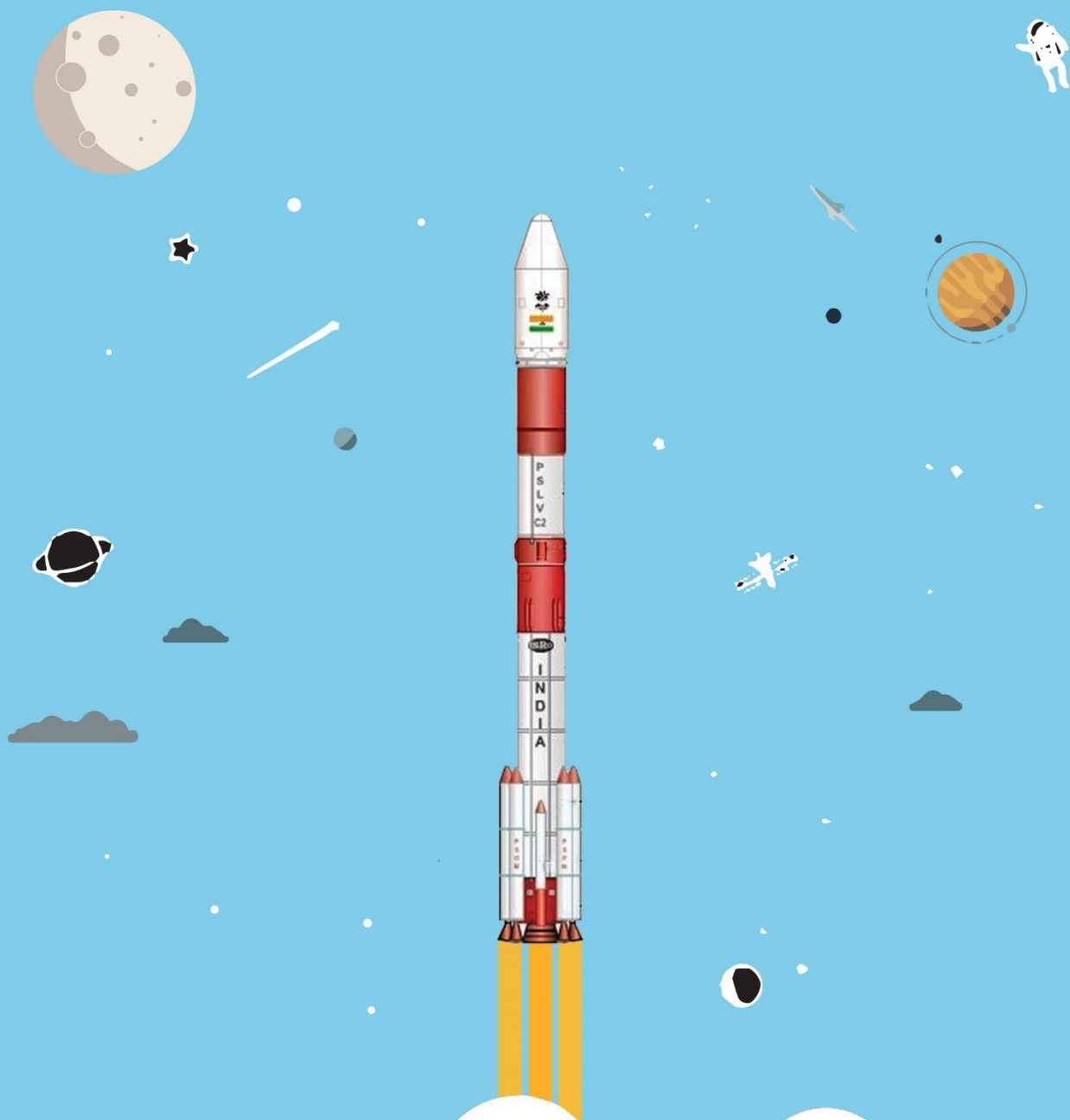


The Indian Human Space Programme

(HSP)– Travel, Explore, Discover, Claim, Inhabit

Document II: Milestone 2020: Further to Aerospace document I: Milestone 2018 presented as Srinagesh Memorial Oration at 57th Annual Conference of ISAM, Bangalore, 14-16 Sep 2018

Preparation: Step 1 Part I: Space Travel: Document II May 2020



Conceived by

Air Vice Marshal (Dr) Pankaj Tyagi, VSM, (Retd), IAF
MBBS, Dip Av Med, MD (Av Med), FeISAM

INDEX

1. Foreword	Page 3
2. Preface	Page 4
3. Introduction	Page 5
4. Only one space travel option in 2020	Page 5
5. HSP to ISCBP under INASA by 2022	Page 6
6. HSP: a step to help India collaborate with others	Page 7
7. Policy options for Indian “Human in Space” programme	Page 7
8. ISRO takes Option 1 Route	Page 8
9. Realtime Understanding HSP timelines and funding	Page 8
10. Give credit to Russian support for HSP	Page 9
11. Current Status of Funding	Page 10
12. Synergy of Intellectual Assets	Page 10
13. Answers to Questions on Current Status of HSP	Page 11
14. Significance of training at GCTC	Page 11
15. key areas IAM will be focussing according to you	Page 12
16. Progress India has made IN manned mission?	Page 13
17. Areas that India/IAM/ISRO have to focus for HSP	Page 14
18. Impact of Covid-19 on the manned mission	Page 17
19. intellectual resource synergy for success of HSP	Page 18
20. If no one responds to your call, then go your own way, alone	Page 19
21. Recommendations	Page 20

Document II: Milestone 2020: Further to Aerospace document I: Milestone 2018 presented as Srinagesh Memorial Oration at 57th Annual Conference of ISAM, Bangalore, 14-16 Sep 2018

Preparation: Step 1 Part I: Space Travel: Document II May 2020

The Indian Human Space Programme (HSP) – Travel, Explore, Discover, Claim, Inhabit

**The Roadmap for Indian Human Space Programme
Preparation: Step 1 Part I: Space Travel: May
2020**

**Recommendations for Stakeholders:
Aerospace Document II: Milestone 2020**

Urgent need to install Space Simulators at Institute of Aerospace Medicine, Bangalore for continuous training of our four astronauts, on their return after training in Russia, while ISRO should start working on original Indian Design and Development of Space Simulators, including Human Centrifuge.

Conceived by

**Air Vice Marshal (Dr) Pankaj Tyagi, VSM, (Retd), IAF
MBBS, Dip Av Med, MD (Av Med), FeISAM**

**Founder CEO,
Space Aviation Medicine & Engineering Creative Solutions Plus (SAMECSPlus)
an enterprise of Timespan Management Medical Services Pvt Ltd (TMPL)
&
TRIOPHS Medical Services Pvt Ltd**

This document is conceived in May of 2020, by Air Vice Marshal (Dr) Pankaj Tyagi, VSM, (Retd), as a response to many a questions raised on current status of HSP, especially in view of the successful selection of astronauts and their departure to Russia for training. It is presented, as the thoughts flew and formed the words. It is not in any formal format. It is just a small step to convey thoughts, on a matter of national importance to the few stakeholders of India. It is a small effort to share the burden of those, who take decisions for our nation, that changes the destiny of its people. It is also, an admiring tribute to ISRO, Space Commission of India and Prime Minister Narendra Modi for making things happen in the domain of Space for India.

Foreword

I feel privileged to introduce this ' Concept to Reality Document ', the author of which is AVM (Dr) Pankaj Tyagi VSM Veteran, a close friend and a colleague of over 45 years. A high caliber professional, Pankaj is known for his pursuit of brilliance and providing practical solutions to field problems. His passion for space medicine and space in general seems to have grown even further after leaving services and becoming an entrepreneur.

The document, which is solely his, is as complete and compact as it can be on a matter, that is a cherished dream and aspiration of our nation. As you read through it, it becomes evident that the human space program that we have embarked upon is full of challenges and will require course corrections along the way. Towards this end, the document provides an insight as well as possible choices that the country could decide upon.

To a few, some content of the document may seem as contrarian to the present perception, but it clearly indicates the single-minded passionate desire, for this national program to succeed better done by anyone else before.

I do agree with him on the use of vast wealth of intellectual asset spread across the country to build a strong programme. Many of the suggestions need a serious study from operational perspective. It would be worthwhile, considering the formation of an umbrella space agency (similar to NASA, ESA CNSA) to oversee all aspects of the extended human in space program. Such inputs as this document will serve the country well in overall interest of the Space Science in India.

Air Marshal JK Gupta (Retd) PVSM AVSM
Ex Director General Medical Services (Air)
16 May 2020

Preface

While I work on the answers to questions that have been raised, regarding my views on the current status of the HSP, specially the impact of COVID 19 on HSP, one should certainly refer to the main and related documents that were released on 15 Sep 2018 after the delivery of Srinagesh Memorial Oration, as answers to many of the questions being raised today are still lying there, waiting to be answered, while precious time flies by.

The Indian Human Space Programme – Past, Present and Future. The Roadmap for Aerospace Medicine; an integral national resource to support Indian Human Space Programme Recommendations of Stakeholders: Document: Milestone 2018 was inspired by “**AVM MM Srinagesh Memorial Oration**” and released at 57th Annual Conference of Indian Society of Aerospace Medicine (ISAM), Bangalore, 14-16 Sep 2018, held at Institute of Aerospace Medicine, IAF, Bangalore.

The present document deals with Part I of Step 1 (Travel). To me, capacity building within India to ‘Travel’ is only a means to make India reach, through success of this scientific pursuit, to the table of space faring nations and put it in a position to collaborate with them.

There are 5 components of any Space programme **Travel, Explore, Discover, Claim & Inhabit**. 15 Aug 2018 is the landmark date, when nudged by Prime Minister Narendra Modi, India initiated the journey towards its first step to ‘Travel’. I have no doubt that we have miles to go, to even conceive the roadmap to get India ready to travel in space. It will take next 20 to 25 years or so to complete this first and most important of the five steps (Year 2045). On the road to achieve this, the next four steps will automatically be attained with relative ease.

Competency development in multiple fields will require a top talent hunt across the world and positioning them under an umbrella like Indian NASA (INASA) to develop the engineering and medical capacity, that will take us through to our first goal to be able to ‘Travel’ in space. The programme will need regular budget for years to come, to be managed by INASA.

This macro level Step 1 on ‘**Preparation**’ to ‘**Travel**’ will be followed by the next document that will contain few of the micro level actions that will unfold space travel for India.

Introduction

Components of Space Programme generally are first travel, then explore, discover, claim and inhabit space. We are at travel stage at the moment. After reaching space, what is it, that we are going to do is more important and yet to be thought, so that we get max value for money from the first flight onwards. Reinventing wheels on someone else's systems, paid by India, is not what I had thought as a good idea.

There needs to be complete clarity on the broad aims of this national programme. Space expedition by India for the moment aims at perfecting the art and science of **'Travel'**. It means ability to reach space and come back safely, repeatedly on our own platforms, from our own soil on our own schedules.

'Exploration' is the process of treading new zones yet unknown. **'Discovering'** is unravelling new finds. **'Claiming'** is creating ownership of your own space. **'Inhabiting'** is making new place one's home. Observing, understanding, absorbing, adjusting, adapting, optimising are the skills used for all the steps. A strong Human-Machine combination appropriate for the mission with enough redundancies is key to success.

In any expedition, travel is planned with selected, trained and healthy travellers, appropriate robust vehicles, work & rest space for travellers, safe macro and micro environments, space for support machinery, sufficient logistic supplies for period of travel, tools and kits for scheduled work, maintenance and repair modules, capacity to deal with expected and new situations, including medical contingencies etc. Training of astronauts is one of the last steps in the stages of planning of the space programme. For us it seems to have become the first. I will try and explain the reasons for this as we proceed further.

Only one space travel option in 2020; next coming up by 2021

Presently the only space programme that is available in the world, monopolised by Russia and nearing its fag end, is that of International Space Station (ISS). The programme is powered by the longest running Russian built rocket Soyuz. Its variant Soyuz FG integrates with Soyuz- MS space craft, consisting of Orbital module, Re-entry Module and Service Module and is presently used to reach ISS repeatedly.

The second option that will be shortly available to the world is that of NASA built new rocket platform for to & fro movement of men and material starting from 2020 or possibly by 2021, as there is an expected delay due to Covid 19. NASA also plans to send American astronauts to revisit moon. By 2024 sending astronauts to the Moon on American platform is planned. The new space launch system as an alternate to Soyuz is likely to establish sustainable lunar exploration by 2028.

NASA plans to explore Mars and beyond. It is also developing new technology to make supersonic aircraft fly more quietly.

Artemis's major milestones in 2020 will be the first test of all four engines of the Space Launch System's core stage. NASA also plans to continue to work with commercial partners to send landers to the Moon, where they will help prepare the way for astronaut landings, including a rover that will map water ice on the Moon.

NASA, Boeing and SpaceX are preparing to launch astronauts from American soil in near future. Since the last unmanned test flights in 2019, they are getting ready to launch American astronauts from the United States for the first time after the space shuttle's last mission 2011. Commercial spacecraft and rockets are already delivering cargo to the space station, with more supply flights this year, while crew vehicles will undergo their final tests shortly.

ISS, the space station is in its 20th year of hosting astronauts in orbit. Astronauts use the space station for exploration technology, advanced life support systems and human and robotic interfaces. It is a unique microgravity test bed and national laboratory where humans work to benefit life on Earth and prepare for destinations farther into our solar system.

NASA's SpaceX Demo-2 mission will usher in a new platform to send humans in space. Astronauts Robert Behnken and Douglas Hurley of NASA are planned to fly to the International Space Station aboard a SpaceX Crew Dragon spacecraft, launching atop Falcon 9 rocket on 27 May 2020. I wish NASA well for this programme and complement the selected astronauts to test fly on a platform, not yet proven for humans. Not only the success of this audacious mission will renew American capability to launch astronauts, it will also kickstart NASA's Commercial Crew Program in partnership to develop and fly human space transportation systems. In next decade or so we in India would like to be in this position to launch two of our own Test Pilots on GSLV platform.

Indian, Human in Space Programme (HSP) to transform into “Indian Space Capacity Building Programme” (ISCBP) under Indian National Aeronautics and Space Administration (INASA) by 2022

Gaganyaan project as part of HSP has given India an opportunity to peak into the hardware, software and processes used by Russia to successfully travel into space, as the only agency in the world to do so presently. USA is hoping to catch up and provide an alternate to Russian ability to space launches by end of 2020.

This is the opportunity, HSP must seize. In the next 2-3 years HSP must position India, to be able to insert itself in both the American and Russian space programmes. That can happen, only by planning and execution of our own capacity building programme. For us, the learning curve has just begun. HSP should in 2020 be renamed under INASA.

The name HSP should be used only for a short programme for next 5 years or so, to finally transform itself into “**Indian Space Capacity Building Programme**” involving many more institutions, private enterprise, academicians, students etc India must try and retain, its option of being able to use both available platforms, for its capacity building. It should not get so entrenched into one programme that it may become financially difficult to extricate for a better programme in future. Prudence must prevail from now itself.

In 2020, to be able to reboot the HSP, we should use the training & other Soyuz platforms available from Russia to create our own capacities, proportional to what we can invest. Wisdom from my understanding would be not to extend the timelines for our first flight but use this understanding with Russia to fit Soyuz spaceship on GSLV III platform over first 4-5 space flights. Get ready in next 10 years or so for a bigger collaboration of “give and take” with Russia, America and Europe to develop our own space infrastructure and then take the first step to travel in space.

HSP: a baby step to create indigenous space travel capabilities to help India reach the table for collaboration with others

India wants to demonstrate, to be the fourth country in the world, to have “Human in Space” capability, with lowest possible budgets. The other three nations have invested huge time, technologies, finances to stand, where they are today. All three have built their own ways to reach space, independently, less so by China than by Russia and America. World prestige and power to do, what others cannot, is the gain, for these nations. Only after clearly demonstrating independent capability, to invest and manage, this high technology programme, can a country reach the stage of collaborating with others. In this field no limits to time, effort and technologies can be laid. This capability constitutes the ability to have access, at will, to rocket and human rated technologies, developed within the country.

No collaboration will occur unless we go to the table with the abilities to travel to space on our own platforms, consistently. Sharing the abilities achieved by Russia, America, China and Europe for a limited time frame in exchange for money or for some countries part sovereignty, cannot be considered collaboration. It is at best a ride with a friend, to be dropped on the way.

Collaboration brings independently developed capabilities of different nations together, for a collective effort beneficial to all involved based on sharing the costs and not necessarily reducing it. Benefits or time share are passed to each in proportion to the investment. It also brings increased safety and redundancy to the collaborative platform. It is not easy to be in a position to collaborate.

India is in a peculiar state in the present situation, with a go ahead from the government and timelines set for 2022. It is not yet fully ready, both in terms of launch platform and in development of crew module. Integration of rocket with Crew Module, along with integration of many related support technologies to complete the picture, are far from the stage of clearing the human ratings of our launch and return mission.

Policy options for Indian “Human in Space” programme

To bring clarity for all the stakeholders, let us put in perspective, the macro requirements of the project to take “Human in Space” by India. The basic idea of the programme is to travel, explore, discover, claim and inhabit space. These five steps will be covered in series of documents. The present document deals with Step1: Space Travel: May 2020, as Annexure 1 to Aerospace document; Milestone 2018 presented as Srinagesh Memorial Oration at 57th Annual Conference of ISAM, Bangalore, 14-16 Sep 2018.

There are two ways to achieve Step1, related to space travel. One is to develop in house capabilities to travel to space and the other is to, so called “collaborate” with those who are willing to do so, through Memorandum of Understandings or MOUs.

At this stage we need to take a call on following options specially in view of Pakistan also setting the same timelines for their human launch on its yet unknown platform.

1. **Option 1:** Buy the Crew Module off the shelf to integrate it with GSLV or pay for customising a proven platform of Crew Module to our requirements for a few flights and buy help in human rating of GSLV from Russians/Americans/Chinese. This same option is also available to Pakistan. It may take or may pretend to take this option, with the sole aim to dilute the prestige that would accrue to India, if it launches an Indian in 2022 or simply to derail India's timelines set by the PMO.
2. **Option 2:** Start from point of already developed technologies and insert the best technology options, through own development, involving all India resources or let the all India resources choose to buy and develop technologies considered essential by them. It will be in the interest of ISRO to pass the decision making to accredited resources of the country, rather than be the decision maker on its own. This option will require much larger investments upfront but will be hugely cost effective in the long run. This option may also shift the timelines of first of our launch beyond 2022, but will ensure an independent programme of India, largely owned by it. This option will give India the means to travel, explore, discover, claim and inhabit space on its terms. It is worth losing the race to foreign cosmonauts and astronauts from many countries who would fly on Russian manned spaceships including UAE, for a long-term gain of creating ability for Indians to inhabit space. Pakistan of course quite obviously, has taken the Chinese route putting itself in race, solely to beat Indian timelines.

ISRO takes Option 1 Route

For Gaganyaan, ISRO seems to have partly taken Option1 and have taken Russia as their partner similar to Pakistan having taken China to launch their astronaut, as we did in launching Rakesh Sharma on Russian platform in 1984. IAF officer Sqn Ldr Rakesh Sharma flew aboard a Soyuz T11 spacecraft on April 2, 1984 and became the first Indian to journey into space. He spent 7 days, 21 hours and 40 minutes aboard the Salyut 7 orbital station along with two Soviet astronauts.

ISRO for Gaganyaan to be worth the mission, as conceived by the Prime Minister Narendra Modi, must grow in multiple fields requiring time and investment in infrastructure, research and infusion of huge funds, if it wants to take on the role similar to what NASA is doing for USA. That would also need huge industrial backups and budgets like NASA, which is unlikely to come by in near future.

Presently, ISRO based on initial funding by GOI is purchasing minimal required used technological platforms from Russia. Per force, it will have to place totally Russian made Platforms on GSLV Mk III, if the vehicle proves itself in time to at least carry 5000 kg payloads repeatedly. Presently ISRO is not even ready to initiate rather than complete the integration and its certification process, which no other country would be willing to do for you, as that would require complete access to ISRO. There

will also be considerable shortfalls in budgets to ISRO, that could change the scope of the Gaganyaan programme to cosmetic, rather than real gain for India.

Realtime Understanding HSP timelines and funding

We should be ready for a deeper understanding of the programme vis a vis ISRO and HSP. HSP to me is a bigger programme, while ISRO is only an existing resource, not at all equipped for the moment, with the capability to deliver HSP, purely on its own.

15 Aug 2020 is just 3 months away. We are nearing 2 years since the announcement of the Gaganyaan programme by Mr Modi on 15 Aug 2018. As brought out in the main document by me, things have not gone right for ISRO. In the initial euphoria of 'go ahead' given by our prime minister, ISRO failed or rather ignored to understand the enormity of the programme and hurled itself, as the sole torch bearer of the programme. No real gap analysis in knowledge, availability of resources, rationing of timelines till target of 2022, budget requirements of ISRO, IAM and other key Institutes of our country was done. No real budgetary estimates and funding which is the key driver for any national programme were made and informed to Space commission.

Instead of taking a realistic view and in a hurry to say 'Yes' to everything ISRO seems to have bit more than it can chew. The situation now is that every shortfall is being put at the door step of space commission to provide solutions, as the prestige of the programme has been raised in public space, to the level that any failure of the programme will be seen as failure of GOI and finally the Prime Minister himself. It is so unfair and so easily seen at many levels in our so called professional bodies, to fall short of expectations repeatedly for the visionary and a dreamer for Indian honour. In this programme the Institute of Aerospace Medicine and the Indian Air Force subtly should have been at forefront of the programme to help develop and make decisions for human rating specifics of the programme.

Covid-19 is surely a huge setback to the programme. The HSP programme should be rethought, completely into a new avatar. The allocated budget has been curtailed. Post Covid it will be curtailed further. That would and should be made the perfect excuse to downgrade the national expectations from HSP.

Give credit to Russian support for our HSP, space programme

Russia has been deeply involved in helping ISRO from its inception. There is a long history of our space connection from supply of sounding rockets in early days to developing cryogenic engines required for GSLV platform now. Later in 1988, the Indian satellite IRS-1A was launched from Baikonur, followed by the IRS-2B and IRS-1C satellites. Glavkosmos took an active part in launching them. In 1991, they helped to develop and deliver a batch of cryogenic oxygen-hydrogen blocks for the third stage of the Indian GSLV rocket. That helped in creating our most powerful rocket that we are still trying to master, to reach increasing payloads to at least 5000 kg, which at world levels is exceedingly small. HSP is completely dependent on GSLV III rocket that is yet to be mastered. Glavkosmos also designed and supplied equipment for upgrading the cryogenic test facilities in Mahendragiri, for ISRO. It has been a journey of nearly 8 decades.

In public perception not enough has been said about the consistently solid support from Russia to ISRO and its programmes since independence. It is time to acknowledge what they deserve and to give credit due to them. This will help in correcting the perceptions to a more realistic level. One must not forget that present help in our space programme, may also be a minor spin off of military hardware purchase from Russia. They have been our true friends who stand by us in crisis. Our space programme owes a lot to them and It is high time someone puts the perspective right.

Current Status of Funding

This year's funding was critical for ISRO to kickstart HSP, to meet the given timelines. The total amount pledged by the GOI in 2019 was 9023 Cr. The amount sanctioned to ISRO in the 2020-2021 budget is 1200 Cr, against a demand of 3600 Cr. thus, it does not have the funding to proceed as it had planned this year, which perhaps is most crucial period. With the COVID outbreak, it is unlikely that any more funding would come in this year for Gaganyaan.

From perspective of funding, It would thus appear that the chances of the mission timelines being met for 2021 as announced by ISRO, or that of 2022 announced by the PM are practically unlikely, even if the Russia route is taken and even with availability of 1200 Cr funds. The Covid crisis has upset many a financial carts and funding of Gaganyaan may also get affected as priority shifts to fight Corona.

It brings us to the point where the return from such a national investment must have worthwhile returns in terms of indigenisation of science and technology through the HSP. ISRO having taken the route of outsourcing virtually everything, none of this is possible. In the past two years, while the level of science and intellectual growth at IAM has improved to considerable extent, the same did not seem to have happened at ISRO. No real man rating of space technological platforms were attempted to be developed. It appears that no new industry has been engaged, no academic institution other than IAM has been brought on board. Thus, science, technology and research have not progressed as much as should have.

Synergy of Intellectual Assets and about ISRO, IAM & Others

Those in the know clearly understand that the role of aerospace medicine, assets of Institute of Aerospace Medicine, Aircraft Systems Testing Establishment (ASTE), IAF, Naval and Army is considered by ISRO, as physical resources to be used and discarded once a specific job is done and not as an intellectual resources to be completely integrated for a long term use in the HSP and similar programmes. How could such a mistake occur unless the urge to keep everything under own domain is strong enough to unintentionally undermine the programme itself.

World over the military is available to the nation at two levels of resources. One as a tactical, strategic and a physical brute force and the other as hugely cerebral, intellectual, scientific soft resource, that is used at all levels of conceptualising and execution of national programmes. It is not a rocket science to know, that the entry level of this force is the youngest and best resource tapped through all India competitive selection process. They are the best at entry and best when they grow in service. That is how they are so good as best 'value for money'.

Simply put no one in India can deny **the intellectual inputs** provided in conceptualising and execution of the national open programmes like LCA, AWACS and closed programmes like Missile development, Nuclear etc. The failures, wherever occurred, happened due to underestimating the challenges and not doing a sincere gap analysis. In many of the programme an individual sometimes became more important than the multifaceted team. Inefficient and weak, powerless internal or external audit system let the programme drift specially in our democratic way of governance.

I now have the changed view, that the thinktank at ISRO have gone completely wrong in overestimating their competency to overcome the intricacy of human rating process required in a non-human rated programme, that they were leading. Not only did they hugely underestimated the intellectual resources that were available, for their taking, from the talent pool of military and others, they also distanced the non-military specialist institutions, by not involving any of them under one strong umbrella like that at NASA, in either budgetary resource allocations or in professional decision making. Surprisingly, no insertion of talent available from India or abroad occurred that was much expected to create the core pool of Programme Leaders, in their respective domains.

The path taken by ISRO to ask for applications from Institutions, starting in April 2020 and if selected by their own panel, to provide these Institutions of India, with some funding is again cosmetic and time consuming irrelevant process that will ever contribute in capacity building. In contrast, the vital systems e.g. like ILSS design should be quickly frozen by a special team and then broken down to smaller independent modules to be made by industry leaders, science enthusiasts, small but high tech entrepreneurs and integrated for testing, human ratings and approvals.

Answers to few relevant questions on Current Status of HSP and Role of Institute of Aerospace Medicine, Aircraft System Testing Establishment, Software Development Institute, Medical resource of AMC, Naval, Army, IAF's intellectual resources and aerospace medicine in the programme.

Certain questions on the current status of HSP and the role of IAM and intellectual military resources of India in enhancing the human in space programme are raised and answered. The following answers are part of this second main document, prepared by me on Aerospace Medicine and HSP. The titles of the two documents are placed at the end. The views in them are solely mine and are based on analysis and experience in Aerospace Medicine domain for last 45 years. These documents are not guided by any other interest, but the passion for the art & science of aerospace medicine and safety of space travellers on platforms created in and by India.

Q 1. The Indian astronaut-selects will be back early next year after their one-year training in Russia. How significant is there training now at Gagarin Cosmonaut Training Centre (GCTC)?

Answer:

The training at Gagarin Cosmonaut Training Centre (GCTC) is a generalised training, that is targeted to upgrade the theoretical and practical knowledge of raw

aspirants for travel to space. The training is all-round generic training as well as specific, using specialised modules to prepare cosmonauts/astronauts from all over the world, who are sponsored by different countries, to travel on Soyuz platform, to its destination the ISS and back to earth.

The syllabus is designed for basics of physics of space flight, understanding in basics of Soyuz platforms, theory of regular flight to ISS and its emergencies, study use of life support systems on board, learning the cockpit layout, understanding of various user manuals, technical manuals, operational SOPs ; study the use of personal protective equipment, understanding of space physiology, medical training etc.

The training uses classroom lectures, ground training simulators related to space travel physical forces and their physiology, operational routines and their variations, survival, escape, EVA, weightlessness simulation, isolation, sleep deprivation and work-related modules. Finally, the generic training is followed by “real flight” simulations and emergencies for practical training. Specific training on specific rocket and spaceship is the next level, which in this case is related to Soyuz.

ISRO till now, though a little amateurishly, through its media connects has created the perception in past 10 to 15 years, specially in India, of having ‘made in India’ breakthroughs, in some of the vital designs and systems for manned flights. It has claimed through various of its press releases and media interactions, that it has succeeded in creating its own design of crew module, service module, escape system, SRE recovery system etc.

GOI from time to time have provided funds to ISRO for various of activities as proposed by ISRO for human in space related work. Even a space suit designed by ISRO was also on display at its annual exhibition at Bangalore in 2018. No further details are known in past 2 years about this project, but this was said to be ready. If ISRO had cracked the above codes, then the training at GCTC should have been partly based on ISRO designs of its Space Craft.

This is far from truth and it will be known soon, that the rocket Soyuz FG which integrates with Soyuz-MS space craft, consisting of Orbital module, Re-entry Module and Service Module to reach ISS repeatedly, will also be used for HSP by ISRO, as it does not have any of its own systems ready. I am not even sure if GSLV III will be the launch rocket or will it be Soyuz FG itself, to be brought to ISRO launch pad, as that would do away with the complex job of integrating the Soyuz Spaceship and its components to sit on a different launch pad from Soyuz FG, that is on GSLV III. Moreover, till now GSLV has only been used to launch non-man rated payloads like satellites.

ISRO has thus, given away their plan to ride on Russia once again as was done for the travel of Rakesh Sharma. It can no more hide behind the garb of non-availability of funds, constrain of time etc., the usual excuses, to now say that they are going to ride on time tested Soyuz-MS space craft fully built by Russia, as we near the target date set by the PM. The significance of GCTC training, lies in the fact that it is being done to ride on existing Russian platform and not on ISRO platform.

For the safety of Test Pilots of IAF, who have so ably been selected by IAM, this is perfectly fine, but to create perceptions in the domestic minds, that we are doing it as a ‘Made in India’ effort is completely wrong and needs correction. Let us be upfront on what we do have or do not have, in terms of our capabilities and shortcomings. This will finally help in filling in the gaps on India’s road to capacity building in space travel. Hence, let the real capabilities be informed to all through ISRO briefings or media interaction. At least that will give us an honest and realistic roadmap.

There is no alternate available to ISRO except to go for existing Soyuz Spaceship. Russian help will inevitably be required and paid for, if at all the rocket platform is chosen as GSLV III rocket. The cheapest option would be to transfer Soyuz-MS rocket to Sriharikota, integrate Soyuz Spaceship on top of that, on an Indian launch pad for lift off from Indian soil. Learning curve for Indian scientists during this exercise would be exceedingly high and worth the cost, while making the whole process very safe for Indian Crew.

Q 2. IAM will be playing a key role when the astronaut-selects return from Russia? What are the key areas IAM will be focussing according to you?

Answer:

In 2008, ISRO signed an MOU with IAM regarding HSP but, as brought out in my main milestone 2018 document, further progress of work planned by IAM with ISRO was stalled. There is no doubt that IAM will play a key role in Space Medicine as it continues to do for Aviation Medicine in past 63 years of its existence. Time has now come to clearly define the areas in which work needs to be done to achieve the programme's overall objectives.

To provide necessary support to the HSP following are some of the areas of work for IAM that can be defined:

- Selection of Vehicle and Spacecraft
- Selection of Vehicle Crew and Training
- User and Technical Manuals of to be used Environment Control and Life Support System (ECLSS)
- Human Engineering Workstation Design for Crew Module
- Isolation and Psychological Management
- Human Factors considerations in Manned Space programme
- Microgravity Research
- Gravitational Stress Management in various Phases of Space Flight
- Clinical Space Medical and Surgical Management
- Radiation Protection
- Toxicology in Space
- Emergency Survival System Design
- Space Station Life Support System
- Extra Vehicular Activity (EVA) Design
- Heat Stress Management
- Operational Space Medicine
- Scientific and Technical Manpower Management
- Infrastructure Development related to Aeromedical Support of HSP

As discussed in Milestone II: May 2020 document, there can be 2 ways possible to get the best out of the HSP. While IAM should get the readymade simulators installed in its Space division, ISRO should plan to design and fabricate all simulators including Human Centrifuge itself and within "Made in India" framework.

Q3. Lots of HSP-related initial decisions were taken when you were at the helm of affairs at IAM? From then to now, what are the key progresses India has made with respect to this manned mission?

Answer:

All are aware that 4 Test Pilots from the pool of IAF, have been selected by IAM and the AF Medical team backed by IAF, with no additional funding by ISRO, meeting all the timelines to complete this task, with excellence expected from them. All four have gone to GCTC, Russia for their training.

That is the progress that HSP has made. Beyond that nothing much has happened through joint effort of ISRO and IAM. No work for setting up space related simulator facilities at IAM have been budgeted or planned.

To make a tangible progress there is a need for immediate provision of additional land for expansion of IAM's Space centre, preferably at or near its present location. There is an immediate need for setting up of following simulators at IAM:

- Space Crew & Service Module simulator
- Microgravity underwater EVA simulator
- Space disorientation Simulator
- Medical Command & Control Simulator
- Realtime Telemedicine connectivity of IAM, Command Hospital Bangalore, Air Headquarters, Delhi with ISRO Centres for Crisis Management Centre related to Space Operational Medicine
- Sets of Training Space Suits of each size and their Test rigs
- Library of World standards for quality control checks related to life support systems
- Space Heat Stress Simulators with biometric monitoring
- Operational Radiation Protection Lab
- Toxicology, Microbiology and Virology Space Lab
- Scientific and Technical Manpower Management
- Infrastructure Development related to Aeromedical Support of HSP
- Release of periodic Capital and annual maintenance budgets through Air HQs

Q 4. According to you which are the key areas that India/IAM/ISRO will have to focus with respect to the manned mission? In other words, the critical areas we need to focus.

Answer:

The key areas of work to be done is given in details in Milestone I 2018 document. Following are few areas that are yet to be worked out. Main issue now is funds and intellectual integration between IAM & ISRO.

- It is recommended to refocus the attention of the country on Operational Space Medicine for use in Indian Human in Space programme.
- A new professional body "Indian National Aeronautics and Space Administration" (INASA) similar to say, European Space Agency (ESA) or Chinese National Space Agency (CNSA) or National Aeronautics and Space Administration (NASA) is recommended to be formed, as the civilian programme expands to include all national resources, for a long-term space programmes and not just a few flights.

- IAM, to split its military and civil responsibilities. Land and resources must be provided by the stakeholders, to gradually form its civil wing as Human Engineering and Life Sciences Institute of Aerospace Medicine.
- Similarly, Aircraft and Systems Testing Establishment (ASTE), IAF must create a civil wing covering Space Operations. It should also be the seed point of conceptualising the “Operational Squadron of Astronauts” in India.
- Announcement of Soyuz Spacecraft as Crew Module should be done at the earliest.
- The existing design of Soyuz Spacecraft be approved at the earliest, as all timelines and processes for HE Selection, to Specific Training, to Operations will emanate from what is inside the module.
- As more information comes out in public domain, ISRO, it seems has not yet frozen the Indian design of three crew module but is also not ready to develop or integrate the life critical technologies in the modules in a very short time. The final solutions reached by ISRO to cross the man rating milestones in last 4 years need to be shared with the stakeholders.
- The Indian milestones of past works in aerospace medicine, specific to micro and macro environment, to help survive and sustain humans in space conditions, to select right people to endure in space and to train them to perform and survive in normal and abnormal situations are chronicled in this study and are recommended to be formalised. The quantum of work over past 40 years or so by IAM towards human in space domain, makes it most ready institute, as much as ISRO amongst many others, who are essential for the success of the programme.
- ISRO and IAM are recommended to have joint roadmaps with specific roles and separate budget allocation to take India on the path to space and moon. These need to be defined urgently by the Space Commission of India.
- IAM needs to learn along with ISRO, to understand the technicalities to integrate the crew module with the selected stable launch platform to carry sufficient payload, against approved human rating standards. This would also fast track the process to quick freeze the designs of crew module, ECLLS, Space Suit for 1/2/3 crew missions of 4-7 days for 400 km orbital flight/ travel to ISS and back.
- Flight Surgeons through IAM by default have a very vital role to play in the human space programme of India, in complete integration with ISRO, being the major driver.
- Based on being prudent and cost effective, it is recommended to not expose three humans in first flight and reduce the risk to 1/3rd while increasing the resources to three times, for one crew. Only after complete confidence is achieved in matching the CM with Launch Platform should we put more people

in the CM. Prepare for three, send one, in the first flight. Prepare for more but initially go for one-man near-earth orbital mission for 24 hours, in the space capsule devised for three people. If Soyuz is the platform then there should be no hesitation to take 3 crew on board, one of them, I suspect would be Russian.

- This concept was meant to reduce the pressure on selection process of first set of astronauts to 3 while training 6, through modified known processes and is estimated to be completed within 12 months, from the pool of existing Test Pilots and other resources of India. In 2020 only 4 Test pilots have been selected for training.
- Basic and Mission specific training, that has already been worked out by IAM, would spread over a period of one and two years respectively, subject to freezing of Crew Module Systems. This would take D+ 3 years. The timeline will shorten, if Soyuz is picked up for use in first few of our flights.
- The period taken for freezing of Crew Module Systems is therefore recommended to be utilised by IAM, to start by Nov 2018, the selection process and on budget allocation initiate immediately the upgrading of existing basic training facilities, including centrifuge training of candidates. Selection is completed for four potential candidates. There is no plan for selection of the next lot. It also indicates that ISRO right now is looking only at first, one flight.
- The intellectual wealth of domain experts from IAM, must get involved at all stages of crew module integration, to be able to support it for multiple and regular space flights.
- For aerospace medicine, based on gap analysis of what we realistically have and what is essentially needed has been documented, to help make a budget estimate of Rs 1000 crores.
- This investment will be required by IAM for aerospace support to utilise effectively the existing Human Centrifuge, High Altitude Simulators, Human Engineering Design Testing Labs, Environment Control Lab, Isolation study Lab, Anthropometric Lab, Night Vision Lab, Gas Chromatography Lab, Control Room Facilities with ISRO Links, Telemedicine links with major hospital resources etc, to match the parallel timeline that ISRO will require to complete the platform at Sriharikota.
- The convergence of both IAM's and ISRO's programmes are recommended to happen by D+ 3 years i.e. 15 Aug 2021.
- The recommendations anticipate an important role of IAF to help ISRO create the aerospace infrastructure resources, as civil extension of its Test Pilots School, IAM and Software Development Institute.
- The recommendation also brings out the need to provide all the support to ISRO and IAM by the PMO, Space Commission of India, Indian Air Force and Armed Forces Medical Services for them to execute the short and long-term plans and

be the fountainhead of aerospace medical and human engineering resources for this national programme.

- The roadmap document recommends utilising all resources available across India, through citizen, institutional and industrial partnership, inclusive of Indians abroad to bridge the technological gaps.
- It is reasoned that the time now is right for our nation to walk into space despite all the identified odds. Details of Industrial & Intellectual Resources collated as seed input has been attempted as part of this paper. This has not yet been done till now.
- The Financial sanction is sought from the Department of Space, Government of India where in an amount of Rs 900 Cr may be sanctioned through ISRO to the Institute of Aerospace Medicine for the Gaganyaan Project under the provisions of Para 6.1.1 of Sanction of Expenditure as per the Book of Financial powers, which allows sanction of Expenditure up to Rs 900 Crores, if the Project is accepted by the Space Commission. Recommended in 2018. Not completed as yet.
- This fund may be made available by way of a Re appropriation from ISRO and can be made in stages based on achievement of defined milestones, which are partly enumerated in an old MOU (Memorandum of Understanding) between ISRO and IAM.
- A figure of about Rs 500 Cr may be considered prudent, since it comes within the Financial powers of the Space Commission, to allot for pursuing a project by way of Re-appropriation of funds from ISRO.
- The CCS route is not recommended since it entails a lot of Ministry like MOD, MOF etc., whereas going the Space Commission route, is a fast track route and can be influenced by the Minister of State for Space Commission.

In India and unfortunately world over, the institutions tend to create their own selfish domains. To bring synergy, amongst the domain experts spread across the country, some known, some unknown is the biggest challenge for a national project. It is quite easy to reach out to Russia and US, very tough to reach out to your own domain experts. In the bargain we have lost out 4 years and an opportunity to indigenise many facilities and processes. Why is it so difficult to take others along is a mystery? The narrow, myopic trait to keep everything for oneself, has crept from individuals to institutions at the expense of national interest. This, I think is happening to cover the internal gaps in knowledge in niche areas, which they are shy to accept in public. In the bargain perceptions are created which later cannot be matched with performance when the crunch time comes. The small gaps of domain knowledge in niche fields, out of one's domain, I feel, should not be taken as their own incompetence, by the Institutions, least the gaps do not get filled, even though the resources are available with smaller, other groups. This unnecessary, institutional egos should better be avoided.

Q 5. Will Covid-19 have any kind of impact on the manned mission? Or will it change anything in the training pattern?

Answer:

Covid-19 will certainly impact the HSP programme and priority work of ISRO as well as IAM. It will greatly impact in the form of considerable delays in already tight timelines of Gaganyaan, a part of HSP as Covid-19 has affected GCTC in Russia as well as stoppage of work at ISRO. IAM also has impacted due to temporary changes in priority to partner IAF's effort to fight Covid-19 being a frontline medical unit of IAF. Major impact would be on funding of all non-essential projects, till financial situation improves. This would not only impact Indian programme but all space programmes of the world including AUSA, Europe and Russia. Maintaining existing platform of ISS with minimal expenses would be the top priority

Q 6. I understand the crew doctor will be a key aspect to this mission and IAM will have to select one person for the same? How significant is this assignment? Did India have any crew doctors who helped astronaut missions in the past?

Answer:

There is an overall change in the basic character of the HSP and ISRO itself, that is likely to happen in 2020. Therefore, selecting one Crew Doctor makes no sense. 'Space Flight Surgeon' as a concept is integral to the whole programme and not just one flight. It is also integrated to the rockets and spaceship that will carry the first test pilots of IAF in its first space flight. Flight Surgeon with aerospace medicine background provides the difference between unmanned and manned spaceflight. The ISRO engineer must be educated on this aspect as on ground the understanding on difference between manned and unmanned spaceflight is considerable. Numerous programmes in the past of manned spaceflight from own soils have failed at Canada, ESA, Iran and Japan amongst others.

Presently, it is not even sure, whether the first flight will be a short suborbital flight mission or will change to more simple, regular ISS visit. Since 4 potential crew have been selected, it is not sure how the crew composition will occur. Will it be 2 main 2 standby crew sets or will it be 2 Indian + one Russian crew composition, while one set stands by. It surely cannot be 3 Indian crew and one stand by. The role of Space Flight Surgeon will therefore get decided only when answers to the other fundamental questions are given by ISRO.

Importance of military intellectual resource and Aerospace Medicine for success of HSP

The way aviation medicine in India has got integrated in matters of aviation; space medicine needs to do so for HSP. When aircrafts were bought and not manufactured by us, aviation medicine helped in fitting the Indian population into cockpits, that were designed to fit the populations of countries that made the aircraft, based on their population data inputs. Aviation medicine experts re-evaluated the 'bought aircraft' from all aeromedical aspects, that involved understanding the flying envelope of the aircraft, to what can happen to the humans operating in that envelop. The details of the safety features of the aircraft from G-loads it can sustain, to physical

force integrity levels of the aircraft was studied. The performance of engine from the routine to extreme situation was studied.

The pressurisation schedules, oxygen delivery systems, the ejection seats, the high G loads on spine, the heat loads in high temperatures, the clothing required for extreme cold conditions of operations, the flying through NBC environments, the combat capabilities, preparing pilot with partial pressure suits and their testing just before the flight beyond 40,000 feet altitude, simulator training requiring to master running the complex human rated centrifuge, operating disorientation simulators to teach the expert pilots, heat load simulators to test and develop indices for Indian population, making sleeplessness protocols, war zone tactics to exploit the aircraft capabilities to the limits, their technical mechanisms, their weaknesses and failure modes, their redundancies in keeping the pilot safe were studied, mainly from user manuals and technical documents sent along with the aircraft.

The methods to prepare the pilot to exploit the aircraft in its extreme envelope given by the OEM and beyond was done by experts in aviation medicine. IAF understood its importance for being operationally the best, hence it consistently invested from its own budget and installed state of the art simulators at IAM. The bonding between the operator and doctor grew to the extent of brother in arms. That was achieved in nearly eight decades of work and not in few months of bonding that went beyond MOUs. On the sides of operational aviation investments, space medicine was also given due attention very early by the IAF, to make itself ready for this new dimension of Space operations. What a phenomenal journey it is, as big, if not less than the journey of six decades of ISRO. IAM is involved in operational as well as academic pursuit equivalent to world levels of competence, acknowledged by NASA, European Space Agencies and Russia.

IAF always remains silent of its capability to keep the element to surprise the world when needed. IAM, on the other hand is intentionally more exposed to the intellectual world of medicine and is therefore, now, considered by its peers, as one of the finest assets for the country and for the world.

Like for operationalising the aircrafts and by deep connect with pilots of IAF, the requirements of space operations, selection, training, integration of astronauts with crew module and service module is well understood by IAM from early days of space travel. All the infrastructure, simulators, life support systems, environment control systems, escape systems, nuances of operational space medicine required for selection and training of astronauts were informed to ISRO at least 10 to 15 years earlier, but no progress in work in this field, except at cosmetic level was made. Even the need for doing it was not understood by the then stakeholders.

If no one responds to your call, then go your own way, alone (*Jodi Tor Dak Shune Kenu Na Ase Tobe Ekla Cholo Re*)

The commander of the spacecraft for many years would be from service background and would be the fittest of all, to take control and carry the space ship to

safety, whenever required, while the other three levels of work can be performed by any specialist from engineering to science to art or tourist background irrespective of age.

Now that the IAF test pilots are selected for the first and many subsequent flights, like for aviation, the responsibilities that were undertaken by IAM for aviation, will have to be taken on by default, for space too, irrespective of what external support it gets from anyone.

It has to be solely dependent on IAF to create the same infrastructure, simulators etc that the IAF created for aviation operations. The role of IAF in support of its airmen in space cannot be passed on to any other organisation. IAM therefore has to be ready for that role.

Recommendations:

1. A new professional body “Indian National Aeronautics and Space Administration” (INASA) similar to say, European Space Agency (ESA) or Chinese National Space Agency (CNSA) or National Aeronautics and Space Administration (NASA) is recommended to be formed, as the civilian programme expands to include all national resources, for a long-term space programmes and not just a few flights.
2. Competency development in multiple fields is recommended through top talent hunt across the world and positioning them under the umbrella organisation like Indian NASA (INASA), to develop the engineering and medical capacity building.
3. Indian, Human in Space Programme (HSP) to transform into “Indian Space Capacity Building Programme” (ISCBP) under Indian National Aeronautics and Space Administration (INASA) by 2022
4. The intellectual resources available within the country recommended to be utilized effectively without bias, to strengthen the national programme under the umbrella of INASA.
5. Recommended a regular yearly capital and operational budget, to be managed by INASA.
6. ISRO/IAM as an engineering/biomedical based frontline organisations, are recommended to be tasked by Space Commission to design and develop all the space simulators required by us including Human Centrifuge, from drawing board to installation, as they are capable of doing that under “Make in India” format.
7. It is strongly recommended to urgently install all available off the shelf ‘Space Simulators’ at Institute of Aerospace Medicine, Bangalore for continuous training of our four astronauts, on their return after training in Russia.

“National Security to me means, the ability to keep part of the economic surplus, created by hard working, intelligent people of India, as a non-productive expenditure, to provide them the freedom to invest beyond food and shelter, in the ever-continuing creation of our civilisation, without the fear of getting destroyed by the brute forces of those ‘who do not have’, the ability, to create on their own”

Pankaj

Aerospace Document II: Milestone 2020
08 May 2020

ACKNOWLEDGEMENT

I very gratefully acknowledge the inspiration that flowed from COAS, PSA to PM, Space Commission of India for their passion towards the HSP.....

To IAF the organisation that made me a warrior and a solution finder.....

To Institute of Aerospace Medicine, IAF Medical Services, AMC, ISRO to have ignited the passion for aerospace medicine.....

To my Teachers, Colleagues, friends and detractors for making me what I am.....

To my special friends Dr JK Gupta, Dr JS Kulkarni, Dr Deepak Gaur, Dr Anupam Aggarwal, Dr Vipin Sharma, Dr Natraj, and many in IAM and ISRO Team for hand holding me at every stage when I faltered.....

To my special family which made the wings of **Timespan Management** unfold as a Pvt Ltd Company, so we could
DARE TO DREAM

Thank You Adi, Arjun, Abhilasha, Natasha & Vikram

Contact Details:

AVM (Dr) Pankaj Tyagi VSM (Retd)

+91-9980668250

pankaj@samecsplus.com

www.samecsplus.com

References

1. Document I: The Indian Human Space Programme – Past, Present and Future; The Roadmap for Aerospace Medicine; an integral national resource to support Indian Human Space Programme, Recommendations of Stakeholders: Document I: Milestone 2018

inspired by

“AVM MM Srinagesh Memorial Oration”

57th Annual Conference of ISAM, Bangalore, 14-16 Sep 2018

Conceived by

Air Vice Marshal (Dr) Pankaj Tyagi, VSM, (Retd), IAF
MBBS, Dip Av Med, MD (Av Med), FeISAM

Founder CEO,

Space Aviation Medicine & Engineering Creative Solutions Plus (SAMECSPlus)
an enterprise of Timespan Management Medical Services Pvt Ltd (TMPL)
& Mindcom Aerospace an enterprise of TRIOPHS Medical Services Pvt Ltd

2. Document II: Preparation: Step 1 Space Travel: Document II May 2020; The Indian Human Space Programme (HSP) – Travel, Explore, Discover, Claim, Inhabit; The Roadmap for Indian Human Space Programme: Preparation: Step 1: Space Travel: May 2020: Recommendations for Stakeholders: Aerospace Document II: Milestone 2020

Conceived by

Air Vice Marshal (Dr) Pankaj Tyagi, VSM, (Retd), IAF
MBBS, Dip Av Med, MD (Av Med), FeISAM

Founder CEO,

Space Aviation Medicine & Engineering Creative Solutions Plus (SAMECSPlus)
an enterprise of Timespan Management Medical Services Pvt Ltd (TMPL)
& TRIOPHS Medical Services Pvt Ltd

JAI HIND

