Space Science and Technology for Advancing Public Health

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Senior Advisor, Health Systems and Innovations Cluster
World Health Organization
Key Messages

• Integration of Space science and technology to health systems strengthening efforts to be more widely practiced

• Closer collaboration between Ministries of Health and Ministries of Science/Technology is essential
World Health Organization
WHO at a glance

- 194 Member States
- Headquarters in Geneva
- 6 regional offices
- More than 150 country offices
- More than 7000 staff

- More than 700 institutions supporting WHO’s work
- Close partnerships with UN agencies, donors, foundations, academia, nongovernmental organizations and the private sector
World Health Assembly
the decision-making body of WHO
Relevant Documents for Discussion
Space Science and Public Health

Special report of the Inter-Agency Meeting on Outer Space Activities on the use of space science and technology within the United Nations system for global health

UN Document: A/AC.105/1091
30 April 2015
Space Science and Public Health

Report on the meeting on the applications of space science and technology for public health organized by the World Health Organization and the Office for Outer Space Affairs

UN Document: A/AC.105/1099
29 October 2015
Space Science and Public Health

Fiftieth anniversary of the UN Conference on the Exploration and Peaceful Uses of Outer Space: theme of the sessions of the Committee on the Peaceful Uses of Outer Space, its Scientific and Technical Subcommittee and its Legal Subcommittee in 2018

UN Document: A/AC.105/L.297
11 May 2015
Space Science and Public Health


UN Document: A/AC.105/1069
10 September 2014
Notion of Health - One Health

the interconnectedness of human health, animal health and the ecosystem
One Health
One Health

- 60% of existing human infectious diseases are zoonotic
- 75% of emerging infectious diseases of humans (including Ebola, HIV, and influenza) have an animal origin
- At least 5 new human diseases appear every year. Three are of animal origin
- 80% of agents with potential bioterrorist use are zoonotic pathogens

Source: OIE, 2016; http://www.oie.int/for-the-media/onehealth/
Relevance of Space Science to SDG for Health

Leveraging benefits of space science, geospatial data for advancing health agenda
Underpinnings

• Need to understand the current needs of healthcare and public health
• Need to understand the relevance of Space science and technology to overall health systems strengthening efforts
• Need to match appropriate public health and health services delivery needs to innovative space science and technology solutions
### SDGs and Benefits from Space Science

<table>
<thead>
<tr>
<th>SDG</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 1</strong></td>
<td>Poverty</td>
</tr>
<tr>
<td><strong>Goal 2</strong></td>
<td>Food Security</td>
</tr>
<tr>
<td><strong>Goal 3</strong></td>
<td>Health</td>
</tr>
<tr>
<td><strong>Goal 4</strong></td>
<td>Education</td>
</tr>
<tr>
<td><strong>Goal 5</strong></td>
<td>Gender Equality</td>
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<tr>
<td><strong>Goal 6</strong></td>
<td>Water</td>
</tr>
<tr>
<td><strong>Goal 7</strong></td>
<td>Energy</td>
</tr>
<tr>
<td><strong>Goal 8</strong></td>
<td>Employment</td>
</tr>
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<td><strong>Goal 9</strong></td>
<td>Resilient Infrastructure</td>
</tr>
<tr>
<td><strong>Goal 10</strong></td>
<td>Reduce Inequality</td>
</tr>
<tr>
<td><strong>Goal 11</strong></td>
<td>Cities</td>
</tr>
<tr>
<td><strong>Goal 12</strong></td>
<td>Sustainable Consumption</td>
</tr>
<tr>
<td><strong>Goal 13</strong></td>
<td>Climate Change</td>
</tr>
<tr>
<td><strong>Goal 14</strong></td>
<td>Marine Resources</td>
</tr>
<tr>
<td><strong>Goal 15</strong></td>
<td>Ecosystems and Biodiversity</td>
</tr>
<tr>
<td><strong>Goal 16</strong></td>
<td>Justice and Good Governance</td>
</tr>
<tr>
<td><strong>Goal 17</strong></td>
<td>Partnerships for Implementation</td>
</tr>
</tbody>
</table>

Source: UNOOSA June 2015
HEALTH IN THE SDG ERA

3 GOOD HEALTH AND WELL-BEING

ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES
Health Systems for SDGs

**RESULTS**
- Global public health security and resilient societies
- Equitable health outcomes and wellbeing
- Inclusive economic growth and employment

**GOAL**
- Universal Health Coverage
  - All people and communities receive the quality health services they need, without financial hardship

**HOCTIONS**
- Health Systems Strengthening
Matrix of Relevance

<table>
<thead>
<tr>
<th>SDG</th>
<th>SPACE SCIENCE AND HEALTH RELEVANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: No Poverty</td>
<td>Prioritizing the health needs of the poor</td>
</tr>
<tr>
<td>2: Zero Hunger</td>
<td>Addressing the causes and consequences of all forms of malnutrition</td>
</tr>
<tr>
<td>6: Clean water and sanitation</td>
<td>Preventing diseases through safe water and sanitation for all</td>
</tr>
<tr>
<td>10: Reduced inequalities</td>
<td>Ensuring equitable access to health services through Universal Health Coverage Based on stronger primary care</td>
</tr>
<tr>
<td>13 Climate Action</td>
<td>Protecting health from climate risks, and promoting health through low-carbon development</td>
</tr>
<tr>
<td>14: Life below water</td>
<td>Supporting the restoration of fish stocks to improve safe and diversified healthy diets</td>
</tr>
<tr>
<td>15: Life on land</td>
<td>Promoting health and preventing diseases through healthy natural environments</td>
</tr>
</tbody>
</table>
### Potential Areas of Collaboration

<table>
<thead>
<tr>
<th>WHO Global Health Priorities</th>
<th>Shared Interest</th>
<th>Current Applicable Technology</th>
<th>Future Applicable Technology</th>
</tr>
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<tbody>
<tr>
<td>In situ Diagnostics:</td>
<td>CSA: Microflow: There is a terrestrial variant of robust flow cytometer</td>
<td>CSA: In situ diagnostics</td>
<td></td>
</tr>
<tr>
<td>possible diagnostic equipment and may develop sample preparation that could be used by both</td>
<td>- Micro-Ecological Life Support System Alternative (MELISSA) for recovering food, water and oxygen from waste</td>
<td>ESA: Minaturised bioreactor with sensor systems; will be tested on ISS in 2015 in the Arthospira Experiment on the ISS (ArtEMISS)</td>
<td></td>
</tr>
<tr>
<td>Water supply:</td>
<td>- Gray water recycling (active at Concordia)</td>
<td>ESA: Black water recycling system development for Concordia station</td>
<td></td>
</tr>
<tr>
<td>(1) Quality</td>
<td>JAXA: Share information on:</td>
<td>ESA: ICARUS project, implemented by the German Space Agency DLR, addressing animal-borne disease tracking &amp; prediction</td>
<td></td>
</tr>
<tr>
<td>(2) Purification</td>
<td>- Food safety</td>
<td>JAXA: Nutritionally enforced (functional food): antioxidant, protein-rich</td>
<td></td>
</tr>
<tr>
<td>(3) Storage</td>
<td>- Eco-systems</td>
<td>NASA: Lab On A Chip water testing</td>
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<tr>
<td></td>
<td>- ECOSAN device designed for prenosological control of health level on the basis of a cardio-respiratory examination (already used in ten world regions)</td>
<td>ROSCOSMOS: Development of special telemedicine programmes and projects on the governmental level with other institutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HEALTH NAVIGATOR round health screening</td>
<td>ROSCOSMOS: Development and creation of new telemedicine technologies and devices for the use in space medicine and in public health care</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Loading tests for the estimation of functional reserves</td>
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Innovation exchange: WHEN SPACE MEETS HEALTH
European Space Agency - Noordwijk, The Netherlands - 8 November 2016
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<tr>
<td><strong>LP 3: Addressing the challenge of noncommunicable diseases.</strong></td>
<td><strong>Ageing:</strong></td>
<td><strong>CSA:</strong> None</td>
<td><strong>CSA:</strong> SHARE initiative to bring together international community of space and aging to work together.</td>
</tr>
<tr>
<td><strong>WHO Global NCD Action Plan.</strong></td>
<td><strong>Muscle loss, bone loss, neurovestibular, vision impacts</strong></td>
<td><strong>ESA:</strong> Human Health related studies in ELIPS programme, including human physiology, biology &amp; animal experiments; flight &amp; ground</td>
<td><strong>CSA:</strong> Research: various areas</td>
</tr>
<tr>
<td></td>
<td><strong>New or enhanced therapies for non-communicable diseases emphasizing ageing populations (typically multimorbid and frail)</strong></td>
<td><strong>JAXA:</strong> Joint research on the aging and space physiology issue for the wellbeings of the society</td>
<td><strong>JAXA:</strong> Mitigation strategies: Measures of neurocognitive state with a Performance Readiness Evaluation Tool (PRET) and look for others</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>NASA:</strong> Neurocognitive test battery</td>
<td><strong>ESA:</strong> European Life and Physical Science Research Platform (ELIPS) offering a programme framework for project incubation, coordination and and experimental platform opportunities</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>NASA:</strong> Non-pharmaceutical interventions for osteoporosis</td>
<td><strong>JAXA:</strong> Series of pamphlet for outreach on e.g. exercise, sleep, nutrition</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>NASA:</strong> Vitamin D and Omega-3 fatty acid</td>
<td><strong>NASA:</strong> Freeze-dried or pouch &quot;super foods&quot; (2018)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ROSCOSMOS:</strong> A treatment for cardio-respiratory diseases with warmed-up oxygen-helium mixtures</td>
<td><strong>ROSCOSMOS:</strong> Non-invasive intracranial pressure monitor (2018)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ROSCOSMOS:</strong> Technologies for neuro-rehabilitation for stroke and Parkinson patients like Corrigent suit, Regent suit, KORVIT, and an IMMERSION FACILITY</td>
<td><strong>ROSCOSMOS:</strong> The conception of physical health centers</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ROSCOSMOS:</strong> High technological training machines for the testing, training and rehabilitation of people of different physical capacity</td>
<td><strong>ROSCOSMOS:</strong> New methods of gravitation therapy on the basis of short radius centrifuge</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ROSCOSMOS:</strong> Foot supporting zone stimulation device adapted for the elderly</td>
<td><strong>ROSCOSMOS:</strong> Probiotics (microorganisms reviving the normal microflora of the human organism)</td>
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<td>LP 5: Increasing access to essential, high-quality and affordable medical products (medicines, vaccines, diagnostics and other health technologies).</td>
<td>In situ diagnostics and products</td>
<td>CSA: NeuroArm surgical robot that can operate inside an magnetic resonance imaging machine for e.g. brain surgery making inoperable brain tumours become operable; very expensive but shows potential of what can be done; a surgical robot for pediatric surgery is in development</td>
<td>ESA: None</td>
</tr>
<tr>
<td>-- Supporting UHC</td>
<td></td>
<td>CSA: Advanced Crew Medical Systems includes remote health monitoring, biosensor devices and textiles, e.g. physiological monitor &quot;Astroskin&quot;</td>
<td></td>
</tr>
<tr>
<td>-- Monitoring and use of information</td>
<td></td>
<td>CSA: Bioanalysis and Biodiagnostics</td>
<td></td>
</tr>
<tr>
<td>-- Access to medicines for noncommunicable diseases</td>
<td></td>
<td>CSA: Research: Looking for biomarkers of disease; data-mining</td>
<td></td>
</tr>
<tr>
<td>-- Rational use of medicines antimicrobial resistance</td>
<td></td>
<td>ESA: None</td>
<td></td>
</tr>
<tr>
<td>-- Access to medicines for HIV/AIDS, TBC, malaria, reprod/mat/child health</td>
<td></td>
<td>JAXA: None</td>
<td></td>
</tr>
<tr>
<td>-- Innovation &amp; local production of medicines</td>
<td></td>
<td>NASA: Infrared machine to measure pharmaceutical potency (2018)</td>
<td>ROSCOSMOS: New devices on the basis of current space prototypes for the effective diagnostic of cardio-vascular system disfunctions (with the three dimensional ballistocardiography, dispersive mapping, etc.)</td>
</tr>
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**JAXA**: Share information on the devices used for stress monitoring

**JAXA**: 24-hour ECG for biological or circadian rhythms and heart rate variability in frequency domain

**JAXA**: Actigraphy to monitor physical activity, e.g. for assessing sleep quality

**NASA**: Long-term efficacy tests across a basic medical kit of about 80 major medicines

**ROSCOSMOS**: CARDIOSON contact-less recording of physiological signals during sleeping and ECOSAN-TM with the translation of physiological signals to a doctor
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| -- Supporting UHC                                                                          |                          |                                                                                                           | CSA: Bioanalysis and Biodiagnostics                                                                                                                                     |
| -- Monitoring and use of information                                                        |                          |                                                                                                           | CSA: Research: Looking for biomarkers of disease; data-mining                                                                                                             |
| -- Access to medicines for noncommunicable diseases                                         |                          |                                                                                                           | ESA: None                                                                                                                                                             |
| -- Rational use of medicines antimicrobial resistance                                       |                          |                                                                                                           | JAXA: None                                                                                                                                                           |
| -- Innovation & local production of medicines                                               |                          |                                                                                                           | ROSCOSMOS: New devices on the basis of current space prototypes for the effective diagnostic of cardio-vascular system disfunctions (with the three dimensional ballisticcardiography, dispersive mapping, etc.) |
|                                                                                           |                          |                                                                                                           | ROSCOSMOS: Contactless recording of physiological signals during sleeping with signal transmission                                                                 |

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European Space Agency - Noordwijk, The Netherlands - 8 November 2016

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World Health Organization
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</table>
| LP 6: Addressing the social, economic and environmental determinants of health. -- Social and economic environment -- Physical environment -- Person’s individual characteristics and behaviours | Environmental factors Stress & behavioral interaction | CSA: EVARM dosimeter variant is being used in cancer clinics for targeting radiation therapy  
ESA: Human Physiology Experiments - ISS & isolation studies, Bedrest  
JAXA: Share the information:  
- Environmental monitoring  
- Eco-systems  
JAXA: SS-HDTV (super-sensitive high-definition TeleVision) camera for Earth observation.  
JAXA: Joint research on multicultural issue related to LP 6  
NASA: Family communication from isolated environments  
ROSCOSMOS: Estimation of micro-ecological status of human with the use of chromatography mass-spectrometry | CSA: Research on psychosocial issues associated with changes in value systems, family relations and work-life issues values and family ties linked to space-related isolation  
ESA: Developing countermeasures and psychological support methodologies for isolated individuals or groups  
JAXA: None  
NASA: Improving psychosocial health through environmental factors (2020)  
ROSCOSMOS: Modified methods of micro-ecological status of human (including express-tests)  
ROSCOSMOS: Expert assessment of toxicological and micro-biological contamination of environment |
Cross sectional View of Relevance of Space Science to Public Health
Use of space science and technology in environmental health and health systems research
Bosnia (1/25,000)

Topographic map from ALOS is useful in developing countries. Road network is essential to deliver vaccines and to visit medical facilities.
JAXA's GCOM-C will continue to observe surface temperature, which can be used for countermeasures of heat stroke.

Source: JAXA, 2014
Mapping WASH and NTDs...hotspot analyses

Source: Rifat Hossain, WHO, 2015
Tracking of spread of animal born diseases:
Small Animal Tracking from ISS: DLR ICARUS Project
Polio eradication project: Locating sample sites on the satellite images and tracking over time using JAXA’s 5-m resolution DEM data.
A Remote-sensing tool applied to Rift Valley Fever (RVF) Monitoring

Identify environmental factors of A. vexans & C. poicilipes presence by remote sensing to obtain risk map

SPOT5 multispectral image high spatial resolution -10m (Program ISIS/CNES)

Zones Potentially Occupied by Mosquitoes (ZPOM)

26/08/2003

Ponds ~ 1%

ZPOM = 25%

Mosquitoes flying range ~500m (Bâ et al., 2005)

Ponds detection

Characterization

NDPI

NDVI & NDTI

Ponds' area

Ponds' characterization

Vegetation activity gradient

Turbidity gradient

Vegetation Cover

Turbidity

Mapping the ZPOM

© CNES/CNES 2003, Distribution Spot Image SA
This shows ALOS 3-D mapping capacity. It is the world’s most accurate vertical resolution, 5m, among satellites.
Use of space science and technology in clinical care settings
Tele-health applications, connecting patients and caregivers
Innovation exchange: WHEN SPACE MEETS HEALTH

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Tele-health applications, connecting two countries

Source: Ivar Mendez, June 2015
Advanced System for Tele-guided Ultrasound Diagnosis

Source: Dr. Gerzer, German Aerospace Center, June 2015

**Innovation exchange: WHEN SPACE MEETS HEALTH**

**European Space Agency - Noordwijk, The Netherlands - 8 November 2016**

**ASYSTED**

- joystick or smartphone-app
- expert in ultrasound scanning
- examiner on-site: space station, off shore rigs, hospitals, doctors offices, ships, aircrafts, patient’s home, research station
- examiner’s system
- change of probe position
- presentation of control commands

**terrestrial**

**cellular**

**ASYSTEd**

- expert’s system
- remote expert located at: control center, hospital, doctors office, telemedical expert center
- www.asyst.care
- markus.lindlar@dlr.de
Innovation exchange: WHEN SPACE MEETS HEALTH

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Tele-health applications, connecting field sites and physicians

Mobile remote-presence devices for point-of-care health care delivery

Tele-health applications, connecting field sites and physicians
Robotics and health care delivery
B-LiFE at Ebola treatment centre

Last Accessed: 13/09/2016 16:14

http://www.esa.int/spaceimages/Images/2015/04/B-LiFE_at_Ebola_treatment_Centre

ESA: Telecommunications and Integrated Applications
Application of Space Technology:
Water filtrations solutions developed and deployed.
Space Science and
Big Data Analytics
analysis and use of rapidly collected extremely large volumes of both structured and unstructured electronic data through multiple data sources to answer complex questions that are ordinarily cannot be answered using single datasets
Big Data

- Mega datasets and longitudinal data
  - Details and location of telephone call logs
  - Daily global airline passengers manifest
  - Hourly mean temperature of all cities of the world
  - Hospital admissions and discharges around the world
  - Hourly weather data
  - Monthly projection of populations worldwide
Data driven decision-making

...large scale pattern recognition, unseen unless combined by various data types...
Earth Observation and Geospatial Data

**Digital Elevation Model (DEM):** Worldwide coverage from NASA’s ASTER mission with 30-meter resolution.

**Water Resource Map:** Aquifer yield data from multiple sources.

**Improved water source location:** Location of wells continually updated with new water projects via interactive Web 2.0 application.


**Water accessibility:** (combination of layers) Access measured in amount of energy per capita (calories) needed to collect water, highlighting access limitations due to terrain. Also shows populations living on marginal land without water access.

**Water resources per person:** Determines whether underlying water resources (aquifer yield) can meet demand of overlying population based on 50 liters per person per day.

**Areas with improved water access:** (combination of layers) Displays 1-km LandScan areas that have achieved water access per guidelines, i.e. at least one access point per 1-sq.km
Integrating space science and technology as part of national health information architecture
## Ideal Dataset Requirement Matrix for Unified Systems

<table>
<thead>
<tr>
<th>Data set required for</th>
<th>Prevention</th>
<th>Preparedness</th>
<th>Response</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data from External sources</strong></td>
<td></td>
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</tr>
<tr>
<td>(National EOC/situation reports, HMIS, routine disease specific active/passive surveillance/notification systems)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exhaustive List of disease/conditions list (ICD)</strong></td>
<td>List of donor and partner agencies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Health facilities</strong> (all types and levels)</td>
<td><strong>Health workforce</strong> (all cadre)</td>
<td>Logistics</td>
<td>Essential Medical devices</td>
<td></td>
</tr>
<tr>
<td><strong>Essential Medicine</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Satellite Imagery</strong> (various types and resolutions)</td>
<td></td>
<td></td>
<td><strong>Other remotely sensed data</strong> (temperature, precipitation, terrain and topology)</td>
<td></td>
</tr>
<tr>
<td><strong>Geographic Information System with shape files, base maps</strong></td>
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<tr>
<td><strong>Transportation assets</strong> (Airport locations, transportation hubs, Road network maps)</td>
<td><strong>Country-specific Population Data</strong> (/sub-national level; projections, census, actual)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future Health Information Platforms

Health information platform for monitoring public health combined with context specific geospatial data.
Future Health Information Platforms

Health information platform for monitoring public health combined with context specific geospatial data.
Locating health facilities using space-based technologies: Mapping of health facilities
Intersections of Space Science and Technology and Public Health
Space Science and Public Health

• Area 1: Space science and technology for epidemic intelligence
• Area 2: Space science and technology Health Emergencies
• Area 3: Shaping the research agenda on Benefits of space science and technology to public health
Key Messages

• Integration of Space science and technology to health systems strengthening efforts to be more widely practiced

• Closer collaboration between Ministries of Health and Ministries of Science/Technology is essential
Thank you