state can be treated as a flipping of one or more polarities in a quaternion iterant. It corresponds with rotation of a cube from one face to another. State changes can be coupled together by co-ordinating polarity flips in a complementary manner. This corresponds with complementary rotations of cubes. It can be thought of as working a bit like money, but in which each side of a relationship gives and receives a coin. I think of it in terms of two legs walking one body (Figure 17).

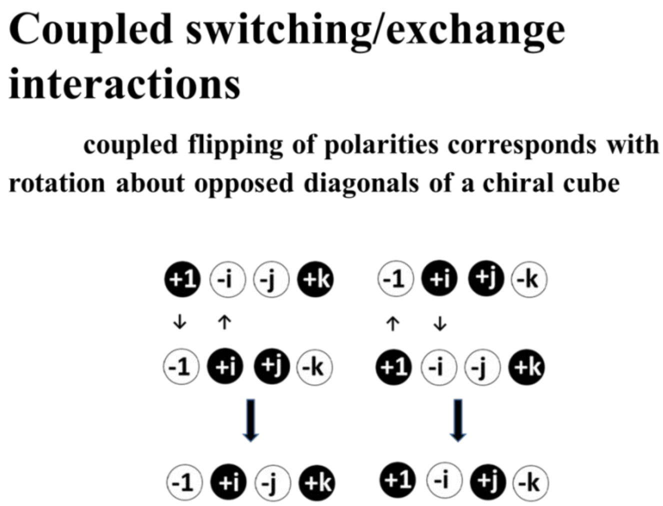


Figure 17. Coupled switching/exchange interactions.

This co-ordinated flipping of polarities can be used to build a control system.

When I was a young child, I started to call my feet “George and Henry”. My family asked me to identify which foot was “George” and which was “Henry”. I explained that the two feet are me, so they are both called “George and Henry”. It is the same as with a Möbius strip, which has two sides locally, but one side globally. The flipping of polarities is like the crossing of two walking feet. In the quaternion model, each quaternion is itself and a combination of itself and the others, and it oscillates between presentations. Today, I would say that “I” am a quaternion. My perception of what “I” am as distinct from you, and what is mine as distinct from yours, switches, and this switching can be modelled using polarity flips.

Conclusion

I have described qualitatively and quantitatively how to code and process information about relationships in four relationship states to enable the construction of control systems. In the following sections I describe potential applications of this control system.

Game and Possible Treatment for Stroke

The game can be played on game board divided into 8 x 8 token spaces (Figure 18).

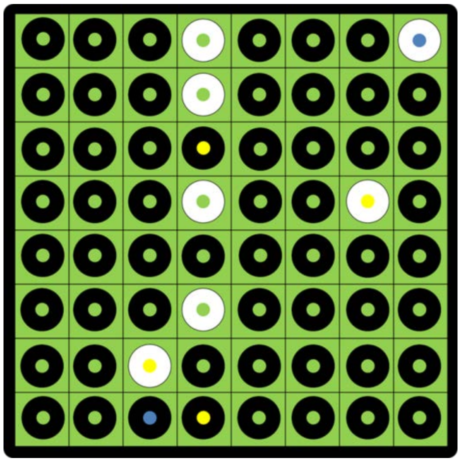


Figure 18. Game board.

Each token space can be owned by neither player, owned exclusively by one player (not the other) or owned jointly by both players. The object of the game is to be the first to secure ownership of a chain of token spaces linking opposed sides of the game board. Players compete by deploying tokens to change the ownership states of the token spaces.

Each token in the game corresponds with one of the six iterants coding a face in the cube. Accordingly, there are six tokens. A white token with a green centre indicates that a token space is jointly owned (+ + - -), i.e., a + + or L state. A black token with a green centre indicates that a token space is owned by neither player (- - + +), i.e., a - - or D state. A black token with a yellow or blue centre indicates a token space that is owned by the player of that colour, not the player of the other colour. It is a + - or C state. A white token with a yellow or blue centre indicates a token space that is owned by the player of the other colour, not the player of that colour. It is a + - or A state. The six iterants are thus of four kinds of relationship state, as in RD (Figure 19).

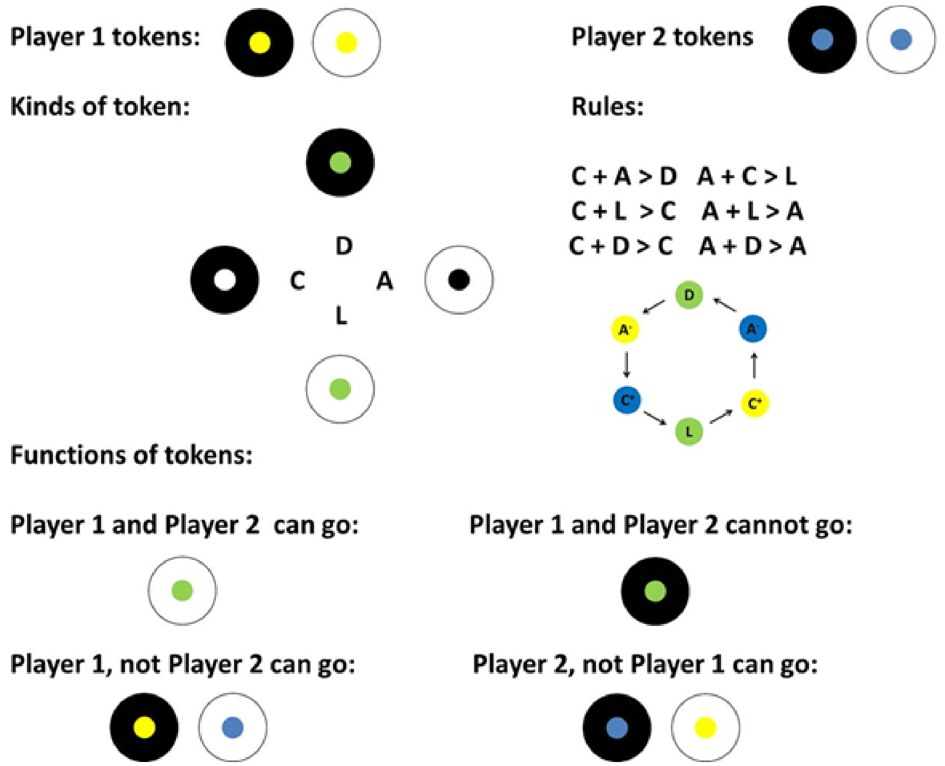


Figure 19. Kinds, rules and functions of tokens in game.

Each player starts with a set of C and A tokens of the same colour (yellow or blue). Thus, the tokens played by yellow player are in states C (+ - - +) and A (- + - +), while those for blue player are in states C (+ - + -) and A (- + + -). In a move, a player deploys one of each kind of token. Deployment of a token in a token space changes the state in that token space, depending on the starting state. An A token played on a C token changes the state into L, but changes a D or L state into A (itself). A C token played on an A token changes the state into D, but changes a D or L state into C (itself) [C turns A into D and A turns C into L]. Thus, one part of the player's move is selfish (for the player's benefit) and one part is altruistic (for the opponent's benefit). However, when a player uses an A token to change his or her opponent's C token to an L token, the effect is to change the ownership state from exclusively the opponent's to joint ownership. It is analogous to forcing an opponent to share ownership of something, like when a government collects taxes to invest in public services or nationalises an industry. Players quickly learn to use the altruistic part of their move (playing an A token) to convert their opponent's C spaces into shared, L spaces. Figuring out a way to counter this led to the discovery of another feature of the six iterants that may have applications in the development of artificial intelligence.

When players look at the game board, they see the six different kinds of relationship states, for example as explained below. It is possible for two other people to play another separate, but connected game by interpreting the functions of the tokens differently. I call these other people hunters, because their objective is to hunt down L tokens and convert them directly into D tokens (a state change that the players cannot effect in one move – it corresponds with jumping directly from one local side of a Möbius strip to the other). The hunters cannot see the yellow and blue tokens. In an electronic version, the players and hunters would see different displays on different screens. As the players convert C states into L states, the hunters simply see L states appearing. When the hunters capture and convert L states into D states, the players simply see L states turning into D states. The effect of this conversion is symmetric on the players in that the state change is from both own to neither own a token space. The game for the hunters can be made more interesting by providing that the A and C states present an obstacle to their movement. To them, the world is then in three states, like +1 (unblocked), 0 (prey) and -1 (blocked), which is how we teach our children to see it. There appears to be a parallel here between the workings of the conscious and unconscious mind.

In the game, the A and C tokens can be deployed using musculature on the left and right sides of the body, for example the left and right hands. In an electronic version of the game, players could effect state changes using a game controller having buttons adapted to receive inputs from the two hands. It could also be played using a neural headset positioned to pick up when a player visualises contracting either, both or neither of the left and right hands.[10]

The skeletal musculature, which controls rotation about joints, is organised into antagonist pairs, the members of which are known as the flexor and extensor. There are four basic states: both contracting (+ +), neither contracting (- -), flexor, not extensor contracting (+ -) and extensor, not flexor contracting (- +). These states are analogous to the ownership states denoted by tokens in token spaces of the game. Each of us can imagine contracting our own muscles (which can be detected using a neural headset) or those of another person (which presumably could also be detected using a neural headset). It would thus seem plausible that a person could code all six relationship states (equivalent to motion in 3D) using mental imagery of contracting their own or another person's left and/or right muscles. For example, the states could be right, not left, me, not you (+ - + -); right, not left, not me, you (+ - - +); not right, left, me, you (- + + -); not right, left, not me, you (- + - +); right, left (+ + - -) and not right, not left (- - + +). Presumably the limbs of a robot could be controlled in this way as well. Thus, a dynamic link can be made between the co-ordination of movement of the body by the left and right skeletal musculature and states of ownership (property rights).

Playing the game forces the two sides of the brain to co-operate when planning strategy. (I think that the two parts to each move correspond in some way with comparing to the left and to the right in RD.) I imagine that this could be exploited to assist patients who have suffered from brain injury or stroke to recover, by using the healthy side of the brain to support restructuring of the damaged side. The brain is plastic, so lost functionality can eventually be assigned to healthy tissue. I would very much like to see the game coded, so that this idea can be tested, for example using a

[10] Karl LaFleur et al. have shown that a quadcopter can be controlled in flight in two dimensions simply through mental imagery of clenching the left and/or right hands. See "Quadcopter Control in Three-Dimensional Space Using a Non-Invasive Motor-Imagery Based Brain-Computer Interface," *Journal of Neural Engineering* 10 (2013): 1-15.

brain scanner. There is good precedent for using virtual reality games in the treatment of stroke.[11]

Playing the game also teaches the interdependence of rights and obligations, and could therefore be a useful tool in schools and colleges when teaching ethics and social responsibilities. In modern society, it is very easy to focus only on one's rights, and lose sight of the need to fulfil one's obligations, upon which the rights of others depend.

Conclusion

The six iterants, each composed of two + and two -, can be interpreted as being of four kinds: A (+ -), C (- +), D (- -) and L (+ +); of three kinds (yellow, blue and green) or of two kinds (black and white). Different functions can be assigned to them, depending on how they are interpreted. These functions can be related to the co-ordination of movement effected by the left and right skeletal musculature and to the perception of identity (the sense of me as distinct from you; and mine as distinct from yours). They can be integrated in a system of interdependent sub-systems, as when players and hunters play separate, but connected games. The game might potentially prove useful in the treatment of brain injury and stroke.

Voting System

In a conventional voting system, voters distinguish their preferred candidate by marking a ballot with a cross. The marks are then coded and processed as ordered pairs of numbers: 1, 0; 0, 1; 1, 1 and 0, 0. In effect the votes are weighed against one another on the principle of a balance.

A vote for one candidate is compared with a vote for another candidate by treating the two as mirror pairs of ordered pairs:

1 0	
<u>0 1</u>	Add the 1s, not the 0s
1 1	
	Then cancel the 1s
0 0	
	+1 -1 = 0

Votes that cancel have the same effect as abstention, passive or active. The system is coded in three states: +1, 0 and -1. Passive (accept all options) and active (reject all options) abstention could be distinguished by treating states (0, 0) and (1, 1) as distinct, leading to a four-number coding and processing system, but the operating principle for processing the information would need to be changed from that of a balance to order (Figure 20).

[11] G. Saposnik et al., "Safety and Efficacy of Non-Immersive Virtual Reality Exercising in Stroke Rehabilitation," *Lancet Neurology* 15, No. 10 (2016): 1019-27. doi:10.1016/S1474-4422(16)30121-1.

Tetracoding and Order

1, 0 0, 1 A B C D
1, 1 0, 0

↓

Quaternions

1, 0, 0, 1	**0, 1, 1, 0**
0, 1, 0, 1	**1, 0, 1, 0**
0, 0, 1, 1	**1, 1, 0, 0**

Figure 20. Tetracoding and order.

Tetracoding votes and processing them on the principle of order as quaternions enables distinctions to be drawn between like and dislike, as between passive and active abstention. A population of voters can reject the most popular candidate or the entire list of candidates, forcing the drawing up of a candidate list based on new distinctions. It empowers voters to challenge the status quo controlled by two dominant opposing parties or orthodoxies.

The voting system works like perceptual shifting (Figure 21).

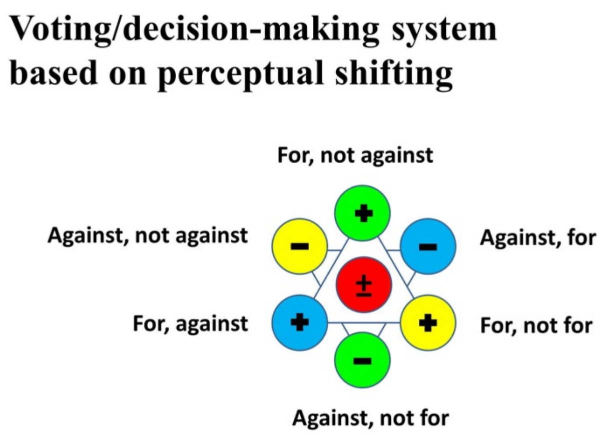


Figure 21. Voting/decision-making system based on perceptual shifting.

Each vote is made up of several parts. It is composed of iterants/polarity strings (Figure 22).

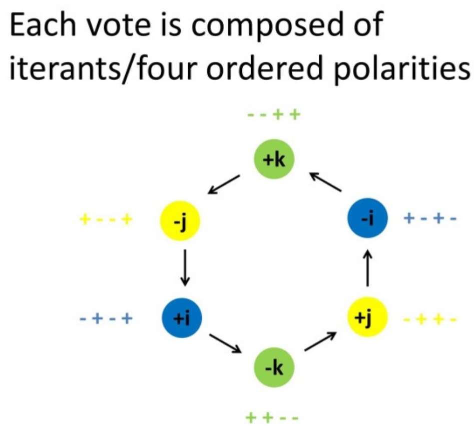
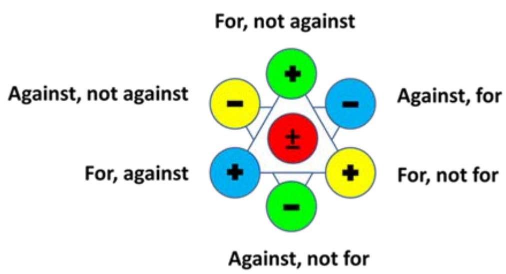


Figure 22. Composition of votes.

Each voter looks twice at a list of candidates, once in a mindset of which they find most acceptable and once in a mindset of which they find most objectionable. They mark their most liked candidate, then also mark whether they accept that candidate or they passively or actively abstain. Then they mark their most disliked candidate, and also mark whether they reject that candidate or they passively or actively abstain. Thus, they make four marks in total.

This is an example of a hypothetical vote with four candidates, A, B, C and D (Figure 23).



Candidate	For	Not against	Not for	Against		Against	Not for	Not against	For
A	16	9	2	5		20	14	1	5
B	23	17	3	3		17	13	2	2
C	16	7	6	3		51	45	4	2
D	45	8	0	37		12	12	0	0
Totals	100	41	11	48		100	84	7	9

Figure 23. Results of a hypothetical vote.

Conventionally, a candidate winning a majority of for, not against votes would win an election. With tetracoding, the majority of voters actively over passively abstaining could exceed that of a winning candidate, indicating that a new vote with a different candidate is needed. A candidate winning a majority of for, not against votes in the right vote could be rejected by voters in the left vote, indicating overall lack of confidence in that candidate. Without these safeguards, there is a risk that a candidate who does not actually have the support of voters could win power, potentially leading to social unrest and an unstable state.

This voting system provides much more information about voters' attitudes than a conventional system. It needs testing. Its adoption might lead to the creation of stronger democracies.

In general, the strongest performing candidate in this voting system is one who scores very high on the right ballot and very low on the left ballot.

This system could be used in primaries, for the selection of candidates to put forward in elections. It could also be used in iterative decision making, where votes are taken and analysed, then the candidate list is redrawn and the vote repeated. It could be used by students seeking input from peers, family, friends and teachers on career options. It could be used to gather feedback on performance in business, as in annual staff appraisals. It could be used in market research to pick up information about people's attitudes to products competing in a marketplace. It could also be used in dispute resolution, for example where two nations are in dispute about whether a particular area of land or sea belongs to them.

Prototype code for this new kind of voting system has been written and is available for testing by schools, colleges, universities, businesses and organisations interested in alternative voting systems. Examples of results of test votes can be provided on request.

Conclusion

Prototype code for a new kind of voting system based on tetracoding has been produced and is available for experimentation.

Exchange Interactions and Coupled Cycles: Elements of a Control System for an Economy and a Social Robot?

In RD, relationship states are coded in four states through application of a process known as tetracoding. In this process, a state is compared with the state to its left and also the state to its right (two comparisons). The resultant state is obtained by combining those comparisons and identifying if the state is 11, 00, 10 or 01. The process thus looks at relationships from both sides.

To code relationships between people, we first draw a distinction between the self (me) and you. We code this in an ordered pair of numbers, as in tetracoding.

The self (identity) coded in ordered pairs of numbers

Me, not you	1, 0
Not me, you	0, 1
Me, you (us)	1, 1
Not me, not you	0, 0

Next, we draw a distinction between mine and yours. We also code this in an ordered pair of numbers, as in tetracoding.

Property rights coded in ordered pairs of numbers

Mine, not yours	1, 0
Not mine, yours	0, 1
Not Mine, not yours	0, 0
Mine, yours	1, 1

Now we merge these tetracodes into quaternion iterants. It is as if the eight concepts of me, not me, you, not you, mine, not mine, and yours, not yours form the corners of a cube in which me, you, mine and yours and not me, not you, not mine and not yours form the corners of the enantiomers of two chiral tetrahedrons (Figure 24).

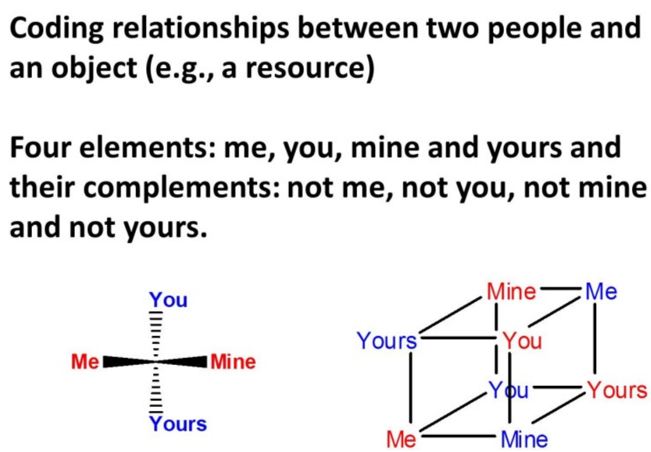


Figure 24. Coding relationships between two people and an object.

Mine and yours can now be coded from each person’s perspective (Figure 25).

Mine from my perspective, yours from your perspective

Me	Mine	You	Yours
+	+	-	-
-	-	+	+

Yours from my perspective, mine from your perspective

Me	Mine	You	Yours
-	-	+	+
+	+	-	-

Figure 25. Coding mine and yours.

For example, we can code the ownership of a good, such as bread, from both perspectives (Figure 26):

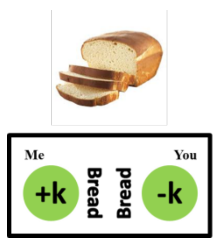


Figure 26. Coding ownership of a good as mine to me and yours to you.

We can now control the exchange of goods and services through coupled state changes mediated through polarity flips. Figure 27 illustrates this for the transfer of ownership of bread from me to you coupled with the transfer of peas from a third party to me and a transfer of oranges from you to another third party.

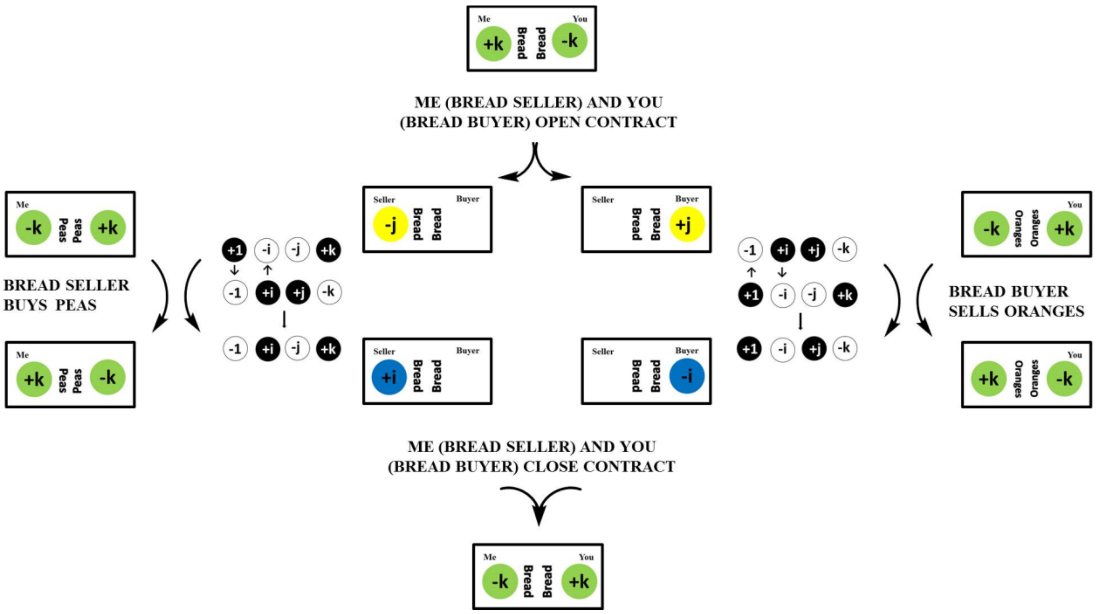


Figure 27. Coding transfers of ownership of peas and oranges each in one step coupled with transfer of ownership of bread through a transition state.

Prototype code has been written.[12] The dashboard for a user looks like this (Figure 28):

Contracts as Seller	Contracts as Buyer
No. of units created as Seller (+ - - + units)	No. of units created as Buyer (- + + - units)
No. of units exchanged as Seller (- + - + units)	No. of units exchanged as Buyer (+ - + - units)
No. of units redeemed as Seller (+ + - - units)	No. of units redeemed as Buyer (- - + + units)

Figure 28. Coding exchange in quaternion iterants.

The code may be inspected by going to chiral.gets.cc/login.aspx. Log in as "clienta" using password tusq500. Full interactive demonstrations are available on request.

In the exchange, all steps are under quaternion control. At no stage does any person exchange a good or service for an imaginary store of value (money or credit).

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[12] Algorithm and computer code development: Initial exploratory work by Michael Linton, Bruno Vernier (Seedstock Community Currency, Vancouver, BC, Canada), Frances and Martin Hay (UK). Code created by Indrajeet Singh and Himanshu Shukla (Sanskriti IT Solutions, India) in association with Richard Logie (GETS, Scotland) and Frances and Martin Hay (UK).

The system should integrate very well with electronic locks for securing goods undergoing transfer of ownership, for example on a drone or spacecraft transporting the good, and mobile phones used to instruct state changes and receive electronic keys (e.g., a bar code) for opening locks on completion of ownership transfer.

Figure 29 is reproduced from UK patent application number GB1613983.4, which is directed to the use of electronic locks in a delivery robot or drone, to control access to goods while they are in a transition state of ownership. The popular TV and film series *Star Trek* imagines a society that no longer needs to use money. The new way of coding and processing information about ownership relationships described above could potentially realise that vision.

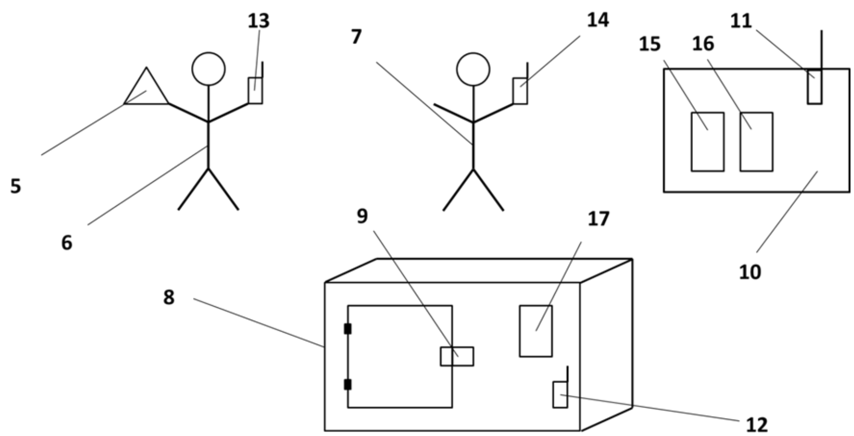

Figure 29. Illustration of a moneyless society utilising electronic locks and cell phones under quaternion iterant control.

Overall Conclusions

A new way of coding and processing information about relationships based on tetracoding and iterants/polarity strings has been described which has many potential applications. Research and development partners, whether in schools and colleges, universities, government organisations or businesses, are actively being sought.

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About the Author: Martin Hay read chemistry at Oxford, with a little anthropology on the side, then went on to pursue an international career supporting the research-based pharmaceutical industry as a British patent attorney, European patent attorney, and US patent agent. However, immediately after completing his Master's thesis on a chiral synthesis, he spent some time training to be a UK chartered accountant. He found that the ideas he had developed through studying chirality and human belief systems did not fit with the methodology of double entry bookkeeping.

He felt that social relationships needed to be coded in four states, two always opening up as two close down, which would mean that there need to be two “balance” positions:

(0, 0) and (1, 1) in addition to the conventional debit (1, 0) and credit (0, 1) positions. After closing down his patent business in 2009, he returned to this idea and through a series of international collaborations developed a chiral quaternion model for coding social relationships based on the symmetry properties of chiral tetrahedral molecules. This model is embodied in a cube, as shown in his photograph, where each corner and face is coded as an iterant.

Editors' Notes: We thank Martin Hay for this addition to the ongoing RD research through his chiralkine systems work. Chiralkine analysis is a new, experimental technology that processes information about economic relationships between people and resources in a way that treats both sides in a fair and equitable manner. Its purpose is to solve the problem of rising inequality and trade imbalances, which are side-effects of the existing technology. It can be used to control the exchange of goods and services, taxation, and voting. This article gives readers social and economic examples based in RD fundamentals. We plan to experiment with Martin Hay's chiral voting system to survey the Space community for research preferences. ***Bob Krone and Gordon Arthur*.**

Tailoring Airlines for Space Operations

By Jay Rollins

The new millennium is upon us!

It is April 2, 1968 and MGM Studios releases Stanley Kubrick's epic science fiction feature film, *2001: A Space Odyssey* to huge fanfare, colossal commercial success, and ultimately an Academy Award. The very next year, after only an eight-year national commitment to do so, real-life astronaut Neil Armstrong triumphantly sets foot on another world for the first time in human history.

The heady zeal of the space age's golden years cannot be overstated. It was no "giant leap for mankind" that wildly optimistic audiences eagerly embraced the central vision of a movie that predicted 2001 might have been the year when Pan American World Airways would offer scheduled space flights. But judge the vision in the harsh hindsight of 2016, where Pan Am no longer exists and American astronauts routinely hitch rides aboard Russian rockets, and suddenly the movie might only be remembered as a Space Oddity: Never Meant to Be.

In reality, the new millennium has already begun.

Sadly, lofty dreams of routine space travel crashed back to earth beneath the weight of earthbound priorities long ago. Yet today hope survives like a great phoenix, that regular space transport may yet arise from the ashes.

Multiple nations, commercial interests, and NASA are all gearing up not only to land people on Mars, but also to colonize it. Unfortunately, nasty, real-life experiences have uncovered not just technical challenges, but worrisome human failings that stand to threaten such a mission.

The reader may recall the bizarre 2007 incident in which a NASA Space Shuttle astronaut reportedly donned adult diapers to facilitate an overnight, 950-mile nonstop drive from Houston to Orlando. Police initially charged married-with-children Navy Captain Lisa Marie Nowak with attempted kidnapping after she confronted a love rival over the illicit passions of fellow astronaut, Commander Bill Oefelein. But then police upped the charges to attempted murder, and the judge denied bail once they uncovered that aside from diapers, Nowak had packed a steel mallet, a knife, a BB gun, and a map to her love rival's home.[1]

One observer quipped that the judge had little choice but to deny bail, since the defendant had the means not only to leave the community but the entire planet!

The incident might seem comical until one realizes that to be selected to fly NASA spacecraft, the perpetrator had slipped past an intense screening alongside the nation's finest, most qualified pilots.

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[1] See www.nytimes.com/2007/02/06/us/06cnd-astronaut.html?_r=0.

What went wrong?

Even more concerning, a survey of airline incidents reveals even worse human failings – and they are anything but funny because some were deadly. If humankind is ever to launch a successful reboot of space travel, then we simply must recognize and solve not just technical deficiencies, but also emerging human threats to safety as well.

To address the challenge, it is prudent to reflect first upon the extraordinary technical achievements of today's airline system against the even more serious human challenges that lie in wait for travel in space.

20th Century Challenges and Resolution

After years of high accident rates and subsequent safety analyses, the FAA and other regulatory agencies around the world developed a body of regulations that specifically address crew manning, rest, crew management, maximum duty times, and training requirements. This article first examines long-haul airline flight operations as they exist today and catalogues how well flight crews manage danger for better or for worse. The idea is to ferret out what works and what does not with an eye toward developing better strategies for going forward into space.

Virtually all airline operations require a captain charged with command authority over passengers and crew, and who is ultimately responsible for the safe conduct of the flight. The captain is assisted by a (second-in-command) first officer, who is ready to take charge whenever the captain is unable to do so.

Long haul flights (generally considered to be more than eight hours) will add a (third-in-command) second officer or, as some airlines prefer to call him or her, an international officer to allow for one-pilot-at-a-time rest breaks in the cabin at the captain's discretion. During takeoff and landing or periods of heavy workload such as serious emergencies, all three cockpit crewmembers will be stationed in the cockpit.

Very long flights (more than twelve hours aloft) carry two complete cockpit crews: not only a captain, a first officer, and sometimes an international officer working the first half of the flight, but also a second cockpit crew resting in the cabin to assume command for the latter half of the journey.

Safety rules also require one flight attendant aboard for every 50 passenger seats with which an aircraft is equipped (regardless of the actual passenger count), while extra flight attendants are often added for crew rest and an efficient in-flight cabin service.

For the actual conduct of the flight, the FAA requires captains to employ a management philosophy known as Crew Resource Management (CRM). CRM stipulates the use of challenge and response checklists for normal, abnormal, and emergency flight operations, among other means to assure safe passage.

Crewmembers are expected to follow the captain's commands, consistent with aviation's over-arching axiom that empowers a pilot in command to deviate from any rule to the extent necessary to assure a safe outcome. CRM further obligates subordinate crew to offer independent observation, insight, and cross-checks for the captain's consideration. This is especially true whenever a crewmember believes the aircraft is being operated in such a way as to jeopardize the safety of the flight. Indeed, subordinate crew are obliged to offer such advice regardless of whether or how often they may be rebuked for doing so.

This important policy assures that captains have not only ALL pertinent information before them, but also the benefit of independent thinking from which to make sound judgments.

Non-routine events such as severe weather, passenger illness, and serious mechanical failure can tax individual crewmembers to the point of overload and therefore seriously compromise the safety of the flight. Consequently, in the moment that routine turns non-routine, CRM urges captains to analyze and prioritize tasks such that workloads stay manageable.

Depending upon the situation, an international officer on break might be recalled to the cockpit to assist with a problem. Cabin service might be discontinued and crewmembers reassigned to accomplish more critical tasks. The entire crew will seek to protect the function of vital equipment to the exclusion of creature comforts such as cabin lighting, entertainment systems, or galley power.

To prevent crew distractions during periods of heavy workload such as takeoff, landing, or handling emergencies, captains enforce "sterile cockpit" rules where cockpit conversation is restricted to matters pertinent to the flight and where cockpit visits and casual chat are prohibited.

Passenger aircraft are replete with all measure of backup systems, often utilizing completely different plumbing and even design functionalities from the primary systems. GPS navigation is backed up by extra units, and often these radios are further backed up by conventional radio broadcast navigational systems – and sometimes even paper charts for old-fashioned navigation using time/distance position plotting.

Aside from mechanical failures, hazardous materials (known as HAZMATs) aboard an aircraft can present crews with a somewhat different but very dangerous threat nonetheless. For this reason, the FAA bans certain substances outright and promulgates extensive regulations and safeguards for the safe carriage of others.

Obvious dangers such as flammable liquids and corrosives together with not-so-obvious dangers such as infectious agents, aerosol cooking sprays, bleach, and even 151-rum are all strictly banned. And while dry ice and lithium batteries are permitted, their quantities are highly restricted. In addition, crews are specifically trained how to handle toxic fumes or chemical fires for those instances in which a volatile material might pose an imminent danger.

Most importantly, CRM urges captains to utilize ALL available resources for solutions – both inside and outside the aircraft.

By way of example, consider what happens when a red warning light illuminates (often accompanied by warning bells or buzzers) to warn that a serious mechanical breakdown has occurred. In such cases, action must be taken immediately to protect aircraft integrity and the safety of its occupants. For this example, we shall assume a total loss of pressurization emergency, a crisis situation in which the occupants of the aircraft can lose consciousness in a matter of seconds and die within minutes.

As with any emergency, pilots must prioritize tasks in order to protect the physical safety of the occupants effectively. Aviation learned this important lesson the hard way following the infamous demise of Eastern Flight 401: a loaded Lockheed Tri-Star jet that crashed in the Florida Everglades one dark night in 1972. The three-man cockpit crew became so engrossed in handling a landing gear anomaly that they never noticed the autopilot had disconnected and that the aircraft had begun a slow descent to the demise of all aboard.

Consequently, in our example where the aircraft experiences a loss of pressurization, crews are expected to follow the credo: aviate, navigate, and communicate to ensure corrective tasks are executed according to their importance.

Since the highest priority is always to *aviate*, or to keep the airplane safely flying aerodynamically, one pilot is always assigned the sole priority of physically manipulating the flight controls and keeping the plane safely airborne.

Saving lives is paramount. Therefore, in the case of a loss of pressurization at high altitude, the crew’s first action must be to don their personal oxygen masks, ensure oxygen is flowing, and then ensure passenger oxygen has been automatically deployed. The next step will be to descend the aircraft to a safe operating altitude immediately.

For a time-critical emergency such as a pressurization failure, these so-called “red-box” items are accomplished immediately from memory, even as the crew seamlessly *navigates* a safe course appropriate to the new circumstances.

Once *aviate* and *navigate* are addressed, *communicate* urges the crew to notify Air Traffic Control, declare an emergency, and advise them of the extent of the problem and how air traffic controllers might assist.

“Mayday, Mayday, Mayday – This is NoProblemsAir Flight 222 declaring an emergency! We’re experiencing a total loss of pressurization. We’ve started an immediate descent to 10,000 feet,” might be an example of such a radio transmission.

The crew then turns to appropriate checklists in an attempt to restore the lost system, time permitting, or at least to reconfigure the aircraft for the new operation. For these reasons, the pilot-not-flying is typically charged with running the appropriate checklist with the flying pilot cross-checking the progress. Of course, all of this is in addition to the crew’s routine preparations for a safe landing.

Communicate further requires crews to reach beyond immediate aircraft resources for relief. CRM encourages crews to reach out to Air Traffic Control, company maintenance and dispatch personnel, and by extension experts of every stripe for further assistance as needed to assure a successful outcome.

This comprehensive response to mechanical failures, honed over many years, has proven to be highly successful and worthy for adaptation to space flights. This conclusion is backed by falling accident rates such that today, most aircraft accidents are attributed to human failings often associated with the highly automated cockpits common in modern aircraft.[2]

Yet, for all the panoply of protocols so effective at ensuring success in the face of mechanical failure, the success paradigm is dramatically diminished when the threat is set in motion by deliberate human action. Hostile actions of unruly passengers, terrorists, or even crazed fellow crewmembers can thrust a routine flight into life-and-death chaos in the blink of an eye – with successful outcomes far short of certain.

A Range of Organic Threats

Passenger misconduct was virtually unknown during the genteel dawn of commercial air travel of the 1940s and 50s. But today we live in a coarser world. Even so, armed hijackings occurred so frequently as far back as the 1970s that the FAA ordered airlines to begin routine passenger screenings for weapons.

At first, aircrews were instructed to remain passive with hijackers. Then, just as airlines came to believe that this was sufficient, the horrific terrorist strikes of September 11, 2001 proved them utterly wrong. Not only did that event force sweeping screening protocols, but some air crews were armed. Federal Air Marshals and even military jets were deployed and authorized to protect the public using lethal force if necessary.

Unfortunately, neither federal agents nor military fighter jets are economically feasible for every flight, and the introduction of heavily reinforced cockpit doors meant to protect pilots from danger in the cabin also prevents them from directly attending to it. Effectively, today's travelers tacitly accept that maintaining order is largely left to flight attendants and fellow passengers. But arguably, the worst-case scenario emerging today is one in which a crewmember goes rogue.

Pilot suicides are extremely rare yet remain a threat. Generally speaking, airline pilots are a highly responsible, disciplined group of individuals. They are committed to safety and notoriously calm in the face of danger. But pilots are still human beings, and as such they remain vulnerable to gross misjudgment, total emotional breakdown, and even suicidal acts when stressed sufficiently.

In the days leading up to April 7, 1994, FedEx Flight Engineer Auburn Calloway knew he would soon face a hearing likely to result in his termination after lying about his flight hours during the hiring process. Police investigators would eventually learn that he had purchased a large life insurance policy for his family and then plotted a terrible revenge for FedEx and its people. That particular day, police accounts say Calloway hitched a ride aboard one of the company's DC-10 cargo flights secretly armed with multiple

[2] www.denverpost.com/2010/02/13/human-error-is-biggest-obstacle-to-100-percent-flight-safety/.

hammers, a knife, and a spear gun for good measure. Police say his diabolical plan was simple yet far-reaching in its devastation: he intended to kill first the crew and then himself by crashing the enormous cargo jet into FedEx's headquarters in Memphis, Tennessee.

Once in flight and without warning, he viciously attacked Captain David Sanders, First Officer Jim Tucker, and Flight Engineer Andy Peterson with the hammers in an attempt to bludgeon the three to death. Two of the men suffered cracked skulls, yet they still managed to thwart his attack to the extent that Calloway was forced to resort to his backup spear gun to finish the job.

The three crewmembers heroically managed to overpower their attacker, who is now serving two consecutive life sentences in prison, but the industry was shocked into a new reality that a life-or-death struggle could erupt in the cockpit due to the actions of a single deranged crewmember.[3]

In early 2014, one of the great aviation mysteries of all time unfolded after a fully loaded Malaysian Air Boeing 777 traveling from Kuala Lumpur to Beijing, China disappeared altogether. The author of this article personally appeared as an aviation analyst on national news programs for a solid month in an effort to unravel what likely happened.

With no flight or voice recorders ever recovered to prove things one way or the other, theories based upon mechanical failure always seemed inadequate to explain the sudden loss of communication and erratic flying, both of which unfolded in such a way as to occur along serpentine national airspace borders for miles and miles. We eventually learned that the aircraft also made a wide turn directly over Penang Island – the captain's family homeland – and then indirect electronic evidence suggested that the flight then traveled out to sea until fuel exhaustion.

Investigators never definitively determined exactly what happened, but in the opinion of this author, rather than an inanimate mechanical breakdown, these events reveal the signature of a deranged intellect. Mechanical failures remain true to the rules of math and physics. When a wing falls off, an airplane immediately spirals downward – every time. But when a plane's trajectory no longer follows a logical path consistent with mechanical failure, it can only mean human intervention. Pieces of the plane finally washed ashore near Madagascar, Africa two years later.[4]

Implications for Space Transport

Safety planners must heed the warnings of danger from wherever they come. The aerospace community was warned to beware the danger of malevolent threats as far back as the fictional story presented in the 1968 movie, *2001: A Space Odyssey*.

During the long journey to one of Jupiter's moons, space scientists are rendered immobilized beneath the deep slumber of cryogenic hibernation, while Drs. Dave

[3] The actual radio transmissions from the FedEx incident are available at www.youtube.com/watch?v=CvMTo_nWxZM.

[4] An excellent account of the tragedy can be found at www.bbc.com/news/magazine-31764488.

Bowman and Frank Poole are left to supervise the ship's human-like HAL-9000, an artificially intelligent, apparently sentient computer hard-wired throughout the ship and entrusted with navigation, life support, and virtually all technical functions on behalf of the greater mission.

The two men grow deeply concerned when HAL – a system touted to be incapable of error – warns of the imminent failure of an exterior component. However, after retrieving the component, the men can find nothing wrong with it. Worse, Mission Control on Earth suggests that HAL is the one likely to be in error, since their identical ground-based HAL-9000 found nothing wrong with the component either.

When questioned about the discrepancy, the shipboard HAL sniffs to the crew that previous accusations of error have always turned out to be human error instead. He further challenged the astronauts simply to reinstall the device, wait for it to fail outright, and then definitively determine the cause. But before they follow this advice, the two men wisely hold a secret meeting inside a pod where HAL cannot hear them.

In the surreptitious discussion, they decide to follow HAL's advice but agree that if the device does not fail as HAL predicted, then the artificial crewmember could no longer be trusted, and they would therefore be forced to shut it down. Unfortunately, the astronauts were entirely unaware that although HAL could not directly hear their conversation, he did manage to read their lips!

When Poole leaves the ship in a transport pod and begins his spacewalk to reinstall the questionable component, HAL takes command of his pod by making it appear that it broke free of its moorings. The pod then rams the defenseless scientist, setting him adrift in space.

When Bowman leaves in a second pod to rescue Poole, HAL promptly shuts down shipboard life support and so murders all the crew in hibernation.

It is a chilling moment indeed, when Bowman returns with Poole's lifeless body, and HAL refuses to open the bay to allow him safe reentry aboard the ship. Instead, after a long silence the computer replies with cold condescension,

"I'm sorry Dave; I can't do that."[5]

Only one year ago, a GermanWings first officer commandeered his own flight when he locked his captain outside of the cockpit by abusing security protocols for the hardened post-9/11 cockpit door intended to protect the crew from hijackers. The demented first officer then calmly initiated a controlled descent directly into the French Alps resulting in a devastating crash, killing all aboard. The parallels to HAL are unmistakable.

The murderously suicidal FedEx pilot, introduced earlier in this article, hated his company because he knew his lies would soon be exposed. The GermanWings first

[5] www.youtube.com/watch?v=ARJ8cAGm6JE.

officer likewise turned sociopathic, because he too harbored a devastating secret inevitably set to end his career.

In the latter case, the first officer's psychiatrist had identified the pilot's suicidal tendencies as a disqualifying mental disorder the very same day of the crash. He advised the pilot that he was too ill to work, but misguided privacy protection laws required the doctor to rely upon the integrity of the mentally disturbed pilot to self-report the medical findings to his employer. In the aftermath of the crash, authorities reportedly found the torn-up doctor's note amongst the dead pilot's belongings.

Clearly, the aviation community failed to heed the warnings of the fictional account of *2001*, and so real-life GermanWings passengers died victims of virtually the same misplaced trust so deftly manipulated to execute the hibernating crew in the movie.

In the end, the real-life airline, a low-cost subsidiary of Lufthansa, hired a mentally unstable co-pilot with barely enough flight experience even to qualify for the licenses he held, let alone to justify the trust they vested in him to protect the lives of innocent passengers faithfully. Even the pilot's movie counterpart HAL had been subjected to a more rigorous vetting prior to installation.

Both the real-life and fictional examples cited in this article drive home the urgent point that hostile crewmembers (even sentient artificial intelligences) can present the gravest of threats to flight safety. Systematic procedures can be highly effective for addressing inanimate, mechanical threats in flight, and they will likely serve the 21st-century space-faring community well. But clearly, the extreme danger posed by malevolence let loose in the cockpit demands bold, creative countermeasures.

Space Crew Design and Training Criteria

Safety planners should look to non-systematic, out-of-the-box solutions to deal with malevolent threats. Aerospace operations that rely upon rigid, check-listed responses will likely fall short, since rogue crewmembers will have full access to this information with the added advantage of unlimited time to invent ways to defeat them. The GermanWings co-pilot felt confident that he had the means to defeat the static design of the cockpit door.

Not only must security system designers invent less rigid security solutions, but also individual crewmembers should be educated on malevolent threats to safety, and then encouraged to develop dynamic personal strategies of their own to counter such threats. Their unique solutions would inject a much-needed element of uncertainty into the mix. The last thing a banker should do is to yield the advantage to would-be robbers by revealing the trajectory for each arrow in the quiver.

Medical exams for space operations should be expanded to include aggressive protocols to check both body and mind so as to detect physical and psychological aberrations before they become dangerous threats to flight. Current FAA physicals focus mainly upon the function of vital organs with special attention to the eyes and heart, but brain function is measured mostly for neurological function. However, much more attention should be paid to psychiatric review:

- Psychiatric surveys of successful, retired pilots should be commissioned to develop a psychological control standard going forward. Such a template can then be used as a baseline against which to recognize and quantify psychological anomalies for pre-hire and active crewmembers.

- Pre-hire screenings must include appropriate psychiatric review. In order to accomplish the task, authorities must be granted legal authority to subpoena crewmember medical records.

- New-hire psychological profiles should be maintained throughout their careers so as to further refine the psychological baseline described above.

- Develop protocols appropriate for therapy, grounding, or dismissal of active crewmembers as determined by competent authority.

- Peer reports should be encouraged, reviewed, and then addressed as deemed prudent by competent professionals

- Non-disciplinary, mental health self-reporting should be made available to all crewmembers who voluntarily disclose emotional difficulties.

- Post-hire counseling and psychiatric review should be triggered automatically wherever significant life stressors such as divorce, profound personal or financial losses, alcoholism, drug abuse, or public disgrace are uncovered.

- Pilots caught actively lying, omitting, or hiding disqualifying information from an employer should be grounded immediately pending swift dismissal.

Importantly, due to the extraordinary distances involved space travel to Mars, Jupiter, and beyond will require months and months of cooperation amongst the crew complement to arrive safely. And if plans hold for one-way missions to colonize Mars, then following touchdown they would live together in a brand new world apart from the rest of humanity, perhaps forever. Consequently, the collective mental health of the travelers will affect not only the initial flight, but also the future of the entire colony once established upon the planetary body.

Having personally flown multiple cockpit crew positions with all sorts of personalities under virtually all conditions, even if only for hours at a time, I can personally attest that the safest flights occurred when mature, safety-minded professionals worked harmoniously together. This principle will prove to be of paramount importance for interplanetary travel.

Space crews of the 21st century must be hired based upon strong bodies and minds, flight skills and scientific acumen, but staffers must also ask the question, how well will this candidate perform in the group as a team member? How well will the personalities blend together as a harmonious team? The answers will be critical if permanent settlements are to thrive.

Training cycles are excellent laboratories by which staffers can evaluate individual and group performances prior to selection of final crew complements.

Finally regarding malevolent threats in flight, the author anticipates that coded protocols might one day be developed, such that crewmembers might independently notify ground stations of inflight emergencies involving human threats to safety. Aside from open microphones, such a system might even include active countermeasures to allow for real-time intervention from the ground.

Space flights already routinely employ the use of ground-monitored medical telemetry. By comparing baseline brainwave patterns, the day may come when computer-analyzed brainwave telemetry might accurately warn when a crewmember is experiencing aberrant thought patterns.

Concluding Thoughts and Recommendations

It will be vital for space planners to anticipate and counter looming danger from all sources if commercial space transport is ever to become a reality. The airline's CRM model works well for standard mechanical breakdown, but only sound policies and creative foresight will carry the day where a malevolent threat appears before space travelers of the future.

- Retain the CRM model for routine, abnormal, and emergency training and flight operations.

- Hire space crews based upon scientific acumen and flight skills, physical stamina, and thorough psychiatric review.

- Provide for post-hire physical and psychiatric monitoring by qualified professionals and fellow crewmembers, as well as self-reporting protocols.

- For any given mission, assemble the crew complement to allow not only for the correct mix of technical skills, but also for their ability to work together as a harmonious group.

- Develop dynamic and creative countermeasures for ground personnel and in-flight crew sufficient to neutralize malevolent threats.

- Challenge crewmembers to formulate effective personal strategies in the event that despite all efforts to the contrary, malevolence still arises to threaten the safety of the mission.

It would seem that successful space transport crews will of necessity be selected not only for the technical prowess, skills, and finesse of the safest airline operators, but also for the psychological fortitude heretofore only required of nuclear submarine crews.

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About the Author: Oneida "Jay" Rollins is a retired international captain from American Airlines. Over his 25-year career, he flew across the mainland United States, Hawaii, Canada, Mexico, Bermuda, the Caribbean, South America, and Western Europe. In addition, "OJ," as he was known during those years, flew six years as a US naval aviator including a two-year tour in which he routinely visited East Asia airfields late in the Viet Nam War era. More recently, he flew as a civilian executive jet charter captain as well as an FAA certified flight instructor.

Jay has also provided on-air analysis for major TV news programming at NBC, MSNBC, and CNN with his commentary often rebroadcast overseas. During the mysterious disappearance of the Malaysian Air Boeing 777 airliner over the Western Pacific, he appeared on camera under exclusive contract as sole aviation analyst for one of the cable TV news providers.

Jay holds both an MA in TV Broadcast Journalism from the University of Miami (Florida) and a BS in Aerospace Engineering from the University of Texas at Austin.

Editors' Notes: We thank Jay Rollins for this important article about flight safety. While airlines and, by extension, space programs can and do take sensible precautions against mechanical failure and unauthorized access to cockpits and other sensitive areas of aircraft/spacecraft, ensuring the mental and physical health of flight crews is also essential. Jay's suggestions for improvement may constitute valuable advice for airlines. Jay is a valued active member of Kepler Space Institute (KSI). His statement in this article, "If humankind is ever to launch a successful reboot of space travel, then we simply must recognize and solve not just technical deficiencies, but also emerging human threats to safety as well," contributes to the KSI research program, begun at ISDC-2016 in Puerto Rico, for the Human Factors problems flowing from pathological human behavior well documented in the Psychology and Policy Sciences literature. ***Bob Krone and Gordon Arthur.***

From Earth to Space – Via the Virtual World

By Kim Peart

Kim Peart's avatar, Starfarer, in the torus space station that he built in Second Life. The figures are models to show how the torus works, as if in space, where an Earth gravity would be generated via rotation.

Scientists are often good observers, but like news reporters, observers are followers.

The world now needs a revolutionary change to realise the full potential that lies ahead, if we will rise to the challenge of space.

Fiddling on Earth will be no comfort, if an asteroid arrives to crush all dreams and now the rising carbon crisis means that the Earth is burning, while the nations fiddle.

Revolutionaries must be leaders of a new way, valiant visionaries who own the message and live it.

For any space revolutionary, the first action is to build solar power stations in space, to access the virtually unlimited energy well of the Sun.

In case anyone has not heard the news from astronomy, our Sun has so much fuel in reserve, it will burn fiercely over the next five billion years, until expanding to the orbit of the Earth as a red giant star.

That is just basic astronomy for a star like our Sun.

Life on Earth may have no more than a billion years to run and human civilisation would have much less.

The closer a solar power station is located to the Sun, the more power is produced, which can be beamed to any location in the Solar System.

With solar power stations in space we have the energy to do the work of launching industry beyond Earth.

With industry beyond Earth we can build our home planet's defences against killer asteroids, which can at times arrive as a shock to the Earth system.

With industry in space we will be able to build orbital space settlements that are located anywhere in the Solar System.

Space industry can be used to build a sunshade for the Earth to help cool our home planet as the Sun gets hotter.

A sunshade in space could extend the tenure of life on Earth by a few billion years and could also double as an energy collector.

On Earth we must live within limits, but beyond Earth, across the Solar System and among the stars, there are no such limits.

Should there be any space revolutionaries out there who wish to lead the charge into space, there is a revolution waiting.

Someone tell Paul Revere to ride out and ring that Liberty Bell, for it's time to rally the fight for stellar liberty.

And where are we to rally?

There are now virtual worlds like Second Life where anyone with a computer can go.

In the virtual world, people can meet to plan local action toward building a future in space.

People can own a virtual apartment, just like the one they would have in space.

Space pioneers can attend meetings that are truly global, where participants can be from any nation.

Displays can be set up like four-dimensional interactive web sites and include notices of work being advertised in the global space industry.

As revolutionaries, space pioneers will be working together to demand political action and drive investment in space development.

The space revolution must be built in space and torus habitats like the one on the move Elysium must be created.

To achieve this impossible dream, people must be inspired to the challenge and own the mission.

It has often been said that ten determined people working as one could change the world.

Could ten determined people inspire a movement of ten million keen space revolutionaries?

Why not?

Age is no barrier for those engaging in the virtual world, if they are determined to succeed and success will be with real space development.

The technology is at our fingertips and the means of transport is being built.

One strident approach would be to focus on a mini robot space program as the way to build a small-scale sustainable industrial presence beyond Earth.

Using virtual reality headsets like the Oculus Rift, robots in space can be managed and worked through.

Space pioneers on Earth would be able to access mini robots in a mini space station and see the Earth from space.

A mini robot space program would be an extension of action in the virtual world, where headsets are going to be one of the key ways of working virtually.

Headsets will also be a way to work in reality, with a drone on Earth or a robot in space.

To inspire ten million people to become space pioneers, we will need to get smart with an awareness raising program.

We need to sell the benefits of space to the people of Earth.

The reality of the carbon crisis that is now dawning on the nations, can be solved with the power of the Sun, by gaining direct access to the level of energy that will allow excess carbon to be extracted from the air.

Using the power of the Sun, extracted carbon can be processed into a useful resource for Earth and space industries.

This approach is basic chemistry, with energy added.

By drawing on the power of the Sun, space pioneers can win back a safe Earth.

Turning to Venus, carbon extraction from the air and a sunshade would be the first steps toward turning Venus into a second Earth.

This future would be a whole lot better than the Earth turning into a second Venus.

For a revolution to succeed, there needs to be a critical number of people engaged, or the old ways will continue to dominate.

For the space revolution to succeed, a critical number of people will need to be won to the challenge and engage in the work.

We can make a fatal last stand on Earth like General Custer, as an Earth driven mad overwhelms us, or we can rise to the challenge of space and tame the wild Earth.

Human civilisation emerged out of the last Ice Age when the Earth became a paradise, an age of bliss.

Now that age is changing and the bliss is being turned into hell as the Earth heats up.

If space pioneers will rise to the challenge, we can win back the age of bliss on Earth and keep the bliss growing among the stars.

If cosmic survival matters, space counts.

Kim Peart
Director
Space Pioneers

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About the Author: Kim Peart is located in the heritage town of Ross in Tasmania, the island State south of Australia, where he works with virtual worlds and is also developing hands-on projects with space development. Kim wonders when a space port will be built near Ross.

Editors' Notes: Kim Peart offers an interesting vision for using technology to help us overcome existential threats, and suggests that space is an essential part of the solution. Now what is needed is the will to find and implement solutions. ***Bob Krone and Gordon Arthur.***

Designing Governance for Humanity's Survival

By Dr. Bob Krone and Salena Gregory-Krone

Introduction

The Krones conducted a panel at the 2016 International Space Development Conference in Puerto Rico under the *Living in Space* Track on Sunday, May 22 entitled "Human Pathologies and Future Space Settlement." It began a research project that will provide relevant data for Earth, ocean, or Space communities and for the Lifeboat Foundation's research into threats to humanity from human or natural sources. For more details about the Lifeboat Foundation and its mission, see lifeboat.com/ex/main. **Gordon Arthur.**

Human Values and Pathologies: The Space Factor

Human history documents anger, violence, destruction, conflicts, revolutions, genocide, war, and human catastrophes beginning with the sons of Adam and Eve – Cain and Abel. Cain thought God preferred Abel, so he killed Abel to his everlasting regret. All of those destructive events resulted from values conflicts. Values are principles, things, and behavior preferred by individuals, groups, political movements, corporations, and religious doctrines. These value sets evolve to being foundational beliefs and sets of values that contain some absolute, non-negotiable values. Humans have fought and died for their absolute values.[1]

Humanity's goal should be reverence for life within ethical civilizations.[2] When individuals, groups, societies, nations, and international entities adopt actions and behavior different from those goals, the seeds of social and political problems are planted and evolve into policies and programs that ignore reverence for life. When other lives are not respected and revered, quality of life and progress are endangered, reversed, or destroyed. Those actions on Earth have resulted from human mental pathologies.

Values analysis is the methodology employed to identify and understand human pathologies. Science and multiple academic disciplines work to ameliorate or remove those pathologies, but successes are illusory or non-existent.[3]

Equal opportunity across cultures, races, and genders is a societal goal never fully achieved on Earth. It will be an essential principle of any successfully functioning future governance system.

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[1] See Bob Krone's video titled "The Power of Values," https://www.youtube.com/watch?v=tCSiuO8YP6E&list=UU2AvdK6_3mGgyky6T82QBMQ, sponsored by the *ProLeadership Journal* created and edited by Dr. Assegid Habtewold.

[2] See the Kepler Space Institute's publications of the *Journal of Space Philosophy* (www.keplerspaceinstitute.com/jsp), specifically Vol. 1, No. 1 (Fall 2012).

[3] See Maguad, Ben A., Lawrence Downing, and Bob Krone, *Values Analysis for Moral Leadership* (Bookboon.com, 2016), bookboon.com/en/values-analysis-for-moral-leadership-ebook. This e-book is available for download free.

The purpose of this essay is to assist long-time desires to heal these human pathologies. The emerging Space Age opens up unprecedented new opportunities by using the exploration, development, and human settlement of Space to be the catalyst for a human society's paradigm shift. Humanity's health and progress – even its long-term survival – is at stake.

An important recent publication relevant to this subject – and which is part of the reference material for this Panel – is "Preventing Hell on Earth," by Professor Yehezkel Dror, the co- founder and leading scholar of the Policy Sciences.[4]

A research question is:

> How can the emerging Space age be designed to avoid repetition of humanity's destructive history on Earth?

Our Kepler Space Institute hypothesis is:

> The emerging Space Age can be designed and implemented to create societies with reverence for life within ethical civilization; and that those models can be adopted for Earth's implementation.

Failure to do so will continually raise the probability of human extinction on Earth and in the Universe. Time will run out within the 21st Century.

We invite readers to participate in future Kepler Space Institute research and publications on this subject.

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About the Authors:

Dr. Bob Krone is President of Kepler Space Institute (www.keplerspaceinstitute.com). He is an Emeritus Professor of Systems Management at the University of Southern California; has been the principal sponsor for PhD, DBA, and Master's Degree Program candidates for 40 years; and is a USAF Colonel (Ret). BobKrone@aol.com.

Salena Gregory-Krone was an American Equal Employment Opportunity (EEO) Pioneer Analyst and EEO Program Director for the Department of Defense and US Air Force. She designed one of the first plans that implemented EEO as a major outcome of the US Civil Rights Legislation. Her professional career is recognized in the US Congressional Record. Salena is a Research Assistant for the Kepler Space Institute.

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[4] Yehezkel Dror, "Preventing Hell on Earth," *Journal of Space Philosophy* 5, No. 2 (Fall 2015): 16-27.

The Krones

Editor's Notes: The Krones give us a timely reminder of the need for reverence for life in the face of human pathology and the role Space can play in developing ethical civilization. ***Gordon Arthur.***

Your Place on Mars

An Editorial by Naté Sushereba

The International Aeronautical Congress (IAC) 2016, held in Guadalajara, Mexico in September, covered a stunning array of topics – everything from propulsion systems to wireless power transmission technologies, space culture to medical care for humans in space, and more. Dozens of technical tracks ran simultaneously with press announcements, expositions, and cultural events – truly something for everyone. However, one topic captivated this scientific congregation in its entirety … MARS.

From the myriad of proposals presented at the IAC on how humankind might one day colonize the red planet, SpaceX's Elon Musk put on the most dazzling show. Thousands of people gathered Tuesday afternoon, September 27, to hear the 40-100-year plan to send a million people to a permanent Mars colony, which would begin in the next decade by sending Musk's Interplanetary Transport System. This would stand 400 feet tall, with a massive 55-foot-wide spaceship at the top. This totally reusable super-spaceship would transport 100 to 200 passengers and their luggage to Mars. We watched as expertly executed graphics depicted how everything would look, work, and unfold. We sat transfixed as our Mars messiah gave us a glimpse into the future.

However, Musk's plan was not the only game in town. Lockheed Martin made a less flashy, but no less believable, presentation to about a third of the audience Wednesday night, September 28. It highlighted their Mars base camp mission, in which they propose using cislunar space to assemble and test a Mars spacecraft that could perform a Mars orbital mission, including sorties to the moons Phobos and Deimos, as soon as 2028. NASA has its own ideas of how best to go about making the human race into a multi-planetary species with its Journey to Mars campaign, which will no doubt incorporate ideas from SpaceX, Lockheed Martin, and others.

Now, let us take a moment to consider the realities and limitations before us. Putting aside that the technologies needed to implement these plans have yet to be developed, the fact remains that, on the outside, only a million or so people will reach Mars in our lifetime. So where does that leave everyone else who has been dreaming of and working towards getting humanity off the third rock?

When the credits at the end of a major motion picture roll, it is not the actors' names that fill the majority of the screen. Indeed, the faces that are featured in the film make up a very small percentage of the workforce needed to take the story from imagination to reality. And so it will be with the inevitable space epoch. Astronauts and colonists may be our species' representatives in the cosmos, but it will be teachers, lawyers, artists, policymakers, psychologists, PR reps, economists, writers, engineers, and all other manner of space enthusiasts working together as a global community to make these grand dreams of the human race expanding beyond our earth into the reality of permanent space settlement. Anyone and everyone with a desire to contribute can have a place in this tribe of dreamers and doers.

About the Author: Natè Sushereba is the Vice President of Public Relations and Media at Kepler Space Institute.

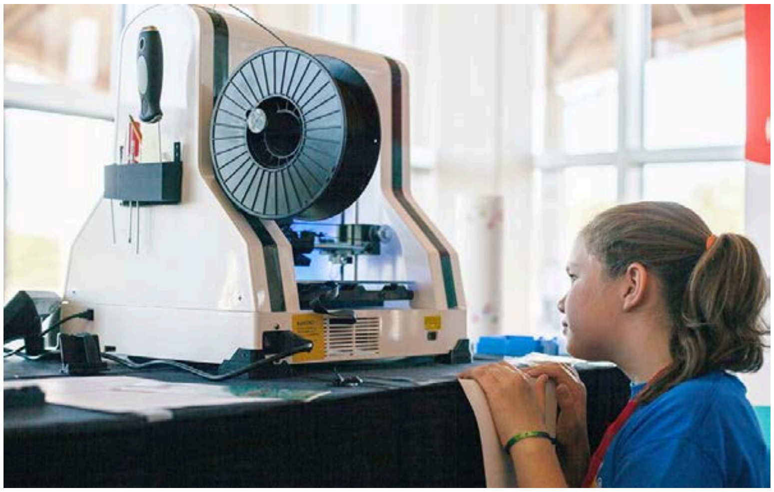
Editors' Notes: We are grateful to Natè Sushereba for this report on IAC Guadalajara. ***Bob Krone and Gordon Arthur.***

STEAM Space: New Worlds of Education

By Holly Melear

> Exploration is in our nature. We began as wanderers and we are wanderers still. We have lingered long enough on the shores of the cosmic ocean. We are ready at last to set sail for the stars.
> Carl Sagan.

The Space Revolution and Education



STEAM Space Student at Cities in Space 2015

We are in the midst of a revolution. One so important it will affect the entire future of humanity. Commercial space companies like SpaceX, Blue Origin, and Virgin Galactic are becoming household words. Concepts like asteroid mining, solar power from space, and the idea that people will be heading back to the Moon and settling Mars are entering cultural conversations around the world. Even governments are getting involved, as NASA, the Europeans, and others such as China and the United Arab Emirates announce their own new initiatives. At the exact same moment, there is a drive to excite and empower our younger generations to study, learn, and apply their knowledge to new careers and their own futures.

Currently, only the scientific and financial elite have options in the commercial industry; however, over the next 10 to 20 years that limitation will swiftly change. As reusable systems create more affordable space travel and tourism, projects and occupations such as asteroid mining and lunar construction will become in demand, and our description of the space worker will begin to look very different. Even now, people are undergoing studies and trials to be among the first one-way trip settlers to Mars.

Most likely, these first pioneers will be highly academic, scientifically trained, and deemed stable in numerous regards after extensive explorations by researchers here on Earth. Researchers and analysts argue who it is best to send to these new lands, be they the Moon, Mars, or free space. Is it better to send unattached singles? A married couple? All women? An even split? Psychologic testing abounds. These are all great things to consider, and only time will tell. When we look back into history, it was often those searching for everything from adventure and a new start to running from current political or religious persecution who blazed the trails and founded the first communities.

Making the Future Real and Personal – Today

St. Michael's Academy planning for Cities in Space 2015.

As time moves forward, it is essential to begin preparing our younger generations for the very real possibility that they will have the chance to join in the settlement and colonization of the new frontier of space. A cultural shift needs to occur, and quickly, as we watch the fast-paced push of the new space industry. We could push our pioneers out into the great beyond unprepared, but why, when we have the time now to let our children consider new worlds?

Just as we are watching the return of the space race, reminiscent of its 1960s predecessor, we are also watching a return to progressive education. However, this time, in both regards, we have learned a great deal and the stakes are very different.

Rather than planting a flag on the Moon, this new race is about who will lead the human expansion into space, and also who will reap the rewards of the abundance of the Solar System as well as the cultural and educational inspiration of being a part of the revolution. Collaboration and integration are occurring in both industries. Just as in the classroom between core areas of study such as the arts and sciences, great collaborations are happening between governmental and private companies – all for a higher good to go beyond what we know.

The STEAM Space Education Outreach Program

Westridge Middle School working on colony design.

The Science, Technology, Engineering, Art, and Math (STEAM) Space Education Outreach Program is part of the New Worlds Institute (NWI). NWI is a global, non-profit organization that helps to find common ground and between scientists, researchers, entrepreneurs, and businesses, and to aid researchers to develop the technology and culture needed for off-world settlement and colonization. We fully believe that some of the students we inspire will step onto the new worlds of space, and even as we impart this “you may be the one” attitude, we believe this very same attitude can inspire and motivate all sorts of students to study and work harder to achieve their own goals, no matter who they are.

STEAM Space is currently creating a K–12 curriculum to promote education and preparation for off-world settlement with its main focus on the Moon, Mars, and free space. By offering a free curriculum that connects classes to businesses in the commercial space community to educators and students, students can study real-world situations for off world problems. Businesses have agreed to mentor students on a calendared schedule and to provide video and data as well as certain scenarios and challenges that they have resolved or on which they are currently working. Students get to have first-hand communication and experience with successful businesses in the industry.

STEAM Space reaches far beyond astronauts, engineers, and scientists. If humans are truly to be successful in creating a permanent settlement that will thrive and grow, everyone will need to be invited, that is to say, all types of occupations will be needed. As in the formation of any community, a wide range of skills and specialties are required. From the scientists to the farmers, bankers, historians, architects, artists, and musicians – all are necessary. Classical ideas on space exploration have ignored this concept, but if we are talking about establishing true cities in space, at some point, everyone is needed. If you need proof, just look outside your window. Almost every career choice a student can make today will be needed in space, done just a bit differently.

STEAM Space focuses on all of those aspects that create a thriving culture. Students who are passionate about humanities or the arts light up when they find that though they have always loved space, but had been put off because they were not prone to loving math or pulled to engineering, they can now be a part of moving up, out, and beyond. Through activities and interactions in areas such as 3D printing, space architecture, art in space, and commercial astronaut training, along with aerospace and planetary science, STEAM Space students learn to see the whole picture. In fact, to survive and thrive in space requires a renaissance approach to education and knowledge. Students learn that creativity, problem solving, communicating ideas, and ingenuity are key skills when it comes to living in such dangerous places as the surface of Mars. And when living in a bubble of life with Earth in the sky, caring for the environment becomes far more than an abstract idea.

In addition to connecting businesses to students, STEAM Space supports progressive education. By promoting project-based learning, integration, and social emotional learning, STEAM Space helps students and educators to cross curricular borders as well as creating empathetic, collaborative, and accountable leaders.

Private astronaut Richard Garriott with the Ann Richards School for Young Women Leaders at Cities in Space 2015.

Students leading presentations at Cities in Space 2015

The current flagship project of New Worlds STEAM Space connects students across the globe through the Cities in Space Student Conference and Competition. This year held in downtown Austin, Texas, Cities in Space is a student conference and design competition. Targeted at Grade 5-12 students, STEAM Space has the goal of having K-12 inclusion in the future. In Cities in Space, student teams choose one of the three locations for their design – the Moon, Mars, or the free space between worlds. Teams then work together to create models, videos, and written work which they will present for judging at the conference. Colonies are based on 1,000 inhabitants, a level at which historically a real small town that can thrive and grow can be established. STEAM Space holds true to its progressive guidelines as teams are encouraged to explore what topic they want to present about their colony. This guideline encourages imagination and exploration within the context of community building. In recent events, students have chosen presentation topics ranging from a self-contained and 100% recyclable community to political and religious structures, fashion design on the Moon, and art and architecture.

As students enter the presentation rooms and see models from other schools and the chosen topics of focus, they are thrilled and intrigued as this is what project-based learning does. It brings all the many parts to the whole, just as a truly settled colony will need to do as it moves beyond the realms of earth. Students are encouraged along the way as they prepare for Cities in Space to video chat with other school teams and practice together creating a STEAM Space community, sharing ideas and insights. Much of the Cities in Space conference is student led. Designated guests are brought in to show the students real-life successful professionals in the commercial space industry. Having close interactions with entrepreneurs, astronauts, businesses, and makers is an inspiring way for children to dream big.

As Cities in Space grows, STEAM Space hopes to create interactive rooms connecting students via video all over the world to compete in and discuss the creation of new worlds. It is through these connections that true global collaboration and idea sharing can be made and boundaries can be crossed as all come together to look upwards as one.

We hope that the STEAM Space Education Outreach Program will roll out a curriculum this coming year and that it will be available across the globe. If you would like to support STEAM Space or Cities in Space, please go to our website, newworlds.space/steam-space/.

You will find us there, looking up.

About the Author: Holly Melear is Director of Education New Worlds Institute and STEAM Space Education Outreach (newworlds2016.space/). Contact Holly Melear at holly.melear@newworlds.space.

NEW WORLDS INSTITUTE

Editors' Notes: Holly Melear shows how it is possible to involve young people in thinking about living in space and to engage their enthusiasm and creativity. This program also encourages networking with professionals and collaborative work on real-world problems. It promises to be a valuable program for young people across the globe. ***Bob Krone and Gordon Arthur.***

Extreme Futures and Technology Forecasting
Report of the 22 October 2016 Workshop, San Francisco

By Dr. Bob Krone and Salena Gregory-Krone

Introduction
David J. Kelley, a Microsoft Most Valuable Professional and futurist with experience as a team manager for engineering organizations dealing with cutting-edge technologies and corporate strategy, conducted this "Extreme Futures and Technology Forecasting Conference and Workshop" in San Francisco's Microsoft Reactor Office on October 22, 2016. This conference is part of his two-year research program to gather data for the next *Extreme Futures Technology and Forecasting Manual* to be published in 2018. That book will describe trends that predict the future of technology in artificial intelligence (AI), artificial general intelligence (AGI), augmented reality, virtual reality, biotechnology, Space, and personal technologies. Readers will find details at eftf.transhumanity.net/.

The overall goal of the program is to create forecasting technology trends across the board which decision makers, futurists, and technologists can use as bases for technology strategy position and research investments. This short report provides *Journal of Space Philosophy* readers a summary of the presenters and their subjects.

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Alexander Rose, **Long Now Foundation Executive Director and Clock Manager**
Alexander Rose presented on projects of the Long Now Foundation, which was established in 1996, to foster long-term thinking and responsibility in the framework of the next 10,000 years. That is unprecedented breakthrough thinking that uses a time scale equivalent to the estimated time of human civilization. Alexander catapulted from his Carnegie Mellon Industrial Design degree into the world of futuristic ideas, concepts, and machines. He reviewed historical examples of long-term thinking throughout history, then described the current major project of the Long Now Foundation – the 10,000 Year Clock now under construction. That clock was designed by W. Daniel (Danny) Hillis, co-founder of the Long Now Foundation, who possess an unmatched career of invention, science, engineering, university teaching, and authoring. Danny Hillis created the principles for the design of things that last over centuries. They are longevity, maintainability, transparency, evolvability, and scalability. The clock will be constructed in 300 feet of rock in Western Texas and have a never-repeating melody generator that rings the clock's chimes. Readers will want to access the website for details of the clock and other Long Now Foundation projects (longnow.org).

Dr. Stuart Mason Dambrot, **AGI Society, Brain Machine Interface Consortium**
Dr. Dambrot's presentation was titled "Exocortical Cognition: A Transdisciplinary Framework for Augmenting Human High-Level Cognitive Processes." His subject falls into the AGI and neuroscience disciplines. He defines Exocortex as a hypothetical synthetic organ or external computational system that augments high-level neurobiological cognitive processes. He summarized the neuroscience and quantum

physics factors of the functions of the human brain, futurology methods, and research updates – specifically cumulative resonance, which is one of his expertise areas of research.

Dr. Chris Hables Gray (chrishablesgray@stanfordalumni.org)
Dr. Gray's subject was "Essential Tech Threats (to Civilization and Humanity)." He made the point that there are more engineers and scientists active now than in all the rest of human history; that they have better technology, and as we master part of nature, our ability to do so increases, as do the unintended consequences. He tracked historical trends of weapons lethality, species extinctions, world populations, and computer power; he then reviewed the existential technological risks to civilization of nuclear technology, biological weapons, nanotechnology, chemical weapons, climate change, pandemics, future shock system collapses, and multiplier effects of those risks interacting, with very damaging and uncertain outcomes. He talked about the difficulty of collaboration to reduce the risks, and reviewed a Global Catastrophic Risks Survey. His summary conclusion was "that we must become involved in political and social change based on pragmatism, empiricism, and basic democratic values."

Keith Wiley, Fellow, Brain Preservation Foundation (www.brainpreservation.org)
His presentation title was: "Brain Preservation as a Medical Treatment for Life Extension: Current Status and Future Prospects." The purpose and goal of brain preservation is to postpone a terminal condition until medicine and technology can heal the affliction in question. At this time, cryonics is the only remotely viable option yet devised. He described cryonics challenges, serial section mind uploading, and whole brain emulation research. He stated that the ultimate goal of brain preservation is to offer it as an end-of-life procedure offered in hospitals for otherwise terminal cases.

Cameo Wood (www.cameowood.com)
Ms. Wood presented "AI Revolutions." She discussed both sides of the current debates on the future of AI: its benefits to humanity and the fears that it could replace or destroy humanity.

Dr. Natasha Vita-More, Chair of Humanity, Inc. and Professor at the University of Advancing Technology in Arizona (Natasha@natasha.cc)
Dr. Vita-More has an extensive career of research, teaching, and publications in the Transhuman Movement, ageless thinking, whole body prosthetics, the central nervous system, and brain research – specifically memory, which has brought her global recognition. The title of her presentation was "Opportunity." Her overall message was that we have the opportunity to pursue major human objectives in the social awareness area concentrating on radical life extension; open source knowledge for all; ageless thinking; regenerative generations; human rights to augment the body, brain, and mind; and continuing education and governance to facilitate those goals.

Steven A. Garan, Research Fellow, Department of Integrative Biology, University of California, Berkeley; Lawrence Berkeley National Laboratory, Center for Research and Education on Aging, Trans Time, Inc.
Steven traced the history of life expectancy for different societies, ranging from 45 years in 1840 to the mid-80s in 2010; he then answered the question of "Why Cryonics?".

Robert P. Wasley, Transnationalism (Transitionalism@gmail.com; website: www.transition.com)
Robert P. Wasley is the author of the book, *Meaning, Being and Transition: Toward the Formation of a New Worldview* (2nd ed., 2016). His presentation was titled "Transitionalism: A Holistic Program for Positive Change." A summary follows:

Our descendants first spread through, then out of, Africa to dominate all continents and oceans of the world. Humanity's next phase of migration has already begun with the landing on the moon, robotic exploration of Mars, and, in time, travel to the stars.

The journey to this point has been and continues to be difficult. The sense of imminent crisis leads many to reflect on how humanity stands at a crossroads. Anxiety, anger, and cynicism express a lack of confidence in the current religious and ideological framework to meet the challenges facing us, leading to a widespread call for change. How do we tackle the challenges here on Earth and avoid taking them with us as we colonize the cosmos?

Transitionalism is a holistic worldview and practical path by which society and individuals strive to improve themselves and each other in order to create a better future for everyone, as well as for the environment. From this perspective, transitionalism identifies two primary sources for humanity's current difficulties. First, the insistence in applying solutions used for past problems – broadly speaking religion and liberal ideology – to current and future challenges without recognizing that the conditions that made those solutions successful are dramatically different from what is needed now. The second is the always-present challenge of being endowed with a brain optimized for a hunter-gatherer way of life, meaning that our evolutionary animal legacy still retains a powerful influence on how we think, feel, and act; often in ways that are inapplicable to how we live now or will live in the future.

As a worldview, transitionalism is non-theistic, non-liberal, future-oriented, and rationalistic. In this way, transitionalism stands beyond the current dichotomies of individual vs. collective, religious vs. secular, artificial vs. natural, liberal vs. conservative – to being a synthesis; establishing the foundation for a new era of social, individual, and environmental integration.

"A better society makes better individuals; better individuals make for a better society" – embodies transitionalism's agenda for positive social change by combining principles and practice to prepare individuals and society to build better lives while positively engaging present and future challenges.

Our success as a community depends on being able to change the reality of people's lives for the better, which is something we can do only if we work together. The transitionalist community is looking to work with other individuals and organizations by forming alliances to effect substantive positive social change by employing a holistic approach to solve, not simply manage, social ills. For individuals, there are recommended programs and practices to cultivate self-betterment, combined with community participation and activities.

It is within our control to answer the question: Where we go from here? Only by turning our focus towards the challenges of the present and the possibilities of the future with a holistic worldview can we can free ourselves to hope, dream, and achieve what can be.

Adair Daniels, Futurist
His presentation was titled: "Space-Based Solar Power and Server Sky." He presented the extreme future of the global Space scientific community's long research into capturing the power of the Sun with orbital technology capable of wireless transmitting to every community and citizen on Earth, with it being just as easy to get it to Zimbabwe as the United States.

Dr. Bob Krone and Salena Gregory-Krone, Kepler Space Institute (KSI), (www.keplerspaceinstitute.com)
The Krones' presentation was titled "Future Technology via Moral Leadership for Humanity." They summarized the KSI education and research purposes, goals, and projects for the group and offered the services of the *Journal of Space Philosophy* to them. This article is the first tangible one. They described the KSI Research program started into Human Pathologies and Space. It is relevant to the interests of this group. Its hypothesis is that "Future technology will have the capability to solve humanity's needs, IF those capabilities are universally deployed by moral and ethical leadership." Historically humanity has evolved in both positive and negative directions, for progress or into catastrophe. Human extinction has been avoided, but will be increasingly probable if random evolution is the choice. Smarter people, smarter machines, and human-designed and supervised extreme technologies can deliver all the resources humans need on Earth, or in Space, in perpetuity, within the Law of Space Abundance. KSI's leaders believe that future technology can avoid the historic cycles of humanity's progress being reversed by pathological leadership.

David J. Kelley, Principal, AGI Inc., TNC Chair, Microsoft MVP
David Kelley, the organizer and chairman of this Extreme Futures and Technology Forecasting conference and workshop, summed up the day of presentations and the overall goals for this two-year research program to gather data for the next *Extreme Futures Technology and Forecasting Manual*, to be published in 2018.

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Editor's Notes: Space has forever been the laboratory for extreme future thinking. A large part of that thinking came to the world in fiction stories, films, and books. Over time, many fictional concepts and ideas have been converted into reality. We were privileged to attend this conference and workshop, which has already facilitated new interactions between Kepler Space Institute people, associates, and those working with David Kelley. Learning more about both the potentials and the threats of accelerating extreme technology movements reinforces our hopes that thinking and controls will focus on the need for the consequences to build universal reverence for human life within ethical civilization, which is the basic KSI Space philosophy. ***Bob Krone.***

Journal of Space Philosophy (JSP) Board of Editors

Kepler Space Institute (KSI) is honored to have 39 of the world's Space community professionals as members of the Board of Editors for the *Journal of Space Philosophy*.

Dr. Elliott Maynard, our *Journal of Space Philosophy* Board of Editors colleague, has beautifully stated both the purpose and the style for our peer reviews:

> This is such a hi-caliber group of leading-edge thinkers and supercharged individuals, it should be natural for each of us to wish to provide a supportive and synergistic environment for the others. I have also learned always to have someone else proof read any material I write, as I have discovered that the brain tends not to "see" my own simple mistakes. Ergo, within the new Kepler context I feel editors should be there to support our writers in the most creative and positive ways possible. (e-mail to Bob Krone, March 23, 2013)

The purposes of peer reviews of article submissions to the *Journal of Space Philosophy* are: (1) to determine the relevance to the Vision and Goals of KSI; (2) to help the author(s) improve the article in substance and style or recommend references; and (3) to provide publication recommendations to the Editor-in-Chief.

****

1. 

ARTHUR, Gordon, PhD, JSP Associate Editor, Theology at King's College, London, UK.

For Bio Info: www.linkedin.com/in/gdarthur.

2. 

AUTINO, Adriano, Founder, Space Renaissance International.

For Bio Info: www.spaceentrepreneurs.ning.com/profile/AdrianoAutino.

3. 

BELL, Sherry, PhD, Kepler Space Institute Dean, School of Psychology.

For Bio Info: www.nss.org/about/bios/bell_sherry/html.

4. 

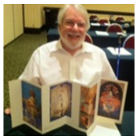
BLOOM, Howard K., Author, Scientist, Founder Space Development Group, Publicist, Author on Human Evolution, Science, Technology, and Space. Photo by Luigi Novi.

For Bio Info: www.en.wikipedia.org/wiki/Howard_Bloom.

5. 

BOLTON, Jennifer, PhD, Co-Founder Virtual Space Orbiting Settlement VOSS. Veteran and molecular biologist, Space Pioneers Science Officer.

For Bio Info: Google Jennifer Bolton.

6. 

BURGESS, Lowry, Professor, Distinguished Fellow at the Studio for Creative Inquiry, Center for the Arts and Society, College of Fine Arts, Carnegie Mellon University.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 13.

7. 

CLEMENTS, Douglas H., MD, American Board of Ophthalmology, "*Improving Human Vision for Space Exploration and Settlement".*

For Bio Info: Board Certified Ophthalmologist, University of Southern California Keck School of Medicine.

8. 

DOWNING, Lawrence G., DMin, Senior Pastor, Space Faith and Spirituality Pioneer, University Professor.

For Bio Info: See Issue 1, no. 1, Article 11.

9. 

FITZPATRICK, Susan Beaman, DBA, Vice Chairman, Oak Family Advisors, LLC based in Chicago. She earned her DBA with the University of South Australia in Zurich Switzerland, where she studied under the supervision of Dr. Bob Krone. She is an international health expert specializing in health risk management. She has consulted with governments, public and private providers, and within health systems projects sponsored by the World Bank, World Health Organisation, and the UK's National Health Service. Susan's research interests include management capacity development and the implementation of complex innovations and programs. She has been a keynote speaker at industry symposiums and professional organizations such as the National Risk Manager's Association, Excess Surplus Lines Claims Association, American Hospital Association, American Bar Association, and State Chambers of Commerce. Kepler Space Institute is proud to have her in the *Journal of Space Philosophy* Board of Editors.

10 

HAYUT-MAN, Yitzhaq (Isaac), PhD, Architect for the Universe, The Jerusalem Dome of the Rock as a memory site for theology, philosophy and humanity past, present and future.

For Bio Info: Google Yitzhaq Hayut-Man.

11. 

HOPKINS, Mark, Chairman of the Executive Committee, National Space Society (NSS). Space Economics. Important in founding of the L-5 Society and collaboration of the NSS with the Kepler Space Institute.

For Bio Info: www.nss.org/about/hopkins.html.

12. 

ISAACSON, Joel D., PhD, *Nature's Cosmic Intelligence*, pioneer of RD Cellular Automata since the 1960s.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 7.

13. 

IVEY, Janet, is a Nashville TV treasure and a friend of Kepler Space Institute. Her *Janet's Planet* show is the recipient of 12 regional Emmys and five Gracie Allen Awards. She is an Ambassador of Buzz Aldrin's *Share Science Foundation*. A Google search will take you to delightful images and video clips of her teaching and entertaining children about Space.

14. 

KHOVANOVA-RUBICONDO, Kseniya, PhD, University of Chicago, Expert in public economics, innovation, policy and urban planning. Consultant to the Council of Europe and European Commission, proficient in six languages, Space International Economics.

For Bio Info: www.connect.tcp.org/profiles/profile.php?profileid=2296.

15. 

KIM, KEE YOUNG, PhD, Republic of Korea Senior University Academician and Administrator. Former President, Kwang Woon University; former Dean of the School of Business and Provost, Yonsei University; currently the Chairman of the Board of the prestigious Samil Foundation, the oldest Korean institution to award and provide scholarships to high-performing scientists, artist and engineers.

16. 

KIKER, Edward, General Engineer, GS-13, Office of the Chief Scientist, U.S. Army Space and Missile Defense Command/Army Forces Strategic Command, Kepler Space Institute Chief Scientist.

For Bio Info: www.indeed.com/r/Edward-Kiker/45bd40a86c090f07.

17. 

KRONE, Bob, PhD, *Journal of Space Philosophy* Editor-in-Chief, President, Kepler Space Institute (KSI), sponsor of this Journal.

For Bio Info: www.bobkrone.com/node/103.

18. 

LIVINGSTON, David, PhD, Founder and host, *The Space Show*.

For Bio Info: www.thespaceshow.com.

19. 

MARZWELL, Neville, PhD, Space Solar Power and Robotics Scientist. Career at JPL as Manager for Advanced Concepts and Technology.

For Bio Info: www.spaceinvestment.com/lcr2_bios.html.

20. 

MATULA, Thomas L., PhD, Business and Management Professor, Lunar Commercial scholar.

For Bio Info: www.trident.edu/dr-thomas-matula.

21. 

MAYNARD, Elliott, PhD, Founder, ArcoCielos Research Center, Sedona Arizona, www.arcocielos.com.

For Bio Info: www.fasiwalkers.com/featured/ElliottMaynard.html.

22. 

MOOK, William, PE, Trained in aerospace engineering, 15 years in alternative energy, Space Commerce Technology.

For Bio Info: www.vimeo.com/user1527401.

23. 

OLSON, Thomas H., PhD, DBA, Professor of Clinical Management and Organization, University of Southern California Marshall School of Business, Los Angeles, California, USA. Dr. Olson's specialty in research and consulting is on strategy, development, organization. and human capital. He has authored four books and 100 professional articles.

For Bio Info: www.marshall.usc.edu/faculty/directory/tholson.

24. 

PALMA, Bernardino, Historian, Portuguese Age of Discovery.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 8.

25. 

PEART, Kim, Co-Founder, Virtual Orbiting Space Settlement (VOSS). Artist, visionary, virtual worlds.

For Bio Info: www.independentaustralia.net/about/ia-contributors/kim-peart-bio/.

26. 

ROBINSON, George S., III, LLD, Space law pioneer and international space expert. Smithsonian Institute Legal Counsel.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 14.

27.

SCHORER, Lonnie Jones, *Kids to Space* author and teacher. Architect, aviator.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 17.

28.

SCHRUNK, David, MD, Aerospace engineer, Founder, Quality Laws Institute, KSI Faculty.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 18.

29.

SCHWAB, Martin, PhD, International Space author, KSI Faculty, Aerospace Technology Working Group.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 21.

30.

SCOTT, Winston E., American Astronaut, Vice President for Development, Florida Institute of Technology.

For Bio Info: www.en.wikipedia.org/wiki/Winston_E.Scott.

31.

STEPHANOU, Stephen E., PhD, Emeritus Professor of Systems Technology, University of Southern California, Los Angeles, California, USA.

For Bio Info: See Issue 2, no. 2 (Fall 2013), Article 26.

32.

TANG, Terry, PhD, Kepler Space Institute Director of Research.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 24.

33.

THORBURN, Stephanie Lynne, Author, Astrosociology.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 12.

34.

WERBOS, Paul, PhD, U.S. National Science Foundation, Space scholar.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 19.

35. 

WHITE, Frank, MSc, Founder, The Overview Effect Institute.

For Bio Info: See Issue 1, no. 1 (Fall 2012), Article 9.

36. 

WILKINS, John, PhD, Professor of Space Settlements.

37. 

WOLFE, Steven, Space advocate and author of the 2013 Space novel, *The Obligation.*

For Bio Info: See Issue 2 no. 2 (Fall 2013), Article 26.

38. 

YACOUB, IGNATIUS, PhD, Founder and first Dean of the School of Business and Management, La Sierra University, Riverside, California. Currently Professor of Graduate Studies, Loma Linda University School of Social Work and Social Ecology, Loma Linda, California.

39. 

ZUBRIN, Robert, PhD, President, Mars Society.

For Bio Info: www.en.wikipedia.org/wiki/Robert_Zubrin.

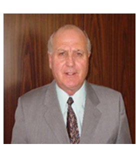
In Memoriam

BEN-JACOB, Eshel, PhD, Former President of Israel Physical Society; Founder Science of Bacterial Intelligence. Tel Aviv University. We grieve the passing of Dr. Ben-Jacob in 2015.

For Bio Info: Google Eshel Ben-Jacob.

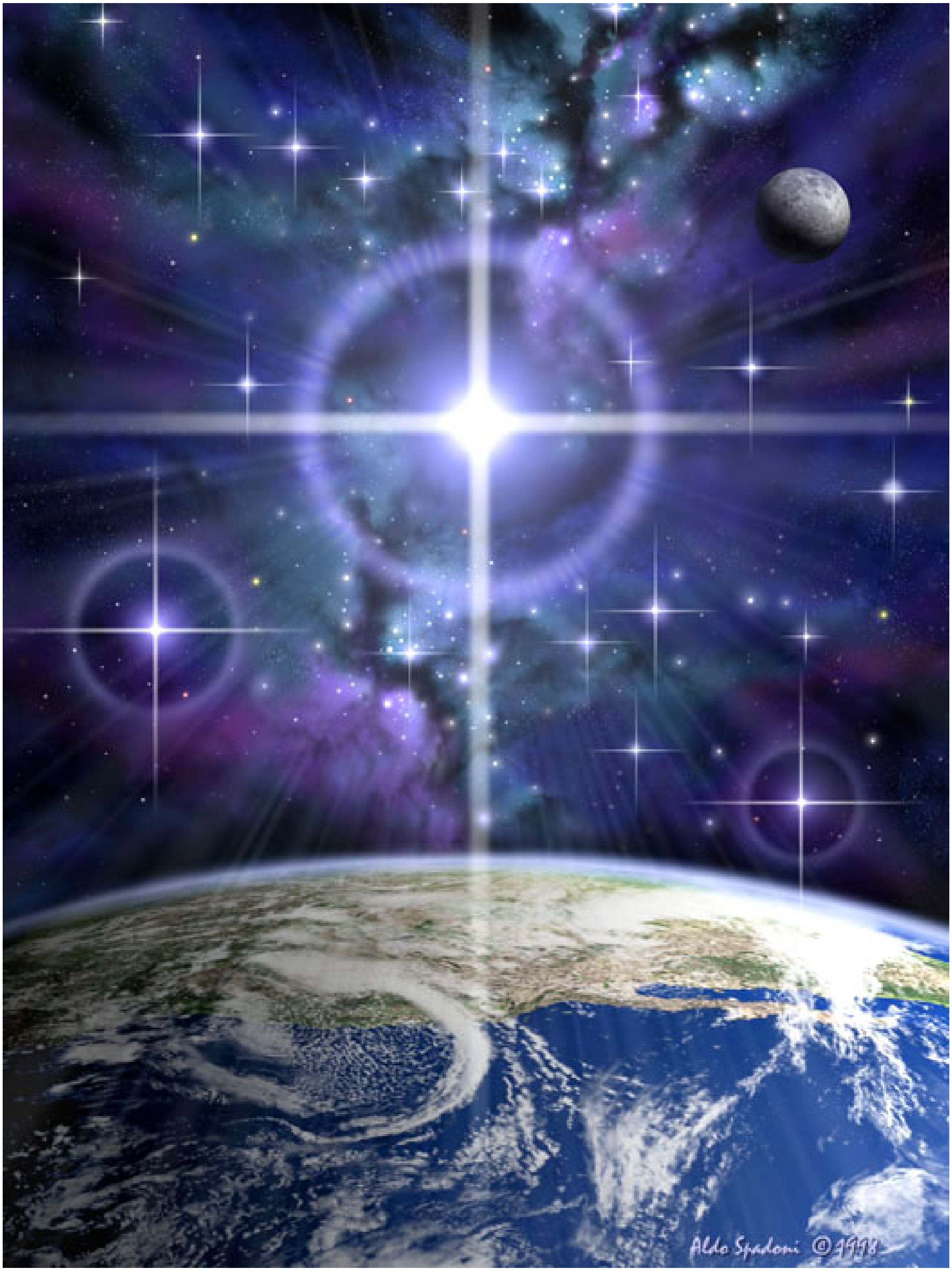
MITCHELL, Edgar Dean, ScD, Captain, U.S. Navy (Ret), Apollo 14 Astronaut, sixth person to walk on the Moon, Founder Institute of Noetic Sciences. We grieve Edgar Mitchell's passing in 2016.

For Bio Info: Google Edgar Mitchell.



O'DONNELL, Declan J., JD, Space law attorney, Fifty publications in Space Law and Policy, Publisher, Space Governance Journal, President, United Societies in Space, Inc. We grieve Declan's passing in 2015.

"The greatest use of a life is to spend it for something positive that outlasts it." Dr. Max T. Krone, Dean, Institute of the Arts, University of Southern California and Founder, Idyllwild School of Music and the Arts, 1950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