SUBMISSION TO THE EXPERT REFERENCE GROUP FOR THE REVIEW OF AUSTRALIA'S SPACE INDUSTRY CAPABILITY

by the

Space Life Science Committee of the Australasian Society of Aerospace Medicine

Introduction

The Australasian Society of Aerospace Medicine Ltd. (ASAM) welcomes the opportunity to provide a submission to the Expert Reference Group reviewing Australia's space industry capability. This submission has been prepared by the Space Life Science Committee of ASAM.

ASAM began as a special interest group of the British Medical Association in 1949, and over the decades has developed and grown into the second largest aerospace medical organization in the world, currently boasting some 830 members. Its aims and objectives can be summarized as:

- The cultivation and promotion of aerospace medicine and related disciplines;
- The facilitation of periodic scientific meetings of aerospace medicine practitioners and researchers for the advancement of aerospace medicine and education;
- The collection and dissemination of scientific knowledge related to aerospace medicine;
- The conduct of essay and other research related competitions open to undergraduate medical and science students;
- The endowment and support of research, development and advancement of aerospace medicine;
- Co-operation and affiliation or holding combined scientific meetings with bodies having similar objects.

The Space Life Science Committee advises the ASAM Ltd. Board on matters relating to biomedical aspects of human spaceflight, and on the dissemination of authoritative information to members by various media, to support the Objects of the Society. Its responsibilities include:

- To arrange and/or promote educational activities supporting space life sciences.
- To scope out the extent of research conducted in space life science and applicable fields in Australia, including such disciplines as aerospace engineering, remote area /expeditionary medicine, psychology/human factors, environmental medicine.
- To promote expansion of space life sciences research in Australia by identifying areas of potential research that could be addressed by Australian academic institutions, identifying potential international collaborators for building research efforts in Australia, and by promoting awareness of ASAM's research grants amongst appropriate bodies.

- To encourage networking of professionals with an interest in space life sciences within Australia via social media/professional networks to raise awareness of current research & opportunities in the field, conference and training opportunities
- To foster the next generation of students and young professionals to build an enduring space life sciences field in Australia. The Space Life Science Committee will seek opportunities to promote education in science, research methods and space life sciences at all levels of the education continuum, from secondary school through to post-graduate and specialty training.
- To advise the ASAM Board on topics of space medicine public interest.

Australia's Contribution to Space Life Science

The field of Aerospace Medicine by definition relates specifically to human spaceflight. Internationally there has been a reinvigorated program to send humans deeper into space than has been achieved for decades. Missions to cis-lunar space, the Moon itself and Mars are back on the table for discussion; a manned presence in low Earth orbit will inevitably persist; and further commercial operations have developed technologies to send fare-paying passengers on sub-orbital flights in the coming decades. For long duration missions into space, it remains the biomedical aspects of human exposure to microgravity, radiation and isolation that pose the greatest challenges. It is the human that is the rate-limiting step. Arguments have been put forth that future robotic-only operations in emerging exploration and in situ resource utilization design references missions are more efficient. However subsequent research suggests the operational efficacy human operators, able to adapt to changing situations results in a cost effective reduction in time requirement and improvement in results of several magnitudes.

It is recognised by the Space Life Science Committee of ASAM that the primary focus of Australia's future space capability will not necessarily be human space flight, focusing rather on satellite technologies supporting communications, data, navigation, defence and national security, geosciences, and Earth observation. It is from these technologies that great economic benefits will clearly arise. However global human spaceflight capabilities and future planning (ie. Cis-Lunar & Mars efforts) comprise a broadening area of development. Global human spaceflight operations are migrating towards a model of national specializations and international coordination given the immense expense and complexity of establishing these capabilities. Thus, there exists an opportunity for Australia to identify existing gaps in knowledge and then apply its existing research strengths in order to annex niche areas of expertise in the international spectrum of capabilities. This approach has the potential to develop marketable Intellectual property with long lasting and internationally desired value in parallel with the evolution of international human spaceflight programs. These life science knowledge gaps can be identified through comparison of resources such as the NASA Human Research Roadmap with existing research strengths in Australia. Research and development in

technologies and techniques that support humans in space inevitably result in innovative technologies and treatments for Earth-based patient populations. We would therefore argue that life science technologies can provide significant economic growth from space related research and the Earth-based spin-offs that this research can generate.

To highlight existing space life science activity in Australia, the following is a cross section of work currently being undertaken by Australian research and development groups as well as divisions with capabilities and skillsets with an interest in supporting future space life science research, which could translate to terrestrial applications:

- A team at the Research Institute for Sport and exercise at the University of Canberra is studying the effects of body positions on dynamic proprioceptive ability at the ankle and finger joints. This work will be used to assess the effects of long stays in microgravity on balance and posture.
- The Australian Antarctic Division (AAD) has been conducting space analogue research with multiple previous grants from stakeholders including NASA. Applications include operational, telehealth, healthcare, education and skill development programs as well as fundamental and applied research with application to both remote and extreme healthcare delivery. Specific foci have been the applicability of Australian medical support models to long-term exploratory missions. Offshoot potentials include application of telehealth technologies to regional and remote Australia.
- Australia's inherent need for remote medical capabilities have resulted in a world leading generalist medical training college, the Australian College of Rural and Remote Medicine (ACRRM) and the innovative development of higher degrees in remote and extreme environment medicine including the Masters of Public Health (Remote and Polar Health) (AAD and University of Tasmania). Both are associated with a series of research projects with potential to expand delivery of internationally recognised healthcare training and higher degrees domestically and internationally.
- The Monash University Sleep & Circadian rhythm research program in partnership with CRC for Alertness Safety and Productivity is a current recipient of NASA grants for conducting space analogue Antarctic research along with current commercial applications. This research has major implications in general healthcare as well as various areas of human performance and occupational medicine.
- Virtual reality training simulation business OPAQUE space is a NASA partner and Australian product with applications in improving task efficiency, training and safety. This immersive product has implications for development of human spaceflight capabilities as well as broad terrestrial applications in

occupational safety processes, healthcare industry development and improvement and in improving clinical patient outcomes.

- Dr. James Waldie of RMIT University is developer of the Skinsuit countermeasure device, which has twice flown on the ISS. The suit applies loads to the body equivalent to standing on earth to counter bone loss and back pain and continues to be developed with potential terrestrial applications in a series of neurological illnesses and sedentary (bed ridden) patients seen in the general population.
- Australia has a strong history of participation in Mars analogue research programs worldwide with research projects covering biological, geological and biomedical sciences. The Mars Society Australia has plans to setup the Mars-OZ analogue program in Arkaroola, SA with significant medical and astronaut health capability development potential.
- Dr Daniel Belavy of Deakin University Burwood is an internationally recognised leader in the field of orthopaedics and bed-rest studies as an analogue for microgravity exposure studies as has previously acted as reviewer for NASA and ESA research.
- Australia sustains a disproportionate representation on the Space Generation Advisory Council, who advise the UN-COPUOS despite the lack of a formal space agency. An Australian currently holds the Executive Director role with participation from a significant biomedical and medical cohort.
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Space Life Science Contribution to Upstream and Downstream Industries

The Issues Paper defines the Space Industry as comprising two distinct streams – upstream and downstream. In Australia, Space Life Sciences can provide significant upstream and downstream benefits in the following key areas:

Space systems

Aerospace medicine and human factors input is required in the design and operation of space based systems for surveillance and maintenance of health in personnel deployed to the space environment, as well as those in support operations.

Ground systems

- Matched to the space systems, technologies to receive and interpret biomedical information and act on the information in a timely, safe way that can maintain crew function where achievable, or avoid harm to crew and passengers. These technologies will also provide data for informing future developments in maintaining healthy human function in the space environment.

- Translation of space and ground systems for remote health surveillance and interventions into civilian and Defence environments where health services are not available at the location of population or personnel.

- Application of data from space-related health surveillance and research to similar health and disease states in the general population.

Space activity support services

- Aerospace medicine provides professional services to support human space-based activities including personnel selection, surveillance of health during preparation and missions and on return from space, and provision of health interventions remotely during missions.

Space-related research and development

- Space-related biomedical research has historically provided new approaches to diagnosis and treatment on Earth, including the use of diagnostic algorithms, robotics for remote medical procedures, telemedicine, and insights into medical and psychological issues relating to operations in remote and austere environments.

Space education and training

- Education aimed at furthering knowledge about space biomedical science, developing graduate skills towards careers in space-related activities to further the industry in Australia, stimulating interest in Science Technology Engineering and Mathematics subjects in students.

- Australia's expertise in training physicians for rural and remote practice in austere environments with limited resources has direct application to the training of astronaut physicians and other non-medical health care providers.

Space-related associations, media and public information activities

- Disseminating information, developing global partnerships, and promoting space-related endeavours between industries through meetings, conferences and other inter-professional collaborations.

In all these upstream and downstream industries Australia has the biomedical expertise to contribute significantly on a national and international level with an outcome of reaping economic benefit from nationally owned Space Life Sciences IP and concurrently supporting the growth of our own medical science assets. Oversight and coordination of research efforts, in particular by seeking collaborations within Australia and with international agencies, could see an acceleration of productive research and growth within the sector.

Review Focus Areas

Principle 1: Capability

The issues identified under "Capability" align with the responsibilities of the Space Life Science Committee of ASAM. An Australian Space Agency needs to identify organizations undertaking research in Space Life Sciences in Australia as well as determine knowledge gaps in international research efforts, to which local research expertise may be applied. The agency would be positioned to better coordinate and support research resources towards those identified areas with the aim of generating robust scientific output and economically desirable IP. It should also promote expansion of space life sciences research through allocation of funding grants and identifying areas of potential research that could be addressed by Australian academic institutions. Oversight through an Australian Space Agency would also assist with identifying and liaising with potential international collaborators for building research efforts in Australia. Australia's contribution to human spaceflight research, as well as biomedical research on the ISS, would accelerate spin-offs and economic benefit for Australia.

A key capability in which Australia has an existing advantage that is transferable to the space sector is the implementation of remote medicine using advanced telecommunications technology. The barriers to access for health care across Australia's remote and distributed populations has necessitated the development of capability for real-time, high-resolution and reliable telemedicine using data and audiovisual linkages. The sustainability of human life in space will include reliance on the ability to monitor, maintain and manage health issues using expertise based on Earth. This might include advances in existing medical robotics for performance of skilled procedures where expertise is not available in space; advanced algorithms for interpretation of clinical images, collected using miniaturized imaging devices; bioinformatics; technology for collecting clinical information with point-of-care testing. Translation of this existing capability into the space sector is an opportunity for both upstream and downstream benefits. These benefits will include development of biotechnologies related to collection and transmission of vital health information for Australian industries, as well as opportunity for application of advanced health technologies within the Australian rural and remote populations. This includes potential application to deployed military environments requiring remote health surveillance and support. Advancement in such technologies are further exportable globally where there is a mismatch in the distribution of population and health services.

Principle 2: Development

The understanding of all the biomedical issues facing humans in space is still in its infancy relatively speaking with much more development required. While the current space industry sector as a whole is considered to be underdeveloped, given

Australia's world leading medical research capability, it could be argued that our contribution to overall understanding of space biomedical sciences is also underdeveloped. We have much more we could contribute not only to solving the challenges of human space flight, but also secondary applications from biomedical research projects utilizing the unique laboratory environment of space to solve research questions of medicine and biology here on Earth.

Australia has a well-established medical research sector that has a global reputation for high-value outputs. The academic expertise in Australian health and biomedical research is well positioned to engage readily with existing research institutions internationally. This engagement will further enable the growth and development of a subspecialized Australian Space Life Sciences research centre of excellence. While Australia may not be positioned to launch our own missions and personnel into space, we will be collaborating with our regional and global partners who will be doing so. A high-value Australian research sector that supports and enables our global space partners in the advancement of their human missions will be to the mutual benefit of Australia and our partners. The development of Australian expertise in Space Life Science research and outputs will translate into permanent and long-term collaborations through which the Australian interests in broader space endeavours can be realized.

Principle 3: Governance

Regional engagements and international collaborations are crucial in further developing a Space Life Science sector of a future Australian space industry. Central oversight and coordination of Space Life Science research, development, education and networking across Australian and international organisations is a requirement if unnecessary and costly duplications and omissions are to be avoided. This type of coordination is best provided by a Space Life Sciences input into a national space agency.

As a rapidly-advancing field of medicine and medical research, there is significant risk involved in investment in Space Life Sciences. Projects and concepts can be presented that appear to be plausible and appropriate, but do not sustain their case under the scrutiny of expert and experienced analysis. The progression of Space Life Sciences research will be pressured to achieve outcomes for current and planned missions in a timeline that is far shorter than mainstream decades-long research and clinical trials. This time pressure presents a real risk of harm or critical failure – to both mission and personnel - if not managed effectively within the risk appetite of the involved space agencies. An Australian expert body of internationally recognised Aerospace Medicine specialists will be ideally positioned to work within an Australian space agency to ensure the most appropriate allocation of resources and funds to research, projects and capabilities that can balance the risks with the intended outcomes. This expert body can analyse existing data and proposed projects to ensure that Australian resources are committed to high-quality outputs that meet the objectives of the agency.

Conclusion

It is the opinion of the Space Life Sciences Committee of ASAM that biomedical sciences must be considered as a key element of the future Australian Space Industry. It is not only an enabler of human space flight supporting future exploration missions, but the scientific spin-off benefits will provide substantial economic benefits to Australia through improved health care, the development of novel technologies by private industry, and stimulation of the academic sector. This Committee looks forward to working with the Expert Reference Group through the process of this Review and into the development of the strategic framework for Australia's space sector.