54 Years in Service of NASA- A Learning Experience*

AIAA Houston Section

Kumar Krishen, Ph.D.

Fellow, Society for Design and Process Science
Assoc. Fellow, AIAA
Fellow & Distinguished Speaker,
Institution of Electronic & Telecommunication Engineers

April 30, 2020

**Views expressed in this presentation may not be those of NASA*

54 Years in Service of NASA- A Learning Experience

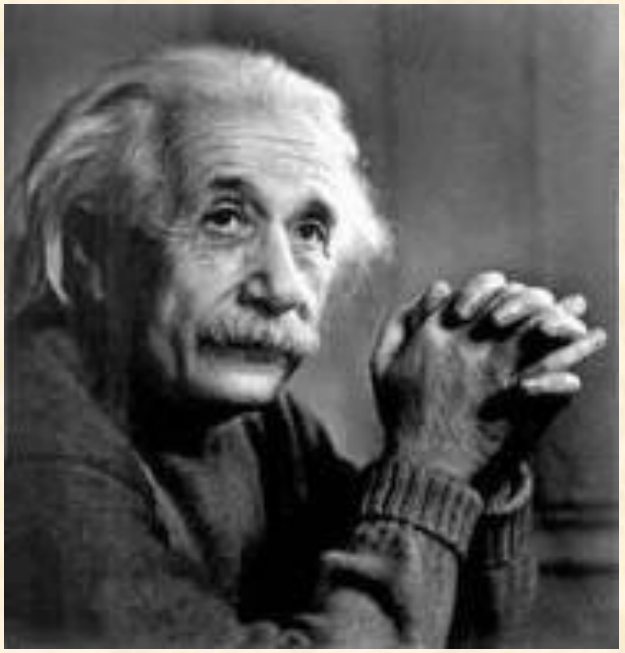
- **Great Accomplishments are Possible by being a Team Player**
- **Factors Determining My Roles, Responsibilities, and Status**
  - **Complex/Complicated & Depended on**
    - **Program/Project Status**
    - **Management Structure of Organization**
    - **Perception of my Capabilities/Abilities**

Towering genius disdains a beaten path. It seeks regions hitherto unexplored.

Abraham Lincoln

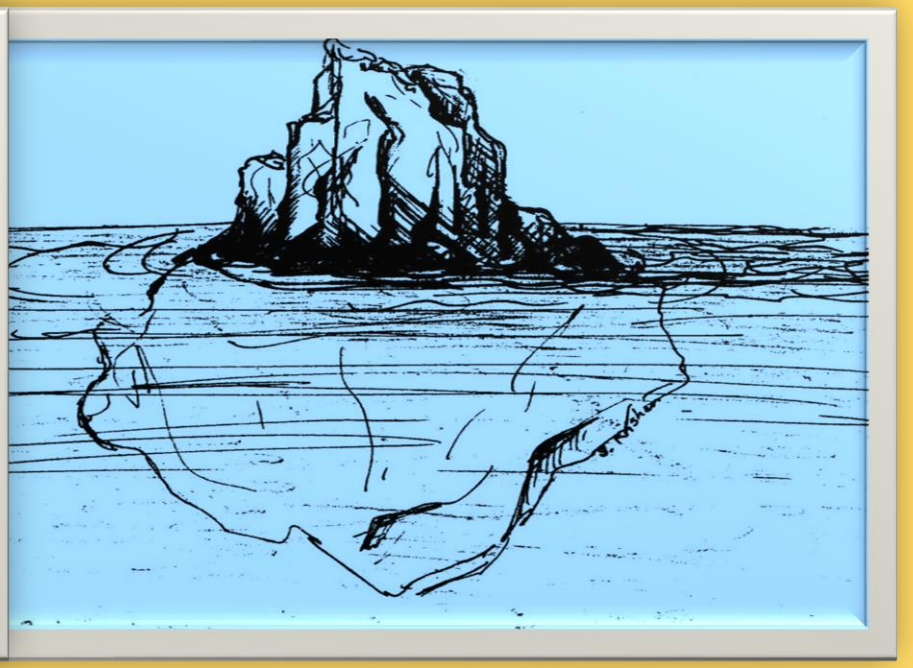
Mysterious Domains & Experience

- “The mysterious is the true source of all art and science.”
- “Imagination is more important than knowledge.”
- "The only source of knowledge is experience."



Albert Einstein

Mysterious domains



Universe of Human Mind

54 Years of Service to NASA

- **Worked on a NASA grant at Kansas State University from January 1965 to May, 1969**
- **Worked on a NASA contract at Lockheed Electronics Company in Houston from May, 1969 till February 9, 1976**
- **Served NASA directly from February 9, 1976 till September 3, 2018**
- **Currently developing game changing technology and techniques for surveillance and object identification for security applications based on NASA patent**

Choice of Environment

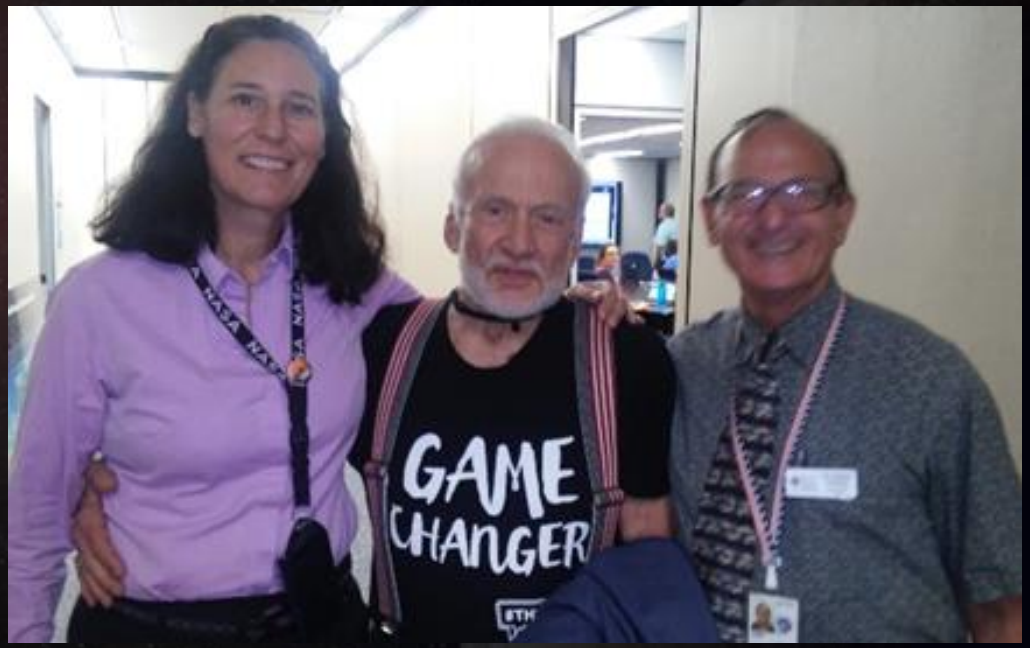
- **President George Washington**

  Associate yourself with [humans] of good quality if you esteem your own reputation for 'tis better to be alone than in bad company.

- **Panchatantra*** written in Kashmir in about 200 BC

  Better with the learned dwell
  Even though it be in hell
  Than with vulgar spirits roam
  Palaces the Gods call home.

*Translated by Prof. Arthur Ryder



Astronaut Sunita Williams

Astronaut Dr. Stan Love

Astronaut Dave Leestma

Dr. Kalpana Chawla

Dr. Krishen interacting with Nobel Laureates Prof. Bob Curl (left) and Prof. Samuel Ting

Other Assignments

- Member, Texas Board of Licensure for Professional Medical Physicists
- NASA Representative to Superconducting Super Collider
- In-Charge of Moving Variable Specific Impulse Magnetoplasma Rocket from MIT and Technical Monitor for the Project
- Co-Chairman of Space Technology Interdependency Group (STIG) Operations Committee
- Program Chairman, World Congress on Superconductivity
- Chairman, JSC Space Radiation Committee
- Technical Advisor, JSC Minority University Program

SPACE CENTER
Roundup

August 13, 1999

VOL. 38, NO. 15 LYNDON B. JOHNSON SPACE CENTER, HOUSTON, TEXAS

Governor Bush appoints JSC technologist to key post

The full senate of the state of Texas recently confirmed the nomination of Dr. Kumar Krishen by Governor George W. Bush to the Texas Board of Licensure for Professional Medical Physicists for a five-year term. This board supports the implementation of the Texas Medical Physics Practice Act, Texas Civil Statutes, Article 4512n, concerning the regulation and licensure of medical physicists.

Dr. Krishen serves as the chief technologist for the Technology Transfer and Commercialization Office at JSC.

"Professional medical physicists support the calibration of medical instrumentation and the analysis and interpretation of medical data for physicians," said Krishen. "This appointment provides me an opportunity to serve the state of Texas in an area of importance to the quality of our lives. It also uses the experience, training, and knowledge I have gained by working at JSC."

Dr. Krishen has advanced original concepts concerning remote sensing, health systems, science payloads, sensor systems, communications and tracking systems, mission support technologies, and automation and robotics technologies through his involvement on agency, interagency, and international panels and committees. These include the

JSC Photo S99-06209 by Robert Markowitz

Dr. Kumar Krishen

NASA Council on Science and Technology, Space Technology Interdependency Group, Sensor Working Group, Microwave Working Group, Photonics Working Group, JSC Wavelet Technology Working Group, High Temperature Superconductivity Working Group, Operations Technology Working Group, In-Space Experiments Evaluation Committee, State of Texas Advanced Technology Panel, Office of Space Flight Senior Technology Team, NASA Minority Universities Technical Steering Committee, Agency Communications Working Group, U.S. National Committee Commission F of URSI, IEEE United States Activities Board, Accreditation Board for Engineering and Technology, JSC Small Business Innovation and Research Technical Steering Committee, and the JSC Technology Coordinating Committee.

Dr. Krishen is the postdoctoral advisor to the NASA NRC Program and doctoral advisor to the NASA Graduate Program and NASA Summer Faculty Program. Dr. Krishen has taught graduate-level courses at Kansas State University, the University of Houston, and Rice University where he served as an adjunct professor from 1986 to 1996.

Dr. Krishen is a fellow of the Society for Design and Process Science and is the recipient of many honors including medals, awards, and commendations from universities, industry, and government organizations. He is listed in *2000 Outstanding People of the 20th Century* (England), *Who's Who in the World*, *Men of Achievement* (United Kingdom), and several similar publications. Dr. Krishen serves on the editorial boards of the *Journal of Integrated Design and Process Science* and the *International Journal of Advanced Manufacturing Systems*.

OFFICE OF THE GOVERNOR

RICK PERRY
GOVERNOR

October 13, 2008

Kumar Krishen, Ph.D.

Dear Dr. Krishen:

Congratulations on your recent appointment. Your knowledge and experience will be invaluable to the Texas Board of Licensure for Professional Medical Physicists.

I appreciate your willingness to serve the State of Texas as my appointee and look forward to working with you.

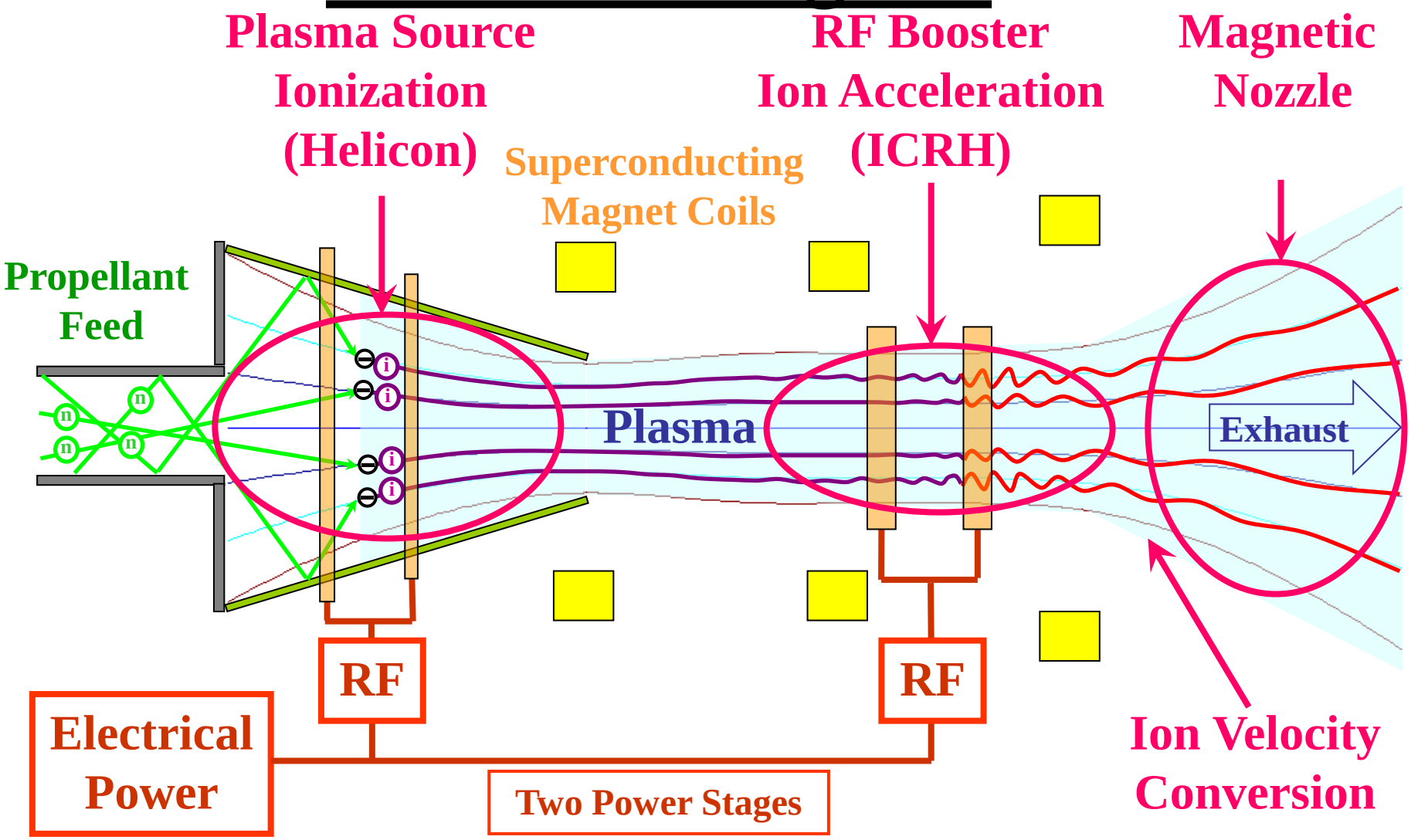
Sincerely,

Rick Perry

Rick Perry
Governor

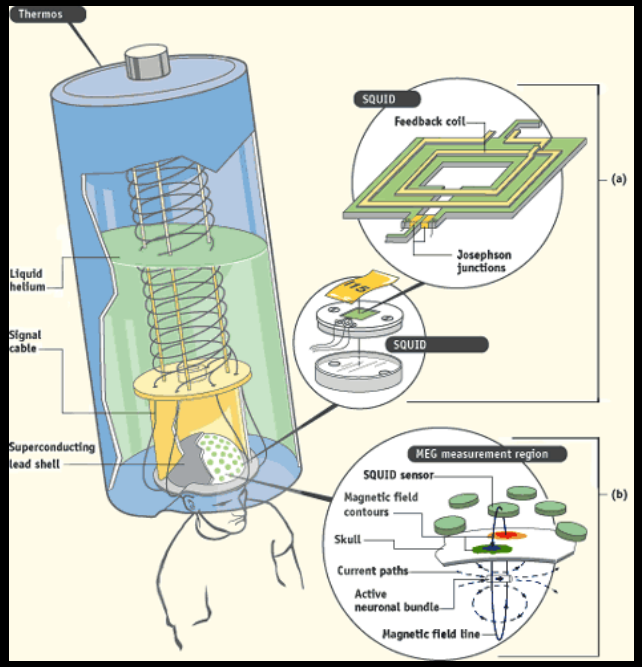
RP:tjs

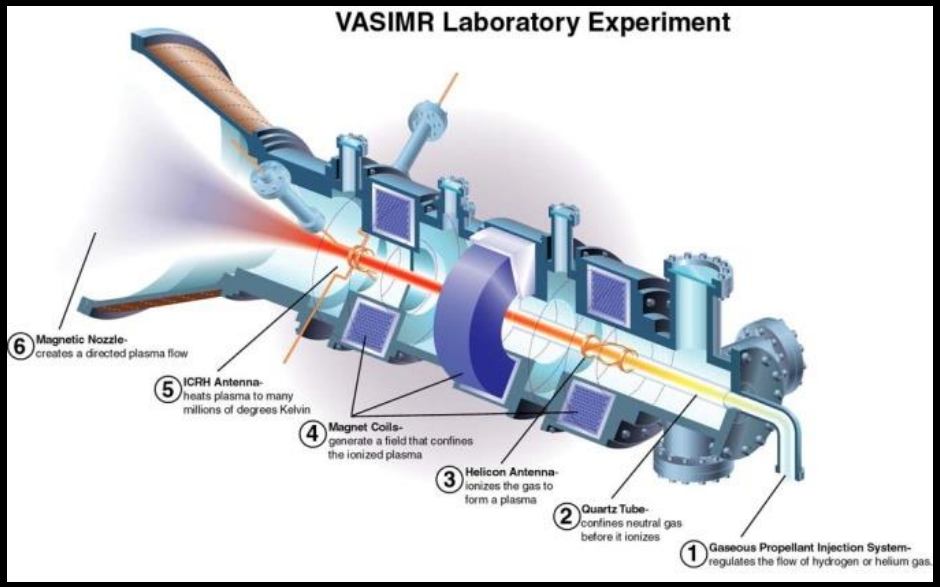
VASIMR Diagram

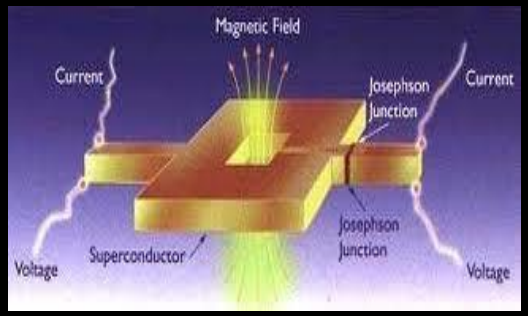


From **Dr. Chang Diaz**

HTS in Development and Research







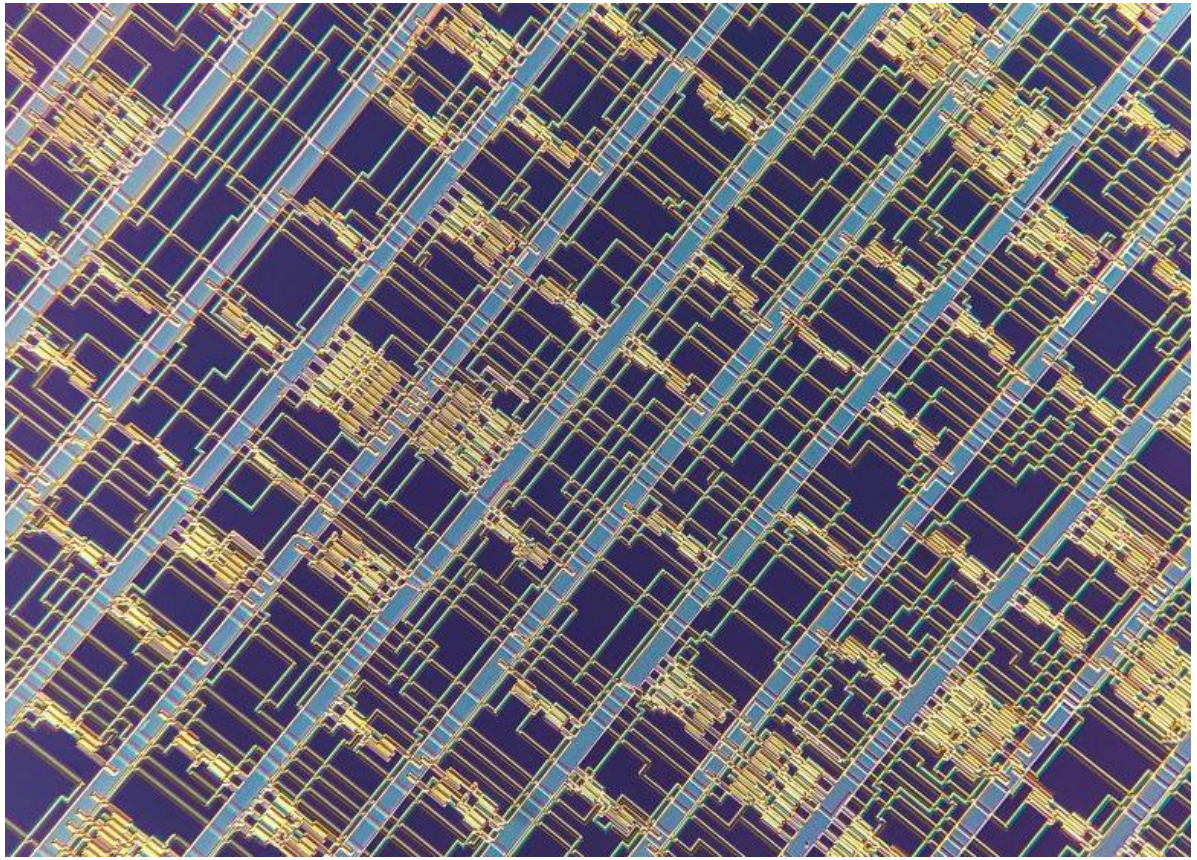
SQUID, SC Quantum Interference Device

VASIMR

Advanced Microprocessor Built with Carbon Nanotubes

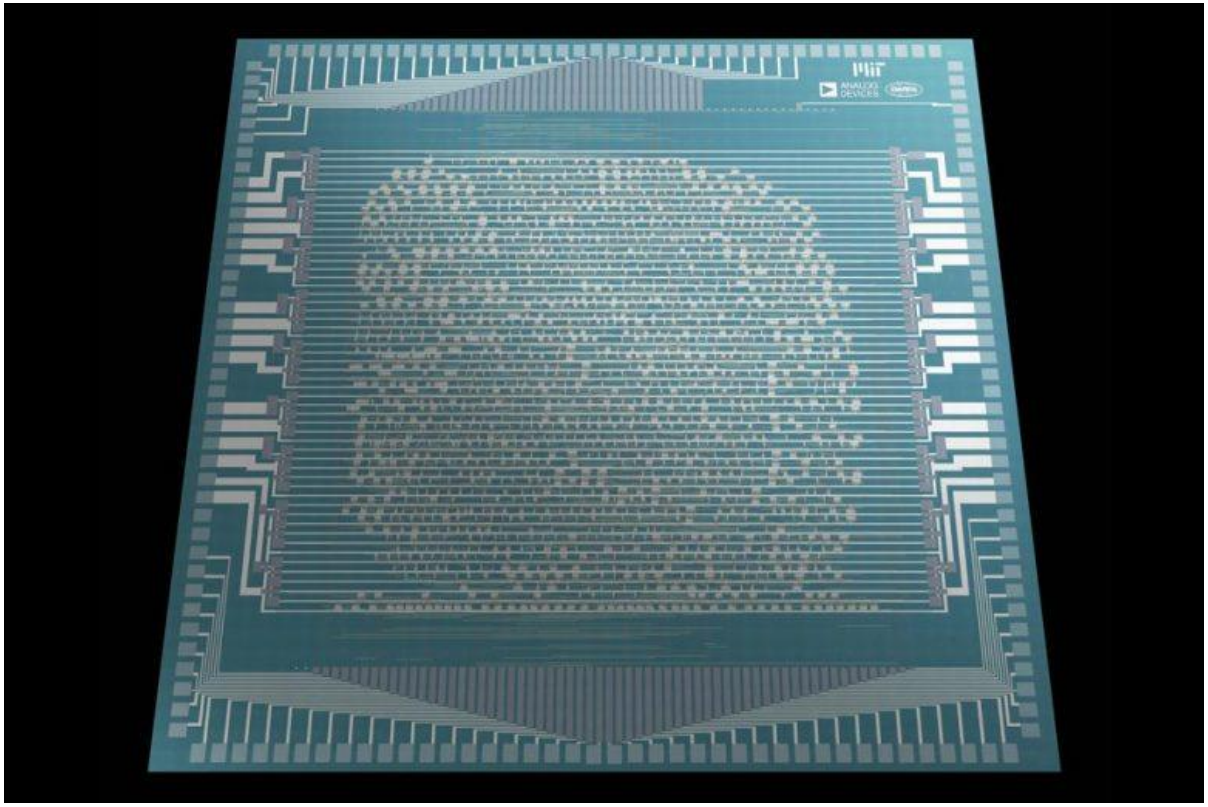
https://scitechdaily.com/advanced-microprocessor-built-out-of-carbon-nanotubes/

By Rob Matheson, Massachusetts Institute of Technology August 30, 2019



Advanced Microprocessor Built with Carbon Nanotubes

(From News Article)



Advanced Planning Office- T. Randazzo
Intern 2011

[with permission

Quarter lifted by an IPMC by the application of a step voltage of 2.8 volts (E=1.4 V/mm). The time internal between the frames is approximately 1 sec

Innovation/Invention

The Need

On Understanding Universe

Expanding the boundaries of our knowledge to understand the birth, existence, and extinction processes of the universe presents one of the greatest challenges of all times. This includes the understanding of **time, space, energy, matter, and life**.

Changing Earth and Environment

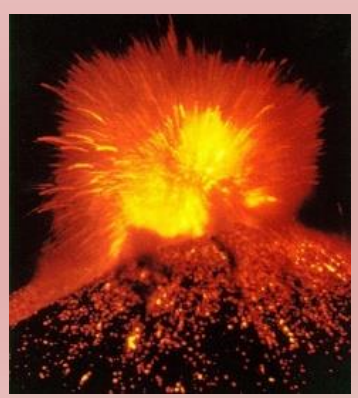
Earth in Universe

- Connected System

Asteroids Hitting Earth

Volcanoes

https://images.search.yahoo.com/search/images?p=universe&fr=mcafee&imgurl=https%3A%2F%2Fimages2.minutemediacdn.com%2Fimage%2Fupload%2Fc_fill%2Cg_auto%2Ch_1248%2Cw_2220%2Ff_auto%2Cq_auto%2Cw_1100%2Fv1555359085%2Fshape%2Fmentalfloss%2Fscreen_shot_2015-12-03_at_3.53.05_pm.png#id=4&iurl=https%3A%2F%2Fi.ytimg.com%2Fvi%2F_cLFeq38yF8%2Fmaxresdefault.jpg&action=click



https://nypost.com/2020/01/03/asteroid-that-could-cause-violent-sky-explosions-approaching-earth/

Photos from Internet

Changing Earth and Environment (Continued)

Earth Plate Motion

Earthquakes

Tsunamis

Floods

Sinkholes

Photos from Internet

Changing Earth and Environment (Continued)

Tornados

Sandstorms

Natural Fires

Hurricanes

Photos from Internet

Changing Earth and Environment (Concluded)

Consequences of Human Activities

- Lack of Resources
- Pollution
- Congestion
- Global Warming

https://owlcation.com/stem/Environmental-problems-of-modern-cities

Human Health Challenges

- Viruses
- Cancer
- Brain related
- Heart

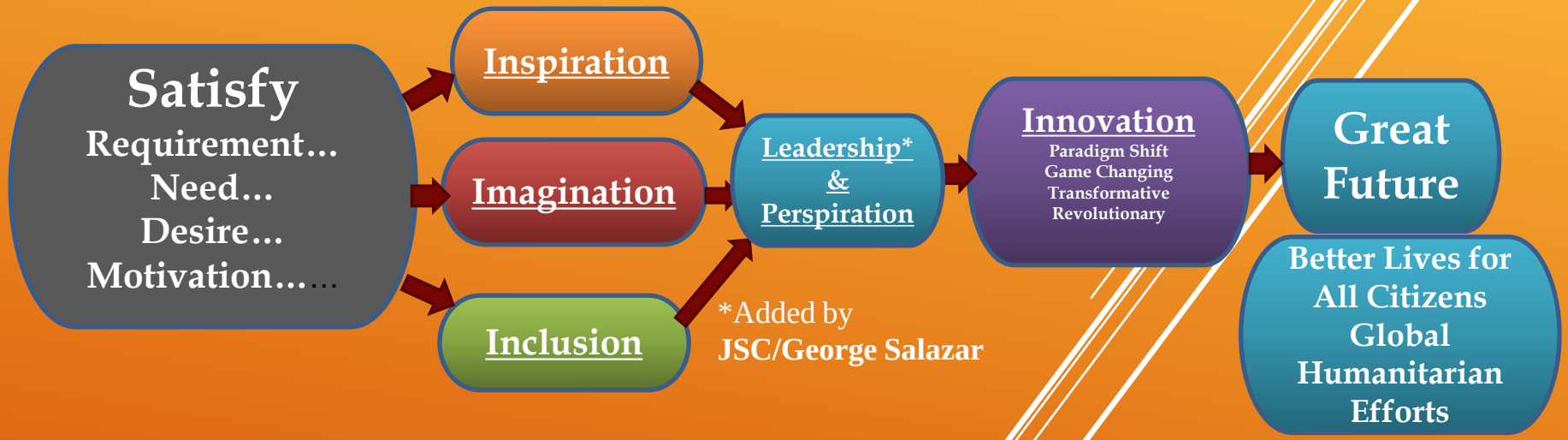
Photos from Internet

What will save this Earth?

Innovation Driven Future

Inspiration, Imagination, Inclusion, Leadership, & Perspiration (I3LP) Lead to Great Future (GF)

Innovation Driven Future



I3LP → I → GF

Dr Kumar Krishen
2020

INNOVATION- THE NEED

"The environment on earth will change drastically in the far future. Places which are habitable at this time may be under water or ice, or may become deserts or mountains. The methods we will then use will be hugely impacted by the space exploration programmes we have completed" *PRESTIGE Magazine*

Innovation For *Everything *Everywhere *Every Time

My Knowledge Journey

Examples of Some Innovations

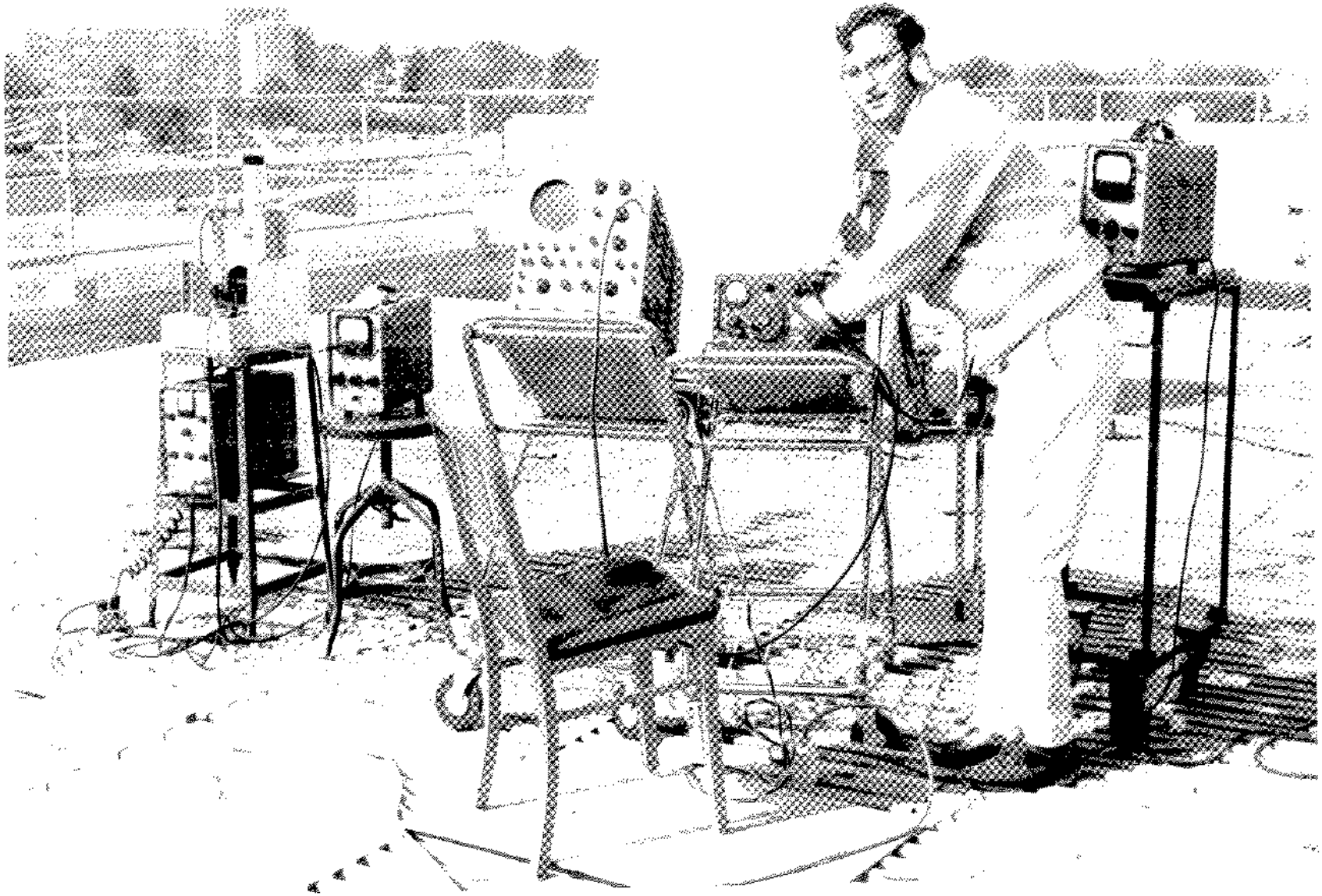
Examples of my Innovations

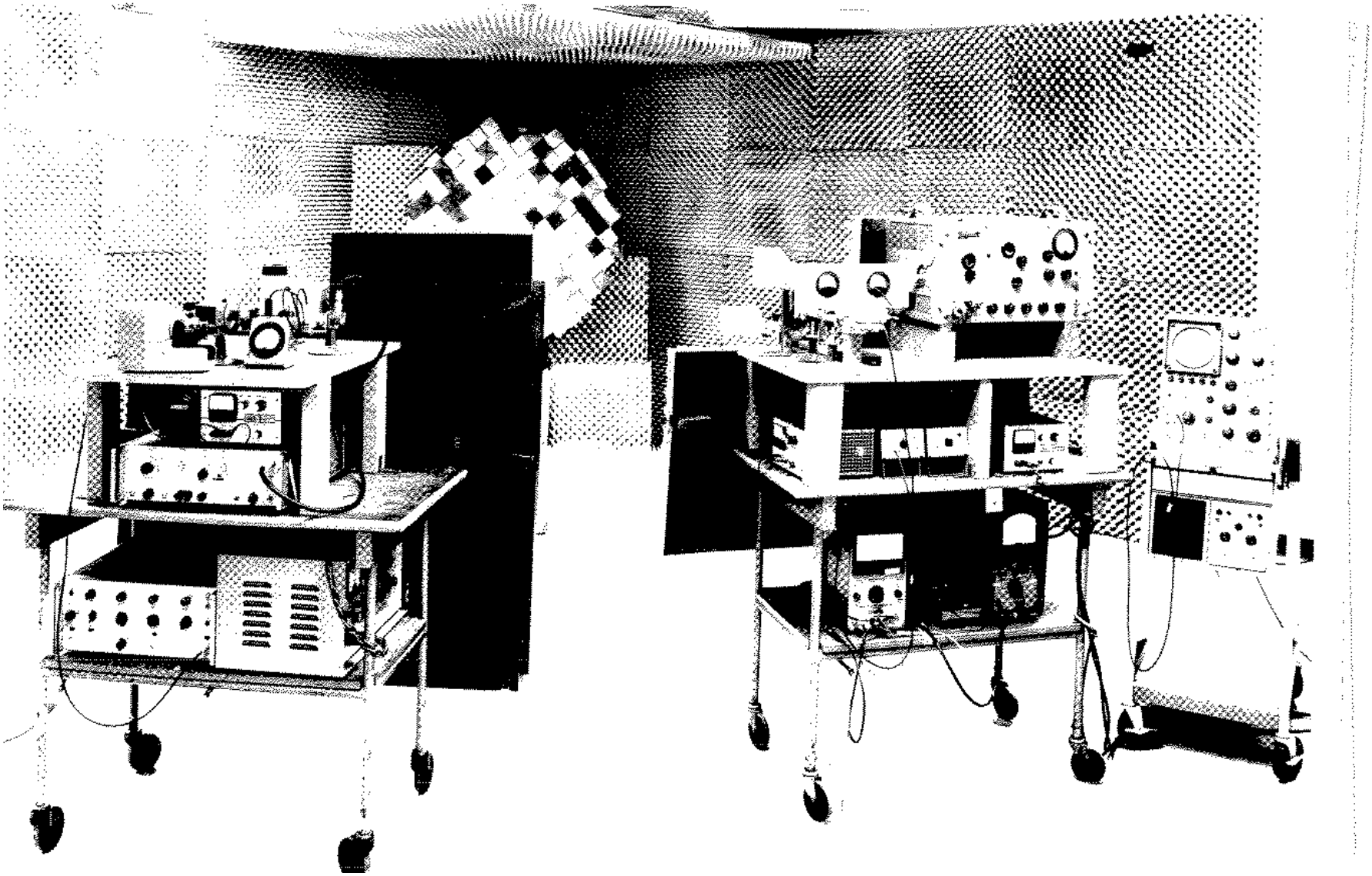
- Remote Sensing Systems/Methods
- Hyperthermia Cancer Treatment System
- Fire Fighter Suit
- Communications and Tracking Systems
- Robotic Vision Systems and Methods
- Other Assigned Projects (Time Permitting)

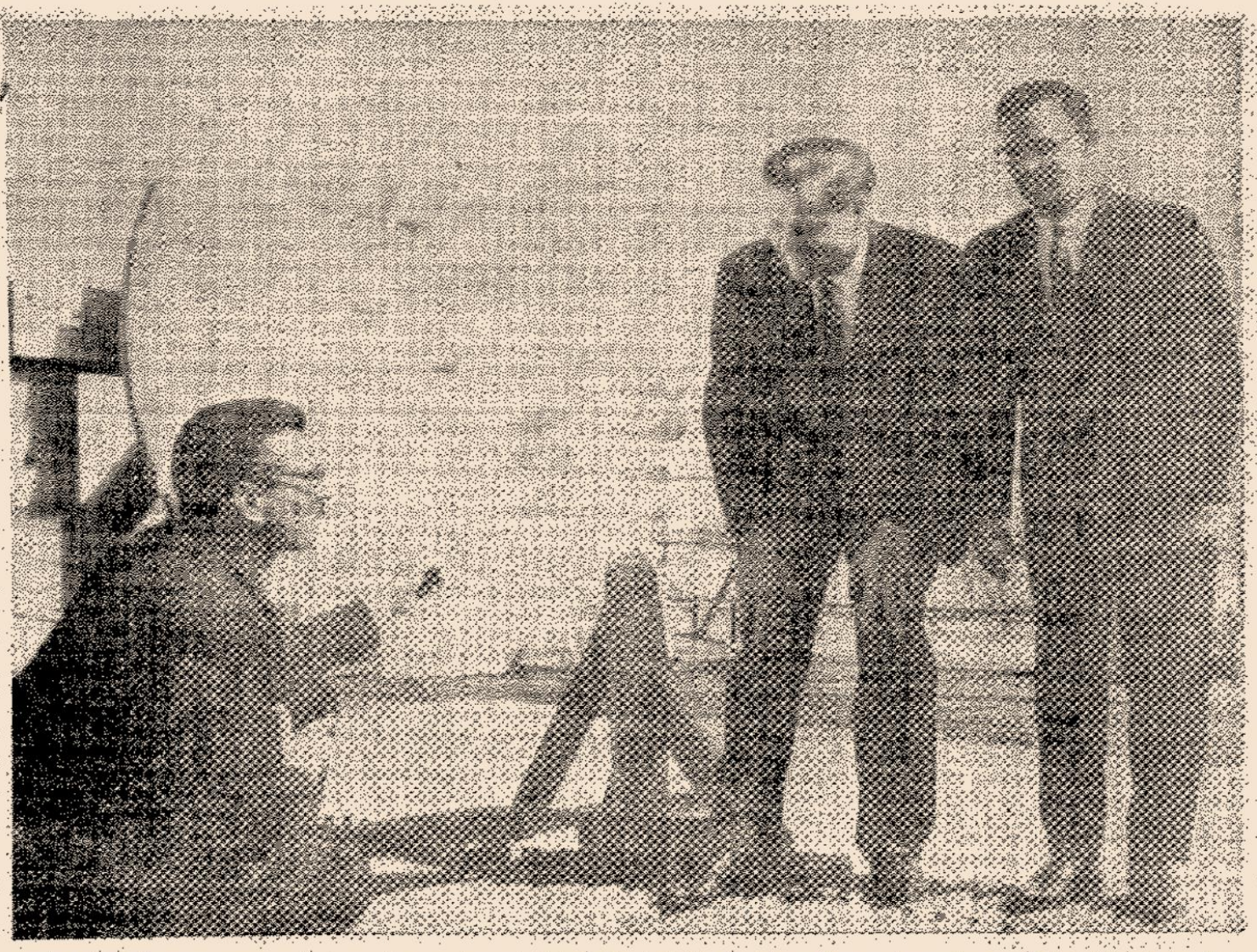
Example of my Innovation

Moon Material Prediction
From
Earth

Earth Sensing/Monitoring Applications







MOON BUMPS—Discussing the characteristics of their styrofoam target, used to simulate the moon's surface during experiments, are (left to right) Dr. S. H. Durrani, W. W. Koepsel, and K. Krishen. The round irregular target is used in honoring radar impulses from a "space camera" that will determine the composition of the moon's surface as well as its contour. The three Kansas State University electrical engineers are presenting the results of their research to date at this year's IEEE Convention in New York City Tuesday.

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ember 20, 1968

Astronaut, Diver Benefit From K-State Research

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By NARIMAN KARANJIA

Astronauts and deep sea divers will no longer be surprised by what they find on the moon or at the bottom of the sea.

"It is possible to predict the composition and surface characteristics of far away and hard-to-reach objects," Kumar Krishen, assistant professor of electrical engineering, said.

Research done by the K-State electrical engineering department and funded by the National Aeronautics and Space Administration has made this possible.

The research is being done to establish a relationship between the degree of polarization of an electromagnetic wave reflected from an object and the object's surface characteristics.

Krishen explained the project. "In radar, electromagnetic waves are sent out by a transmitter."

These waves travel till they hit an obstruction and are reflected. These obstructions are called targets, and the electromagnetic waves reflected from the target are called reflected signals.

When a wave hits a target and is reflected, it undergoes changes. One of these changes is depolarization. There is a relationship between the degree of depolarization and the surface characteristics of the target.

Industrial concerns have been trying to do this for a long time.

"They flew around in planes or helicopters and sent out electromagnetic waves and recorded the reflected signals," Krishen said. "They were unable, however, to control the variables in their experiments.

"For instance they found that signals bounced off the surface of the bottom of the sea underwent a certain amount of depolarization. However, they did not know the nature of the surface from which these signals reflected. They could not therefore establish a relationship between the two."

At K-State the waves are bounced off artificial targets whose composition and surface can be varied. Some of the targets are made of wood, others of styrofoam. The reflected waves are analyzed by an analog computer.

Wellington Koepsel, head of the department of electrical engineering, worked with Krishen on the project, Koepsel believes the facilities in this area of research are far above average.

The applications of the results of these studies are numerous, Krishen said. Radio communication with a minimum of distortion may be one of the benefits.

Development of Microwave Techniques for Remote Sensing of Oceans & Hurricanes

Correlation of Radar Backscattering Cross Sections with Ocean Wave Height and Wind Velocity, Krishen, K., Journal of Geophysical Research, Oceans and Atmospheres, Vol. 76, No. 27, September 20, 1971, pp. 6528-6539.

The Composite Scattering Model for Radar Sea Return, Krishen, K., Sea Surface Topography From Space, NOAA Technology Report ERL 228-AOML 7, Vol. I, Boulder, Co., February 1972, pp. 14-1-14-18.

Perspectives on Remote Sensing of Earth and Space Environments, Kumar Krishen, Proceedings of the 17th Congress of the World Energy Council Division 3, sponsored by United States Energy Association, September13-18, 1998, Houston, Texas, ppgs. 631-638.

First study on oil spill detection and now used for deep sea oil prospecting

Detection of Oil Spills Using 13.3 GHz Radar Scatterometer, Krishen, K., Journal of Geophysical Research, Oceans and Atmospheres, Vol. 78, No. 12, April 1973, pp. 1952-1963.

Development of Microwave Techniques for Soil Moisture Monitoring

Cross-Polarization Measurements and Their Relation to Target Surface Properties, Krishen, K., et al, IEEE Transactions on Antennas and Propagation, Vol. AP-14,
No. 5, September 1966, pp. 629-635

Remote Sensing of Surface Parameters Using Skylab S-193 Radiometer/Scatterometer Data, Krishen, K., Proceedings of the URSI Commission II, Specialist Meeting on Microwave Scattering and Emission From the Earth, Edited by E. Schanda, University of Berne, September 1974, pp. 77-84.

The Correlation of Active and Passive Microwave Data for the Skylab S-193 Sensor, Kumar Krishen, Remote Sensing Images and Technical Notes, Geocarto International Journal, ppg. 53-62, September 1993.

The Space Race and its Future Face

Shaan Ghosh, India

June 15, 2015 · by United Youth Journalists · in Asia. ·
http://unitedyouthjournalists.com/2015/06/15/the-space-race-and-its-future-future-race-sampurna-ghosh-india/

"Scientists on the ground often have to turn their research to more earthly pursuits. Dr. Kumar Krishen, who started space research at a university in India and continued it after he won a research grant at Kansas State University, entered the field with Microwave Remote Sensing directed at the Moon. This allowed him to predict the properties of moon rock with impressive accuracy prior to the Apollo 11 landing. However, in the following decades, he turned his research to remote sensing oil spills on the world's ocean and surface moisture on the soils of Africa. He was also commissioned to create equipment for hyperthermia in the treatment of cancer."

Example of my Innovation

Hyperthermia Treatment of Cancer

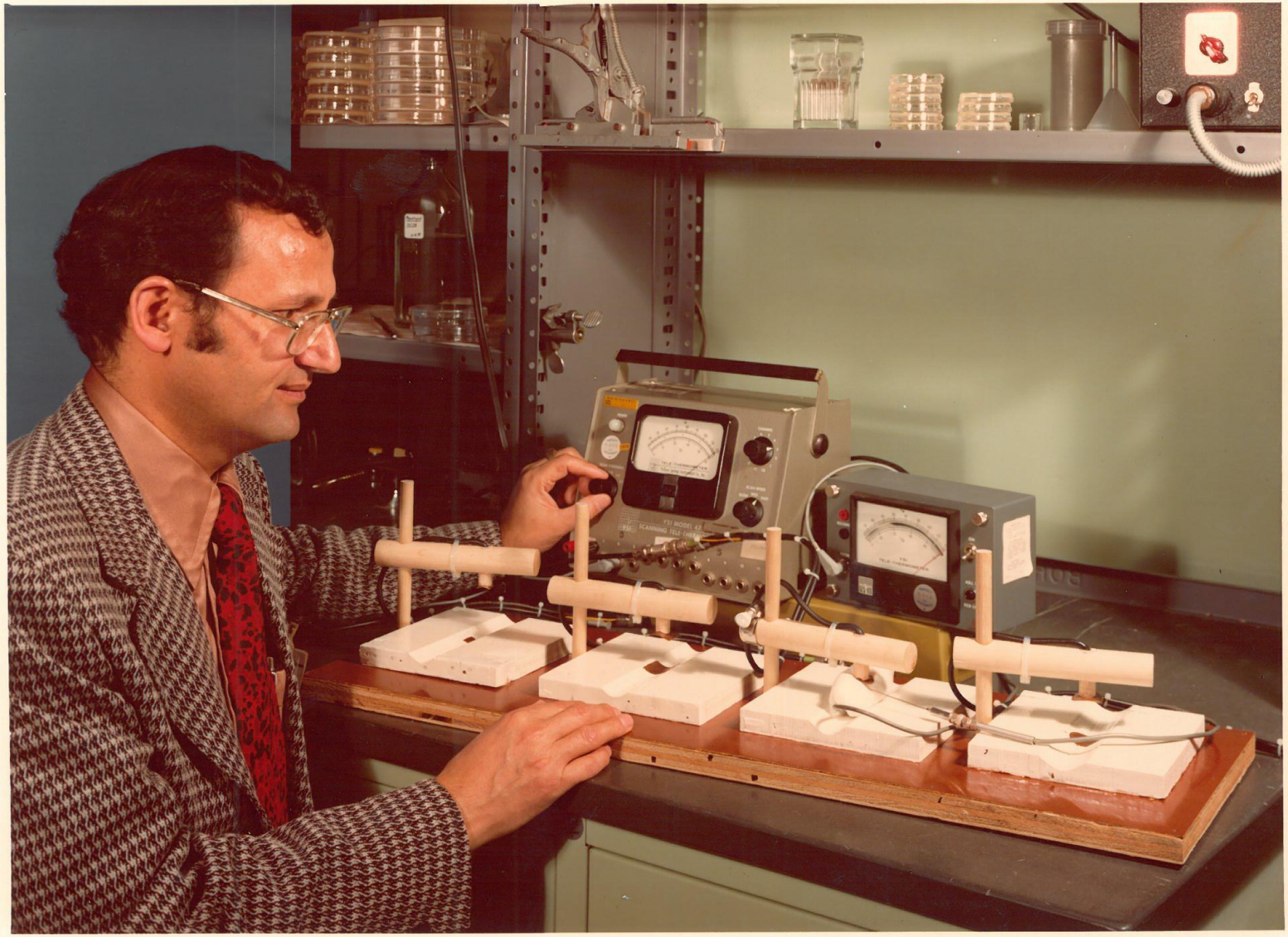
Development of Innovative Radio Frequency Treatment for Cancer

Dr. Krishen was the Lead for the Development of Innovative Radio Frequency Treatment for Cancer. The system developed by Dr. Krashen's Team received international attention and was publicized in JSC Roundup article on front page, BBC London, March 7 1980, Electronic News, City of Houston, and by the Stehlin Foundation

NASA National Aeronautics and Space Administration

S- 79- 26695

Lyndon B. Johnson Space Center
Houston, Texas 77058



NASA National Aeronautics and Space Administration

581-40030

Lyndon B. Johnson Space Center
Houston, Texas 77058

NASA National Aeronautics and Space Administration

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Lyndon B. Johnson Space Center
Houston, Texas 77058

NASA National Aeronautics and Space Administration

581-40029

Lyndon B. Johnson Space Center
Houston, Texas 77058

ROUNDUP

Lyndon B. Johnson Space Center

NASA

March 7, 1980 Houston, Texas

Vol. 19, No. 5

NASA invention applies heat to cancers

RF applicator used in treatment at St. Joseph Hospital

Cancer research has shown that heat treatments can destroy cancer cells without harm to adjacent healthy tissue. Methods for producing heat have grown steadily in sophistication—starting in 1893 when doctors induced fever in cancer patients to today's techniques such as ultrasound, radiated microwave, and blood perfusion.

In mid-1978 LBJ Space Center signed a Memorandum of Understanding with the Stehlin Foundation for Cancer Research at St. Joseph Hospital in Houston, saying the space center will provide technical support for the foundation's work with heat, or hyperthermia, treatment of cancer.

Tumors will heat faster than healthy tissue, perhaps because they hold more fluid to contain the heat and fewer blood cells to carry the heat away. Tumors have restricted blood flow. So, heat concentrated on a cancerous area can destroy cancer cells without harming healthy tissue nearby.

The challenge for JSC engineers was to improve radio frequency (RF) heating techniques being used at the Stehlin Foundation. First step was to develop a machine for treatment of small animals.

Then after a year of tests on mice, JSC scientists developed an advanced RF hyperthermia system for treatment of humans.

Krishen with small animal device—finding optimum frequency

"The human RF system has performed successfully on several cancer patients," said Kumar Krishen of JSC's Experiment Systems Division. Dr. Krishen is technical coordinator of the project.

"Developing the advanced human RF hyperthermia system involved acute concerns about safe and reliable performance."

For work on the machine to be used on humans, Dr. Krishen's team called for assistance from JSC's Safety, Reliability, and Quality Assurance Directorates. SR&QA monitored and reviewed the overall design and performance of the equipment.

In January 1980 the team delivered an experimental human treatment system to St. Joseph Hospital.

"The RF system for human treatment uses a gradual buildup of power to its preselected value," Dr. Krishen said. "Two pairs of sequentially driven electrodes provide more concentration of RF power at the tumor and disperse heat at the skin."

The team also developed a feedback control which allows regulation of temperatures within a specific area to an accuracy of 0.2 degrees Centigrade.

One area of concern was heating of the skin below the electrodes which in some cases causes burns. "Our approach was to circulate temperature-controlled water through metal tubing soldered onto the back of flexible electrodes," Krishen said. "This scheme has been found to be very useful."

A data printer added to the system records temperatures and power levels as a function of time.

"The small animal experimental system we first designed yielded very valuable data," Dr. Krishen said. After trying different combinations, the ESD team came up with an optimum size and shape for the applicator. They determined the maximum heat the animal's body could tolerate, 41 degrees Centegrade, and gave the applicator a convex shape to keep "hot spots" from coming into contact with the skin.

"A notable feature of the small animal system is the ability to apply up to 50 watts at five frequencies from three MHz to 30," Dr. Krishen said. "This helps us to indicate the advantages, if there are any.

Please turn to Page 2

A Japanese spokesman adds that the government can only speculate on

of the two satellites are still up in the air.

Electronic Cancer Treatment

NEW YORK — Medical institutions around the country are using microprocessor-controlled microwave devices in experiments they hope will lead to the successful treatment of cancer without the painful experience of chemotherapy.

The method of treatment, called "hyperthermia," involves heating a cancerous tumor with microwaves, thereby providing an unsuitable climate for the tumor. The computerized portion of the device provides safeguards against damage to surrounding healthy tissue.

The technique was first developed at the Stehlin Foundation for Cancer Research in Texas in the early 70s by Dr. John S. Stehlin and Dr. Beppino C. Giovanella, who discovered that 41° to 43°C is a critical temperature at which tumor cells can be killed, leaving normal cells alive. Experiments are also being conducted at the University of Rochester, Stanford University and the Memorial Sloan-Kettering Cancer Center.

The technique depends on the fact that, compared to healthy tissue, cancer tumors have a relatively restricted blood flow and accumulate more liquid. Because of this, the tumor normally contains more heat than does healthy tissue, and will reach a higher temperature when subjected to microwaves.

The microwave device used at the Stehlin Foundation was developed by the Johnson Space Center and manufactured by Lockheed Electronics. The microprocessor was made by Motorola. The components are all off-the-shelf and manufactured in the U.S. to cut down on lead times when replacements are needed.

The device, which emits energy through two electrodes placed on either side of the body where the cancer is located, is capable of generating up to 1 kW at frequencies between 10 kHz and 200 MHz, as compared to conventional diathermy devices, which operate at 2450 MHz. The operating range of the machine, though, is restricted to between 3 to 30 MHz, with up to 400 W of power.

A problem with the microwave treatment has been the burning of skin immediately below the electrodes. Dr. Kumar Krishen, who heads the NASA team from the Experiment Systems Div. of the Johnson Space Center, found that circulating temperature-controlled water through metal tubing soldered on the back of the electrodes cools the skin. "Burns are no longer a concern," says Dr. Krishen.

Dual-Purpose Probes

The computerized elements not only guard against burning healthy tissue but also control certain functions of the device. Two probes are inserted into the normal tissue surrounding the tumor and provide feedback to the system, regulating the temperature and duration of treatment. The probes will automatically shut down the device if normal-tissue temperature exceeds 43°C, if excessive ground leakage current exists, or if the microwave power exceeds 400 W, considered the uppermost limit of safety for humans.

In addition, the probes provide feedback that enables the device to be tuned to the body's resonance. The machine will not operate if a system mismatch is present. The device also automatically shuts down every half-minute for three seconds of full analysis, the results of which are printed on a line printer.

"We're not ready to report all the results yet," says Dr. Stehlin, "but there is a lot of hope for this method of treatment. The signs are good, and the patients are responding well."

Dr. Krishen says, "As the system becomes more sophisticated and we learn the limits of the computerized feedback system, we'll be able to fine-tune the microwave frequencies to specific types of cancers."

John S. Stehlin, Jr., M.D.
Peter D. De Ipolyi, M.D.
Pierre J. Greeff, M.D.
777 St. Joseph Professional Building
Houston, Texas 77002

Surgical Oncology
General Surgery

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Info Copy to AA BC EA4 EA SA
Rec'd in Mailroom 3-4-80
Response Due

February 25, 1980

Dr. Christopher Kraft
Director
Johnson Space Center
2101 NASA Road 1, Building 1
Houston, Texas 77058

Dear Chris:

We were certainly thrilled to receive the new radiofrequency hyperthermic unit which your department built for our use in patients with advanced cancers. The unit is already in use and thus far, it is functioning beautifully. It is an impressive piece of machinery which has been superbly engineered.

Kumar Krishen has been in constant communication with us and has exhibited a great deal of interest in this program and has been of invaluable assistance in promoting this project and bringing it into a working status. Much time is needed to evaluate its effectiveness, but I have little doubt that this unit will prove to be superior to our present units. We will keep you informed as to the progress of our unit.

I am presently preparing to go to the United Arab Emirates for one week. Upon my return, I would like to discuss future cooperative efforts with you.

With kindest regards, I remain

Sincerely yours,

John

John S. Stehlin, Jr., M. D.

Example of my Innovation

Fire Fighter Suit

Development of an Innovative Fire Fighter Suit

Dr. Krishen was the Team Leader and interviewed on Discovery Channel

From Space to Earth, NASA focuses expertise on Firefighters

A new fire-protective suit will be displayed at Johnson Space Center's "Inspection 2000“

The new suit is only partly completed, but all the design elements are in place and feasible for manufacturing, said Kumar Krishen, chief technologist for NASA's Technology Transfer and Commercialization Office in Houston.

The new suit is comprised of new materials that greatly increase heat resistance and impact protection. It also incorporates a new water-cooled undergarment that uses circulation tubing to keep the firefighter from overheating quickly and a new cryogenic liquid air breathing pack that will provide air for two to three times as long as compressed air packs of similar weight. A new helmet in the works will include thermal imaging capabilities, an improved communication system, greater impact protection, and a technology that tracks the location of each firefighter, Krishen said.

Another innovation that may be included in the design is a sensor array that will send information about firefighters, such as heart rate, respiratory rate and other physical data, to the firefighting commander on the scene, Krishen said.

"We believe that one of the things we have learned the hard way is that the health of the firefighter is very important to the extent that, when you are in the fire your temperature goes higher, you are a lot more stressed, and there's a lot of burden on the heart," Krishen said.

"So it's very important that we monitor the burden on the heart and respiratory rate. First generation systems will measure heart rate and heat rate, and eventually you might be able to take an electrocardiogram directly from the suit's sensors."

Fires in the United States kill more than 5,000 people each year, and injure almost 30,000. About 100 firefighters die each year as a result of fire-related stress or injury, and about 100,000 firefighters are injured. Fires cause about $130 billion in economic losses, including property loss, time lost from work for injuries, and other factors, Krishen said.
"Our goal is to develop a suit that will withstand temperatures from 500 to 700 degrees Fahrenheit for one hour," he said.

Today's firefighter protection suits can withstand a maximum of 300 degrees Fahrenheit, and only for a few minutes if exposed to direct flame, he said.

Published: Monday, October 30, 2000
MICHAEL GAFFNEY
LubbockOnline

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Suspense No

JSC Form 684 (Rev Oct 89) 1000-D

02-23-2001

TEXAS ASSOCIATION OF FIRE EDUCATORS

Mr. George W. Abbey
Director
NASA Johnson Space Center
2101 NASA Road One
Houston Texas 77058

RE: Dr. Kumar Krishen

Dear Mr. Abbey,

I would like to take this opportunity to express my appreciation for the efforts of one of your employees, Dr. Kumar Krishen. Dr. Krishen has been the team leader and coordinator for the Fire Suit project, on which I serve. During the last several years, I have had the opportunity to get to know Dr. Krishen and to observe first hand his dedication and efforts to make this dream a reality. He has worked tirelessly toward our goal of providing the American Fire Fighter the highest level of personal protection possible as they strive to save the lives of endangered citizens daily. Through the efforts of NASA, the citizens of the United States may soon have the technology that would provide them the best chance of surviving a fire of any population in the world.

Under his leadership and direction, our project has grown from a simple request to see if anything could be done to assist the fire fighters that risk their lives daily, to a project of local, State, and national interest. I have been asked to explain the Fire Suit project and its promise to newspapers and media across Texas, elected officials at every level of government, the National Fire Academy, and fire service professionals throughout the world. It is the hope of each of us who have lived through the suffering of human loss to fire that NASA may be able to provide the technology to win the battle. This project would not have been possible without Dr. Kumar Krishen and his extraordinary efforts. Many times, this project seemed doomed from a lack of resources and financial support. In each case, Dr. Krishen rallied the team to answer the challenges that confronted us, developed a plan to meet the new challenges, and restored the vision to continue forward. Considering the financial resources utilized for this project, to produce a product of any type is a major accomplishment and success.

It was a tremendous moment when the fire suit mock-up was displayed to the Texas fire service at the 15th Annual Texas Association of Fire Educators Instructors Conference in Austin Texas January 2001. As a result of that display, the subsequent article in the Austin American Statesman, and fire service interest, I will serve as the keynote speaker discussing NASA and the Fire Suit project in Port Neches Texas March 1, 2001 at a fire service banquet. I will also be discussing the NASA Fire Suit project while I am in Sydney at the Australian national emergency training center later on in March.

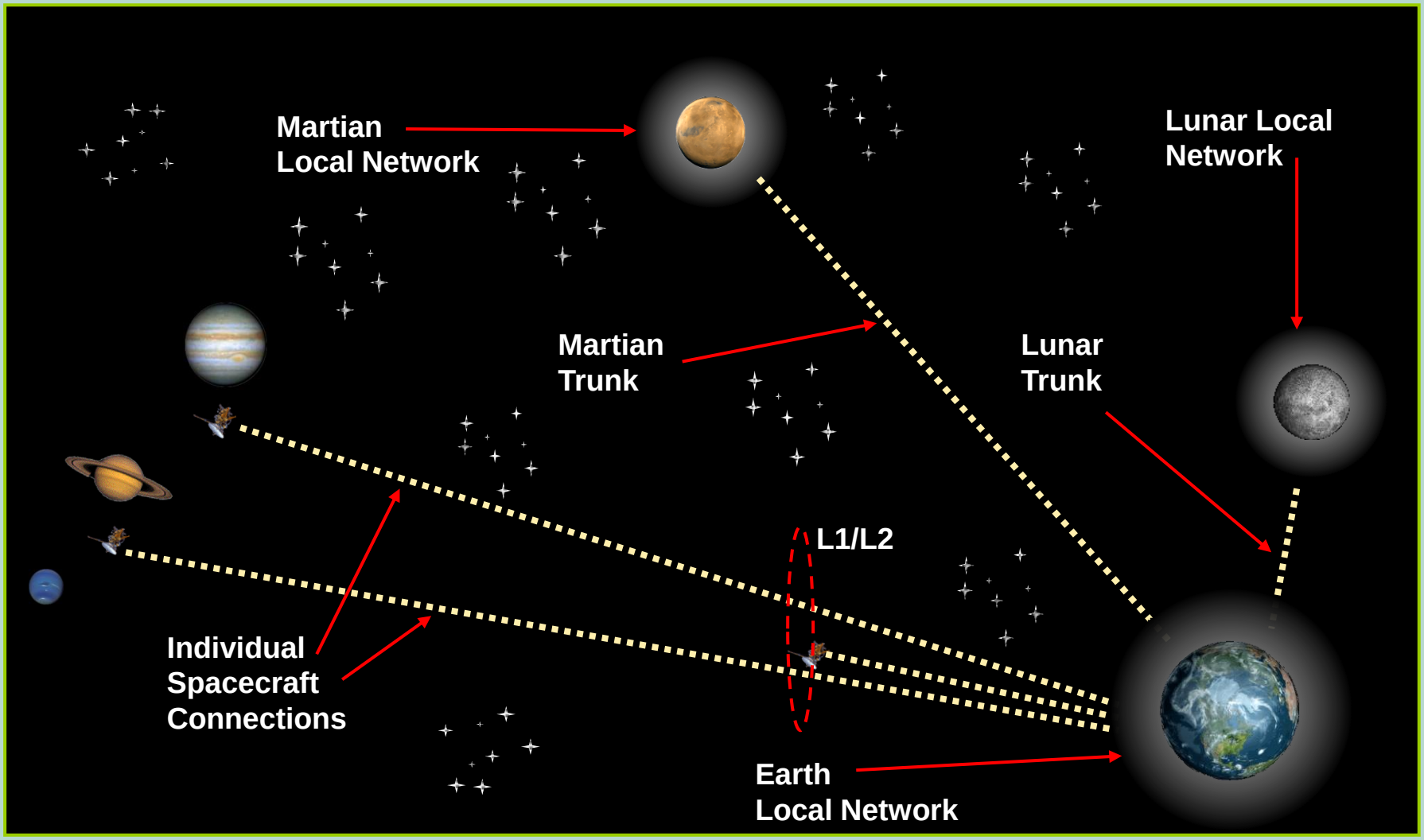
From day one, it has been evident that the only limitations on the success of the Fire Suit project were funding based. The abilities of the NASA employees are truly remarkable. Let me again thank you for your support on this very important project and express the Fire Services appreciation for Dr. Kumar Krishens efforts and leadership to make this dream a reality.

Gary M. Vincent
President
Texas Association of Fire Educators

Example of my Innovation

Communications and Tracking Systems

Top Level Conceptual Communication Architecture ~ 2030



Development of Advanced Communication and Tracking Systems

- Advanced Technology for Space Communications and Tracking Systems, K. Krishen, Acta Astronautica, Vol. 21, No. 1, 1990, pp. 29-44.
- Future Trends in Antennas and Propagation for Space Programs, K. Krishen, Vol. 36, No. 1, February 1994, pps. 31-35, IEEE Antennas and Propagation Magazine.
- Review of Laser and RF Systems for Space Proximity Operations, Krishen, K. and Erwin, H., Proceedings of the International Telemetry Conference, IFT/ISA, October 1985, pp. 1-25.

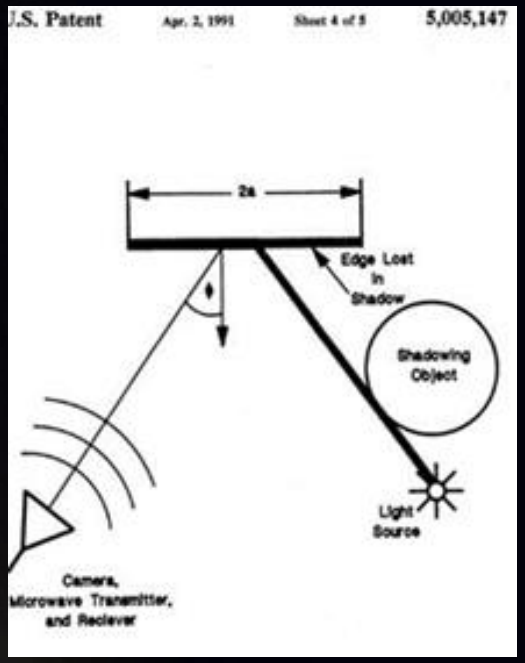
Example of my Innovation

Robotic Vision Systems and Methods

NASA Robonaut

Assured Robotic Vision Methodology

Krishen Kumar, Shaw Scott W, deFigueiredo Rui J P: Method and Apparatus for Sensor Fusion. The United States of America as represented by the Administrator the Apr, 2 1991: US 5005147



Assured Robotic Vision Methodology

Adaptive Multisensor Fusion for Planetary Exploration Rovers, M. Collin, K. Krishen, and L. Pampagnin, Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, organized by CNES, Cepadues Editions, Toulouse Labege, France, September 30-October 2, 1992, pp. 113-116

Technology Reviews, Evaluations, and Assessments

- **Dr. Krishen has reviewed/evaluated more than nine thousand proposals, reports, papers, and presentations from 2004**
  - Enabled the identification, protection, and tracking of JSC Intellectual Property (IP)
  - Enabled shaping JSC technology portfolio for Evolving Mars Campaign and JSC 2.0 initiative
  - Provided opportunity to point out areas of improvement in technical approaches advanced by JSC colleagues

How to Prepare for a Future of Technological Innovation?

- Expect Impossible to be Made Possible
- Have an Open Mind
  - Expertise/Education
  - Experience
- Lead by Example in inventing, commercializing & using Innovation/Invention for promoting hope, peace, and prosperity

Thank You!

Back-Up Charts

Examples of my Projects

Other Assigned Projects

Examples of Some Achievements

- **Advancement of Technology through NASA Small Business Innovation Programs**
- **Publication of JSC Research and Development Reports for Partnership development**
- **Identification of NASA Innovations through Data and Documentation Reviews**
- **Advancement of Technology and NASA Image through Participation on Interagency, Inter-organization Panels, Working Groups, Committees, and Conferences**

Examples of Some Achievements (Continued)

- **Identification and Communication of Technology Needs for NASA Mission Success**
- **Development and Communication of NASA Technology Transfer and Commercialization Success Stories**
- **Unique and Extensive Contributions to NASA Doctoral, Post-Doctoral, Undergraduate Fellowship, and Minority University Programs**
- **Advancement of NASA Space Systems through Contribution to NASA Missions**

Examples of Some Achievements (Continued)

- **Advancement of Technology through Review of Research Projects, and Papers and Books for Publication**
- **Internationally Recognized Contributions to NASA Research and Technology Thrusts Development**
  - **University and Research Organization Collaboration**

Examples of Some Achievements (Concluded)

- **Identification of New Technologies for NASA Mission Applications (Dr. Krishen Coordinated two Experiments Proposed for International Space Station Program)**
  - **More than 30 Technologies Identified and Championed**
- **Trail Blazing Contribution to Strategic Management and Productivity**

NASA technical expert comes to Tech

Kumar Krishen, chief technologist for the Technology Transfer and Commercialization Office at NASA Johnson Space Center, joined the faculty in October under an **interagency personnel act agreement** to help further key initiatives at Virginia Tech. As a technology transfer fellow, Krishen will **lead an entrepreneurship program with the private sector, develop a working consortium of members for a Critical Technology Transfer Program, and work with technical programs at the NASA-Langley Research Center.** Krishen will also serve as an **adjunct professor, teaching in the electrical and computer engineering department.** **VT Magazine News/Research**

http://www.vtmagazine.vt.edu/spring02/news.html#Anchor-NASA-33869

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

University Special Initiatives
Associate Vice President for Special Initiatives
2000 Torgersen Hall
Blacksburg, Virginia 24061-0285
(540) 231-7682 - FAX: (540) 231-9682

June 28, 2002

Gen. Jefferson D. Howell, Jr.
Director
NASA Johnson Space Center
2101 NASA Road 1
Houston, TX 77058

Dear Gen. Howell:

Dr. Kumar Krishen of your Center is at this University on an Intergovernmental Personnel Act (IPA) working under my supervision. I recommend him for an outstanding achievement award on the basis of his work here.

As a technology transfer fellow, Dr. Krishen reviewed the Virginia Tech (VT) entrepreneurship program and developed a comprehensive plan for achieving best results in terms of technology transfer and commercialization. As part of this initiative, Dr. Krishen is leading the effort to organize and execute the VT's Vision for Technologies Exposition. This Exposition will be held this fall in Northern Virginia/Washington D.C. area.

I am leading several initiatives for this University. Dr. Krishen has provided outstanding technical support to these initiatives, which include International Institute for Information Technology, feasibility study for International Space Station research, and development and technology transfer facility, the Homeland Security Institute, Aerospace Institute, and Critical Technologies Institute. He has also initiated joint technical programs at the NASA Langley Research Center and Naval Research Laboratory.

As a Visiting Professor, Dr. Krishen taught a short course on Remote Sensing, reviewed research done by faculty and students, participated in a seminar course on Earth Resources and Geographical Information Systems (GIS), and presented a series of lectures on space technology development and transfer. His contributions in this area have been highly commended by both faculty and students of this University.

I appreciate your consideration of my request. Please feel free to contact me for additional information.

Sincerely yours,

Leonard Ferrari
Vice Provost for Special Initiatives

NASA technical expert comes to Tech

Students of the Signal and Systems Courses at Virginia Tech, Virginia

“Dr. Krishen is the best Professor I have had at Virginia Tech – very intelligent and explains well.”

“This guy knows too much. He needs to give us all some of his brain.”

More than Five Hundred Presentations

Ms. Leslie Roche, Director, TIO, United Space Alliance

"What I find particularly remarkable is your ability to communicate with such a diverse group of people with specialties in myriad areas, and make the information relevant to every listener. This takes a special gift, but also demonstrates your own expansive breadth of knowledge."

Mr. Richard A. Huebner, President, Houston Minority Business Council, Houston

"For the first time in 20 years I think I understand the Small Business Innovation Research program (from Dr. Krishen)."

Mr. Jairo E. Pertuz, NASA Intern

"Kumar, thank you for the presentation it was excellent.
It makes me want to go out and get an SBIR even though I don't have a commercially viable idea."

More than Five Hundred Presentations

Dr. Krishen,

Dr. Krishen you are cool, fun, funny, hyper, nice, and a great teacer. You are cool because what you tought us is cool. You are fun because you just were fun. You are funny because you made all of us laugh. You are hyper because you were very crazy. Finally you are a nice teacher because….Turn to back please →

You are a very nice teacher!

Those are the things that you are and will be forever.

Wallin, E. S.

Sincerely,

Cecelia

A mind – boggling presentation by Dr. Kumar Krishen , an eminent scientist from NASA. Imparted knowledge about astounding aspects of Space to galvanize the students.

Vidya Mandir H. S.

Identification and Communication of Technology Needs for NASA Mission Success (Examples)

- **Advanced Technologies for NASA Space Programs**, Proceedings of the 10th Annual International Space Development Conference, Blackledge, Robert C., and Carol L. Redfield, (Editors), Univelt Inc., San Diego, Calif., 1991
- **Technology Needs for Future Space Exploration**, the Institution of Electronics and Telecommunication Engineers Technical Review, Vol. 26, No. 4, pp. 228-235, Jul-Aug 2009. (IETE Gowri Memorial **Gold Medal & Certificate Best Paper Award)**
- Several presentations at International Conferences from 2009 to the present including, "**Living in Space or on Other Planets, Keynote Presentation**" at the 2011 International Conference on Computer Science and Logistics Engineering held in Zhengzhou, China, Nov. 11-13, 2011"; **"Technology Needs for Future Human Space Missions",** American Center, US Embassy, Delhi, Oct. 29, 2013."

Identification of New Technologies for NASA Mission Applications (Examples)

- New Technology Innovations with Potential for Space Applications, Acta Astronautica, Vol. 63, pp. 324—333, 2008.
- Space Applications for Ionic Polymer-Metal Composite Sensors, Actuators, and Artificial Muscles, Acta Astronautica, Vol. 64, pp. 1160-1166, 2009.
- Space Applications for High Temperature Superconductivity Technology - Brief Review, Progress in High Temperature Superconductivity, 2nd World Congress on Superconductivity (WCS), World Scientific Publishing, 1992, New Jersey, Volume 28, pg. 43-46.
- Coordinated three Proposed Experiments for International Space Station Program

NASA Technology Transfer and Commercialization Process & Opportunities (Examples)

NASA Technology Developments and Associated Spinoffs, Keynote presentation, Business of Engineering Science and Technology Expo '92 Conference, Oct. 26-29, 1992, sponsored by Engineers Council of Houston, Houston, Texas

Multiple Aspects of Space Technology Transfer, the Institution of Electronics and Telecommunication Engineers Technical Review, Vol. 28, No. 3, pp. 195-205, May-June, 2011

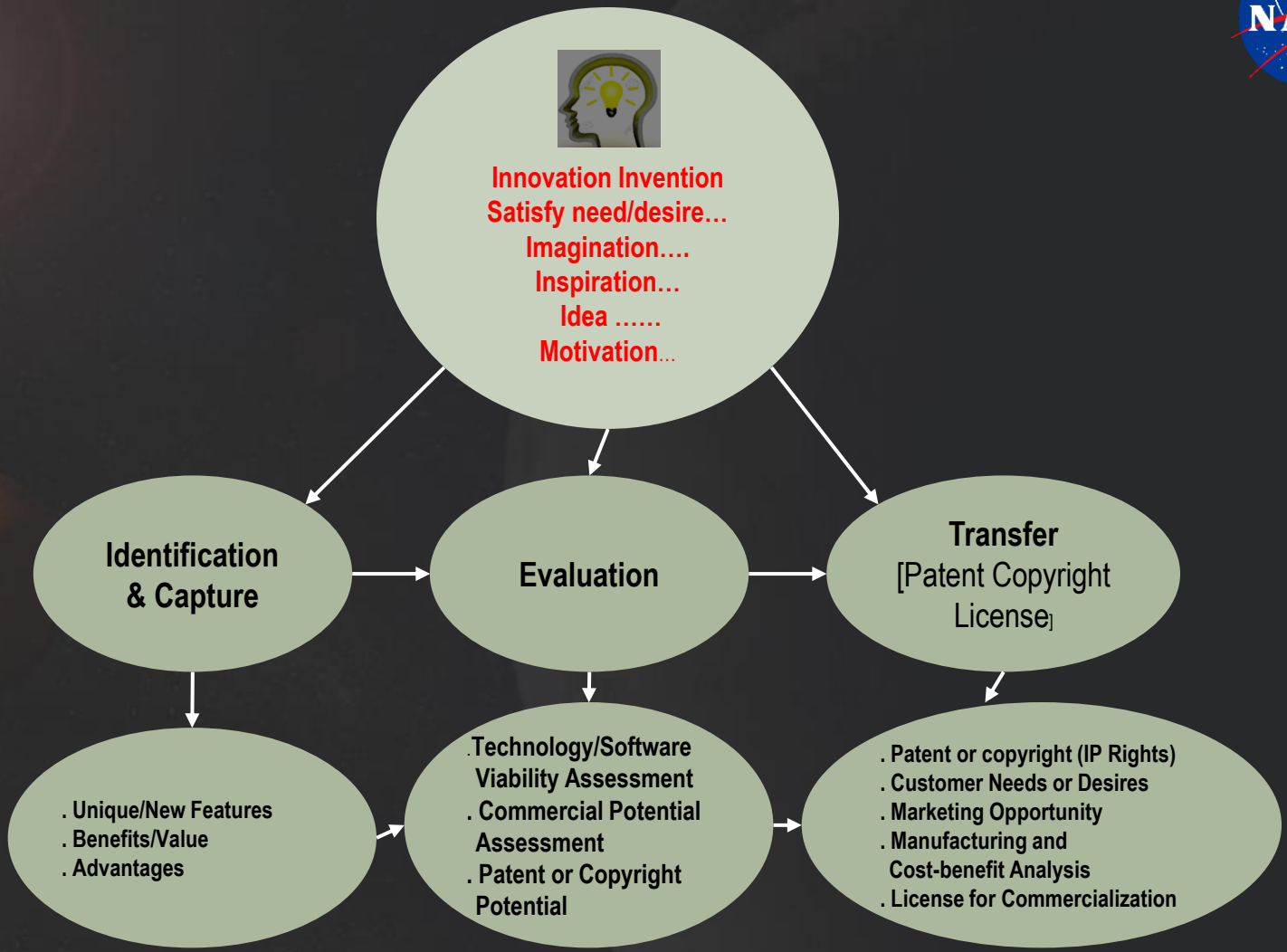
Applications of Space Technologies to Commercial Sector, Advances in Industrial Engineering and Management, Vol.1, No. 1, pp.1-9 2012

Unique and Extensive Contributions to NASA Doctoral, Post-Doctoral, Undergraduate Fellowship, and Minority University Programs

- Dr. Krishen was the Post-Doctoral Advisor to the NASA NRC Program, and Doctoral Advisor to the NASA Graduate Program and NASA Summer Faculty Program.
  - Guided more than 12 Fellows in engineering and science-related programs
  - Guided several NASA Interns
- Dr. Krishen was responsible for initiating and monitoring several NASA JSC research and technology projects at minority universities.

Advancement of Technology through NASA Small Business Innovation Programs

- **Dr. Krishen made significant and noticeable contribution to NASA Small Business Innovation Research and Small Business Technology Transfer Programs as Manager of the Programs at NASA JSC, developer of technology taxonomy, and developer of data management system**



From Innovation/Invention to Market (Krishen 2015)

Dr. Krishen's Work Appreciated by National Research Council report titled, "An Assessment of the SBIR Program at NASA" 2009, Washington, DC

5.14 JOHNSON SPACE CENTER (JSC)—HOUSTON, TX

JSC has the largest mission program-based research budget of the field centers. JSC's SBIR program has a complex interaction with multiple Mission Directorates. ESMD and Space Operations are the principal customers and drivers of SBIR topic/subtopic development, with the Explorations and Aeronautics directorates also playing substantive roles. Discussions with directorate program leads and technology element managers align JSC's SBIR program with the center's mission priorities. SBIR Program Manager Dr. Kumar Krishen also reviews agency Broad Area Announcements (BAAs) and Intramural Calls for Proposals (ICPs) to parse them for information that can inform the topic/subtopic development process.[58]

As with other field centers, SBIR Phase I activity includes evaluation of infusion/commercialization opportunities in the Phase I proposal technical review process. Phase II proposal evaluation also includes a formal outside peer review of infusion/commercialization opportunities.

JSC's unique practice focuses on interaction between SBIR principals and mission program principals. When subtopic managers brief the ranking committee on Phase II proposals, they must cite evidence of infusion opportunities, including summaries of specific discussions and meetings with directorate technology element leads on SBIR technology viability.

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[56]Some other field centers reportedly use a lower dollar threshold to determine Phase III success.
[57]It should be noted that there is only one Phase III contract cited on the NASA EHB Web site.
[58]Interview with Dr. Kumar Krishen, February 24, 2005.

Dr. Krishen's Work Appreciated by National Research Council report titled, "An Assessment of the SBIR Program at NASA" 2009, Washington, DC

Dr. Krishen reaches beyond NASA in the greater Houston area to advocate for SBIR commercialization and investment in SBIR firms with federal program infusion opportunities. At the time of his interview with NAS program staff in early 2005, his most recent SBIR marketing pitch, for example, had been made to the Houston Area Economic Alliance.

JSC SBIR Program Office actively promotes its Phase III successes through its annual Johnson Space Center Spin-Off Awards (which also reward "spin-in" technologies infused into NASA mission directorate programs) and *Success Stories*. In addition, it annually nominates SBIR candidates for NASA's *Space Technology Hall of Fame*—with two inductees in both 2004 and 2005.

JSC uses NASA's *Success Stories* Quad format of one-page summaries of SBIR projects, for use in infusion/commercialization marketing and Phase III recordation work.

Although JSC SBIR Program Office does actively monitor its SBIR portfolio of companies to assess Phase III success, tracking statistics are not available except to NASA SBIR Levels 1-2 principals for inclusion in the agency-wide *Spin-off* and other publications. According to the NASA Electronic Handbook Web site, JSC has had 44 Phase III contracts over the years.

JSC SBIR's main venues for evaluation are the semi-annual meetings of SBIR Level 1, 2, and 3 personnel, and the weekly/monthly electronic conferences. Infusion/commercialization issues—including Dr. Krishen's innovations regarding infusion/commercialization opportunity consideration in Phase I and II proposal rankings—have been reviewed by the NASA SBIR community at the semi-annual events. Internally, informal evaluation discussions of SBIR program effectiveness are held between the SBIR Program Office and local Mission Directorate personnel. In 2005, the principal emergent issue was the need for closer ESMD participation in the subtopic review process.

Dr. Krishen's Work Highly Appreciated by Headquarters Program Manager

Date: Tue, 13 Sep 2005 16:19:08 -0400
To: jhowell@ems.jsc.nasa.gov
From: Paul Mexcur <Winfield.P.Mexcur@nasa.gov>
Subject: Dr. Kumar Krishen's Contributions to NASA's SBIR/STTR Program
Cc: Carl.Ray
Bcc:
X-Attachments:

Dear General Howell:

I am pleased to bring to your attention the outstanding results of the JSC Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs.

Last year two of the JSC SBIR/STTR developed technologies were inducted in the Space Technology Hall of Fame. This year again two of the JSC SBIR/STTR developed technologies were inducted in the Space Technology Hall of Fame. In addition, several JSC SBIR/STTR companies have been identified and publicized by NASA Headquarters as NASA success stories. One of these companies got the NASA runner-up Software of the Year award and was chosen as one of the top five DOD technologies of the year. Dr. Krishen's work in promoting the application of SBIR STTR developed technology for space missions has resulted in contracts worth $10.5 million for SBIR companies at JSC.

Dr. Krishen's Work Highly Appreciated by Headquarters Program Manager

Dr. Krishen has greatly energized and motivated JSC science, engineering, and procurement colleagues to make the JSC SBIR/STTR Programs very productive. Dr. Krishen maintains contact with other Centers, academia, industry, and government organizations jointly working on research and technology challenges. One such example is his initiating a greatly successful joint project with DARPA.

JSC has also developed and implemented a plan to alleviate the SBIR/STTR Program process deficiencies identified in a memorandum for action by JSC Deputy Director, Robert Cabana. Currently, Dr. Krishen's procedures are in use and great efficiencies have resulted with no ethics and procurement integrity related violations being identified.

Congratulations on a very successful JSC SBIR/STTR program.

W. Paul Mexcur, NASA's SBIR/STTR Program Manager