Romance to Reality : Operational Aeromedical Status of Indian Journey into Space

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Based on updated 'Key Note Address' delivered during Space CME held at IAM on 25 May 2007

Abstract: The paper brings out the perspective of aerospace medicine in India, the role this special field has played in manned space programme of other countries and how it will contribute, to our own manned space programme. Romance with space will always remain in the hearts of the people, but the reality of covering the technological gap of 60 years and putting the man into space and safely retrieve him with the limited resources available in our country, is the challenge that will be discussed. GSLV MKII launch vehicle has created for India, the possibility of launching man into space. The overview will cover the current status of Manned Space Mission, the aeromedical issues and the assets that we have within our country in this area. To make it a well-conceived programme efforts would be made to identify the areas in which we need to work keeping the mission objective in mind.

IJASM 2008; 52(2): 1-8

Key Words: Manned space mission, aeromedical issues, aeromedical assets.

Introduction

It is a historic moment for Space Medicine chapter of India as 160 delegates and guests from ISRO and distinguished units of IAF, from various parts of the country have been able to assemble at IAM, in the Aviation and Space City of Bangalore. I am well aware of the inherent responsibility of this task and would speak from the perspective of aerospace medicine in India, the role this special field has played in manned space programme of other countries and how best we can sincerely and truthfully contribute, to our own manned space programme that we are contemplating. Certain impingements are bound to occur into the domain of the experts in the other related areas, not with the intent of diluting any discipline's importance but by virtue of the complexity of the aeromedical field itself. Today the focus is on the subject of aerospace medicine but this by any means, is not the core or mainstream of a manned space programme, but is a very critical link from the conception stage itself, as seen in the US and Russian programme. Even in the field of medicine, the importance of various specialisations will remain and be vital, to translate this massive dream, which ISRO has triggered as a national project, though still in its infancy.

Romance with Space

Romance is described as a pleasurable feeling of excitement and wonder associated with love, a love affair, a book or film dealing with love in a sentimental or idealized way, a feeling of mystery, excitement and remoteness from every day life. Space is a region remote from the earth. It is mysterious, exciting, beautiful and out of reach and therefore worth romancing. It is the longest ongoing romance, a universal romance of humanity; 5000 years have gone by and we are still, flirting with its edges only. The compelling urge to explore, to discover, to reach unknown territories and to try and go, where no one has ever been before, is as strong in an Indian, as it would be in anybody living on the technologically advanced part of the world. After all we also took our first steps into dark areas, took first plunge into the sea or a pool, sat on the

horse for the first time and went on first flight in the aircraft, a boat or a ship. All these pioneering small steps also extracted great amount of courage, from each of us as young children of India. However, the adult age reality is that, we in India are still trying to do a makeover from the romantic phase to a technologically independent phase, which will actually make us reach into space and survive. This transition will require a great amount of courage, leadership, perseverance, planning, ability to absorb failures, education in special fields and optimum utilization of limited resources available in our country.

The Space Technology Gap of 60 years

History of course, is full of path breakers; few of them are known and majority of them unknown, who dared to take such first steps. The name of Indians in the list of known pioneers is scanty for some reason, not the least of which can be due to lack of courage, imagination or innovations, as much before the modern world came into existence, the population on this peninsula had created a civilization with surplus resources and the luxury of engaging into higher forms of art, crafts, textile, sanitation, science of economics, mathematics, astronomy etc. India of that time was much ahead of the rest of the world, ready to be exploited and plundered by the people who were finding new frontiers and holding on to new territories.

The inconsequence of India in the larger affairs of the world was the perspective of the western world till recently, which is gradually being transformed into a grudging admiration as a successful, stable democracy, which has probably found the right balance in scientific growth and the general growth of the country. One of the examples of such a growth, Ladies and Gentlemen is the progress made in the field of Space by ISRO since 15 Aug 1969 and in the field of Aerospace Medicine by the Institute of Aerospace Medicine, IAF, since 1957, now in its 50th year of existence.

The Current Status of Manned Space Mission

Availability of V-2 rocket at the end of WWII in 1945, created the possibility of going into space by America. ISRO has established its credibility in designing, developing and making operational, launch vehicles and satellites comparable to those of developed countries. In 2004, with its GSLV MKII launch vehicle, it has created for India, the possibility of launching man into space. ISRO now finds itself ready, in its technological voyage, to forge ahead with a national effort for an Indian Manned Space Programme. It is well aware that the manned space programme calls for a synergy of technical capability, political will and social commitment and that, the presence of human being makes the program a demanding exercise. All systems involved have to be designed meticulously, tested to limits and demonstrated for performance. Detailed studies have been carried out by VSSC to assess the feasibility of putting a man in orbit and bringing back safely. Director VSSC constituted a team, which has brought out a good document on manned space programme, covering broadly, all aspects like need for an Indian Manned Space mission, cost of undertaking such mission, various infrastructures to be built and the overall schedule. The true picture would emerge only after each segment is worked out in greater details, in next few months. The overall programme is multi-faceted in nature and includes selection and training of crew, establishment of appropriate man-machine interactions and associated simulators, man rating and reliability enhancement aspects of launch vehicle, overall mission management and safe rescue of the crew after the completion of mission.

The ISRO-IAM Link

On 07 Nov 2006, a meeting was organized on

Indian Manned Space Programme at ISRO HQs attended by 80 scientists and Heads of Institutes, chaired by Shri Madhvan Nair, Chairman ISRO and Secretary to Govt of India, Dept of Space. Following this meeting a team of thirteen scientists from VSSC, SHAR and ISRO HQ visited IAM on 22 Nov 2006. During the years that ISRO was bridging the gap in launch vehicle technology, the IAF had been investing in IAM in the form of training manpower and acquiring world-class simulators for aeromedical training of air crew for its high performance aircraft. IAMs earlier experience in evaluating astronauts and its involvement in life support system design for aircraft, functional testing of aircrew life support system, human engineering aspects in work space station design and earlier facilities on sleep and isolation lab, studies in Hot and Cold exposure labs, High altitude simulators, Human Centrifuge and survival training etc were shown to the delegates from ISRO. We are in this business for last 50 years and thanks to the foresight of IAF and the synergy created with sister establishments, who on their own are world class, like Aircraft Systems and Testing Establishment, National Flight Testing Center, Air Force Technical College, Software Development Institute, all based in Bangalore under Training Command, that a great deal of confidence and knowledge base has got created, basically to serve the interest of IAF, Indian Navy, Army and Civil Aviation sector. This existing synergy is required to be fine tuned and developed towards use by others for planning the manned space programme, right from the beginning.

IAM presented the ISRO delegates with the first document "An IAM appreciation of aeromedical issues for Indian Manned Space Programme". During the visit it was realized that though vehicle technological gap has been reduced by ISRO, both IAM and ISRO need to start afresh to meet the challenge of putting man onto GSLV MKII which till now has only been used to launch satellites. Following this meeting, a good realistic perception on IAM-ISROs assets and the knowledge gaps, which need to be covered, had been achieved.

Lessons from History

In 1948 Maj Gen Harry G Armstrong organized a meeting at the USAF School of Aviation Medicine to discuss aeromedical problems of space travel. In 1952 two primates were launched into space although none survived, it was the beginning of space journeys and the need for reliable life support systems and to define the parameters for protecting mammals against the rigors and stresses of weightlessness and reentry into gravity. Our situation is probably the same as that of Americans in 1950, except that a huge amount of knowledge had been gained by the western countries form the ac manufacturing industry during WWII, which became precursor to the development of systems required for space technology. The first space suits, for example, were a direct outgrowth of the Navy full pressure suits used for high altitude flights. Also the cockpit environment technology developed for high altitude flights helped in making sealed cabins for astronauts.

The National Space Aeronautics and Space Administration (NASA) was formed in 1958 and was charged by the US President, to launch a person into space within an environment that allowed effective performance and to recover the person safely. The charge by the US president was given a high national priority next to defence. A lot of time has flown since then. We are in the similar situation awaiting go ahead from the Govt of India. What national priority that we are going to get is a big question? This is a reality. Let me now quote from the *John F Kennedy's Rice Stadium*

Moon Speech of 12 Sep 1962 **:**

Quote: ….. During the next 5 years NASA expects to double the number of scientists and engineers in this area, to increase its outlay for salaries and expenses to $60 million a year; to invest some $200 million in plant and laboratory facilities; and to direct or contract for new space efforts over $ 1 billion from this Center in this city. To be sure, all this costs us good deal of money. This year's space budget is three times what it was in 1961, and it is greater than the space budget of the previous eight years combined. That budget now stands at $ 5,400 million a year- a staggering sum, though somewhat less than what we pay for cigarettes and cigars every year. Space expenditures will rise some more, from 40 cents per person per week to more than 50 cents a week……**Unquote**

This just shows the kind of investment that US had made for its first manned programme in 1961. In comparison a budget of Rs 9000 Crores spread over 12 to 14 years may seem unrealistic, but if we succeed, the credit will go to the innovative spirit of the people engaged in this great challenge, a challenge, that I feel is greater than that faced by the people who were made responsible to put a man in space by US Govt in 1961.

What is the Roadmap to resolve the Aeromedical Issues in manned Space Flight Programme?

In a well conceived programme it is always better to define early and clearly the areas in which work needs to be done to achieve the programme objectives. To provide necessary support to the Human Space Programme (HSP) of ISRO, the Institute of Aerospace Medicine IAF Bangalore has defined the following areas of work:

(a) Selection of Vehicle Crew and Training

(b) Environment Control and Life Support System (ECLSS)

(c) Human Engineering Work Station Design for Crew Module

(d) Isolation and Psychological Management

(e) Human Factors considerations in Manned Space programme

(f) Microgravity Research

(g) Gravitational Stress Management in various Phases of Space Flight

(h) Clinical Space Medical and Surgical Management

(j) Radiation Protection

(k) Toxicology in Space

(l) Emergency Survival System Design

(m) Space Station Life Support System

(n) Extra Vehicular Activity (EVA) Design

(o) Heat Stress Management

(p) Operational Space Medicine

(q) Scientific and Technical Manpower Management

(r) Infrastructure Development related to Aeromedical Support

It is a vast subject and I will cover some aspects which may be of interest even to our aircrew to give you an overview based on the US and Russian process.

A Glimpse

Medical Requirements for various Crew Positions:

The minimal medical criteria for 'astronaut pilot' who actually pilots the spacecraft is highest as compared to 'mission specialist' who assists onboard operations and performs extra vehicular activity. The criteria for 'payload specialist' whose

task is to execute specific onboard experiments is still lower and that of 'participant' who is basically a passenger is the lowest. NASA has designed their medical criteria; Class I to Class IV respectively for four crew positions. IAM can design similar criteria based on medical and operational evidence, the experience gained in aircrew evaluation in India, astronaut selection during Sqn Ldr Rakesh Sharma's space flight and on the principal of good medical practice.

For project Mercury; the first major space undertaking by US, 508 records of Test Pilots were screened to select 110 candidates, which was brought down to 32 through a series of interviews and written tests. Further stringent physical, mental and psychological tests including whole body X-Ray, pressure suit tests, cognitive exercises and unnerving interviews seven Mercury astronauts were presented to the public during a press conference by NASA in 1959. Next year Soviet Union announced selection of 20 Fighter Pilots for its space mission. On April 12, 1961, Yuri Gagarin became the first human to orbit the Earth.

The medical evaluation process for Russian cosmonauts is carried out in three phases: an evaluation by questionnaire from specialists, a hospital evaluation and a final selection carried out at the Yuri Gagarin Cosmonaut Training Center, in Star City near Moscow. Basically all test results conducted so far are reviewed and involves one-week in-patient evaluation in Moscow at the Central Military Aviation Hospital for military Cosmonaut Candidates and at the Institute of Bio-Medical Problems for civilian Cosmonaut Candidates.

Crew Training

Astronaut Candidates receive training at the Johnson Space Centre near Houston, Texas. They attend classes on Shuttle systems, in basic science and technology. Mathematics, geology meteorology, guidance and navigator oceanography, orbital dynamics, astronomy, physics, and physiology are among the subjects.

Candidates also receive land and sea survival and scuba diving using space suits. All Astronaut Candidates are required to pass a swimming test during their first month of training. They must swim 3 lengths of a 25-m long pool in a flight suit and tennis shoes. The strokes allowed are freestyle, breast, and sidestroke. There is not time limit. They must also tread water continuously for 10 minutes.

Candidates are also exposed to the problems associated with high (hyperbaric) and low (hypobaric) atmospheric pressures in the altitude chambers and learn to deal with emergencies associated with this condition. In addition, astronaut Candidates are given exposure to the microgravity of space flight. Airbus A-300 jet aircrafts produce period of weightlessness for 20 seconds. During this brief period astronauts experience the feeling of microgravity. The aircraft then returns to the original altitude and the sequence is repeated up to 40 times in a day.

Further a large number of Mission Specific Simulators are used for training, which carries on at multiple levels in different time frames. We will be working on this issue purely from aeromedical point of view in this CME.

Environment Control and Life Support System (ECLSS)

Open loop system will be used as it is relatively simple, reliable and every one has used it for short duration space flights. The system has to provide temperature and humidity control, total and partial pressure control, atmospheric composition monitoring and airborne contaminant removal system. The life support resources have to be taken from Earth and discarded once they are of no use.

Food, water, oxygen is to be used from stored source. The working group will discuss details the day after tomorrow.

Isolation and Psychological management

Long duration space flights can test the crew's psychological well being and 7 days in the confines of 6 cubic meters can be quite testing. Factors such as confinement, under or over work, sleep loss, and monotony can combine to worsen interpersonal tensions or even lead to frank depression, suppressed anger etc. Conflicts can develop with ground control resulting in loss of trust and teamwork. Both crew and ground control need to be aware of potential damage, that such a situation can cause to the mission itself.

Microgravity

Simple acts become difficult when the 1 g gravity is missing. Sky lab had a shower, while standing in collapsible cylindrical cloth bag, the astronauts squirted water from a water gun and scrubbed liquid soap. This shower was a failure, as two other crew members had to spend valuable time vacuuming water, which escaped into air and installations on board. They don't bathe now and have gone back to sponging.

Trousers are changed weekly, socks, shirt and underwear are changed every two days and are sealed in airtight plastic bags to be taken back to Earth. The toilets are in a private section. To remain seated the user must insert his boots into foot restrain and snap together the seatbelt for waist restrain. There are two handholds. Instead of water flushing away solid wastes, this toilet has a fan that draws away the waste from the user and sends them to a compartment below. Urine is drawn into a contoured cup and flexible hose by airflow and the fluid is pumped into wastewater tank under the floor.

What we Have

The aeromedical assets

Let me present to you what resources we have been using in our area of core competency, to support our stake holders, which may be of use to ISRO, taking the VSSC document as the broad guideline. We in India, have the functional and maintenance expertise of many years in the following areas, extension of which will be useful for manned space programme.

- Institute of Aerospace Medicine IAF
- High altitude simulation chambers with air lock and main chambers with climatic control
- Hyperbaric chamber to create more than one atmospheric conditions
- Functional testing rigs for use of partial pressure suits used by our aircrew as
- Hot and cold environmental simulation with medical monitoring of human subjects
- Facility for dry flotation to simulate sub gravity situation
- The old human centrifuge
- New high performance state of the art human centrifuge
- Spatial disorientation and motion sickness simulator
- Survival aids and survival drill in water
- The vibration lab
- The head up & down tilt facility
- Expertise in anthropometric requirements of crew in clothing

The Launch Vehicle

Dr Swaminathan has already given us the plan and the GSLV MKII rocket that is capable of launching an Orbital Vehicle consisting of Crew Module and a Service Module with a habitable volume of 6 cubic meters, a payload limit of 4000 kgs for two man mission, lasting for 7 days. The reality is that presently the rocket is being utilized for non man rated commercial tasks. ISRO is quite clear that a huge amount of effort is required to meet the man rating requirements. The machine would then be many times more complex with the introduction of Emergency Mission Abort, Crew Rescue provisions, a safe Crew Module, a Service module to provide support for seven days, launch escape system, man rated avionics etc which are the unchartered territories for both ISRO and rest of us. Hence many a bridges need to be crossed in terms of miniaturizing the technology and transferring it to the vehicle. This was the most difficult task even for the western scientists in the early sixties. The pitfalls in the attempt of bridging the technological gaps to save time is to buy the technology off the shelf, if at all available and make the programme a one time affair. This would make the next attempt as difficult as the first one. The answer probably lies to go for quick freezing of design that is as simple as possible for the mission objective, go for innovative use of whatever is available, desist from developing many a fancy facilities which may not be of direct use to mission objective, go for minimum publicity till mission is ready, while rolling plan continues for more complex next missions.

A Space Medicine seminar had just concluded 10 days back in USA, one going on in China ended. In the pre-project phase of manned space programme activity the CME by IAF is the first step in taking on the challenge, with two aims:

(a)To update the knowledge base of the delegates to current status

(b)To discuss, define and formulate aeromedical aspects of manned space flight

through Special Interest Working Groups

Post CME progress

A number of documents have been brought out by IAM for ISRO after interactions at all levels, to keep pre programme phase of HSP.The first IAM Space Document in2006 dealt with "IAM's appreciation of aeromedical issues for the Indian Manned Flight" and the second document was a "Report on visit of VSSC, SHAR and ISRO HQ team to Institute of Aerospace Medicine on 22 Nov 06 for technical discussions on the Indian Manned Space Programme". The third IAM space Document deals with "Facilities required at national level (including budgetary estimates) for Aeromedical support to the Human Space Programme (HSP) ISRO and with "Projection of facilities enhancement at the Institute of Aerospace Medicine for immediate requirements for HSP ISRO, including exposure & training at national & international facilities.

To conceptualize and then decide on the roadmap for aeromedical support to HSP at national level was a huge responsibility placed by ISRO and the IAF on a small group of faculty at IAM. Through a world review of literature, numerous meetings and brainstorming sessions the team has made the roadmap document by a pioneering effort mostly in unchartered territories, to the best of its ability in a very short time. Continuous updates are being made by nine directors at IAM in specific areas to keep the concept dynamic.

As the leader of this team it is my duty and honour to place on record deep appreciation of extraordinary effort by each one of the members on the posted strength of IAM during the momentous year of 2006-08. At the same time constant encouragement, technical guidance, administrative support by IAF, HQs Training Command, office of DGAFMS, DGMS (Air), medical, technical and aircrew fraternity of all three services have placed us where we are today; on the road to manned space missions of India.

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Start studying Aeromedical Study guide. Learn vocabulary, terms and more with flashcards, games and other study tools.Â Exogenous aeromedical, aviation life support. US Army Aeromedical research laboratory (USAARL) conducts research and the effects of _. _ factors in the aviation environment and the development of____. Rated and non rated. US Army school of aviation medicine (USASAM) conducts training for all ____ and ____ crewmembers.Â A false perception of reality caused by the conflict of orientation information from one or more mechanisms of the equilibrium. Visual. System is the most important/Dominant sense providing orientation. The Aeromedical Isolation Team (AIT, or SMART-AIT) of the US Army Medical Research Institute of Infectious Diseases (USAMRIID) at Fort Detrick, Maryland was a military rapid response team with worldwide airlift capability designed to safely evacuate and manage contagious patients under high-level (BSL-4) bio-containment conditions. Created in 1978, during its final years the AIT was one of MEDCOMâ€™s Special Medical Augmentation Response Teams (SMART teams) comprising a portable containment laboratory Space biology research began to expand as a field of practical interest shortly after the end of World War II. An early example of a biological experiment elevated to the extreme upper limits of the atmosphere was the exposure of fungus spores to cosmic radiation on the flight of 17 December 1946.Â However, even when no operational difficulties arose, the aeromedical flights to and including those of 1952 did not produce much useful biological information. The animal subjects, if successfully recovered, showed no signs of radiation damage.