Space Science and Technology for Advancing Health-related SDGs

Ramesh S. Krishnamurthy, PhD, MPH, PHIF
Senior Advisor, Health Systems and Innovations Cluster
World Health Organization

Presentation prepared for
World Space Forum - 18 – 22 November 2019 Conference Room C1 | 2nd Floor C-Building Vienna International Centre, Vienna
Key Messages

• National mandate is needed for full adoption of space science and technologies to advance health-related SDG goals at national and sub-national levels.

• National ownership, inter-sectoral collaboration, technical infrastructure, competent workforce and adequate finances are essential for full adoption of space science and technologies in health sector.
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
One Health

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

60% of existing human infectious diseases are zoonotic

At least 75% of emerging infectious diseases of humans (including Ebola, HIV, and influenza) have an animal origin

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/
Outbreaks and Emergencies Bulletin, Week 04: 19 - 25 January 2019

- Ebola virus disease in the Democratic Republic of the Congo
- Measles in Madagascar
- Humanitarian crisis in Nigeria
- Humanitarian crisis in South Sudan.

Week 04: 19 - 25 January 2019
Relevance of Space Science and Technologies to health-related SDGs
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
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
### Example of Space Science and Technologies Relevant to Health Sector

<table>
<thead>
<tr>
<th>WHO Global Health Priorities</th>
<th>Shared Interest</th>
<th>Current Applicable Technology</th>
<th>Future Applicable Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP 5: Increasing access to essential, high-quality and affordable medical products (medicines, vaccines, diagnostics and other health technologies). -- Supporting UHC -- Monitoring and use of information -- Access to medicines for noncommunicable diseases -- Rational use of medicines antimicrobial resistance -- Access to medicines for HIV/AIDS, TBC, malaria, reprod/mat/child health -- Innovation &amp; local production of medicines</td>
<td>In situ diagnostics and products</td>
<td><strong>CSA:</strong> 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><strong>CSA:</strong> Advanced Crew Medical Systems includes remote health monitoring, biosensor devices and textiles, e.g. physiological monitor &quot;Astroskin&quot; <strong>CSA:</strong> Bioanalysis and Biodiagnostics <strong>CSA:</strong> Research: Looking for biomarkers of disease; data-mining <strong>ESA:</strong> None <strong>JAXA:</strong> None <strong>NASA:</strong> Infrared machine to measure pharmaceutical potency (2018) <strong>ROSCOSMOS:</strong> New devices on the basis of current space prototypes for the effective diagnostic of cardio-vascular system disfunctions (with the three dimensional ballistocardiology, dispersive mapping, etc.) <strong>ROSCOSMOS:</strong> Contactless recording of physiological signals during sleeping with signal transmission</td>
</tr>
<tr>
<td><strong>Telemedicine</strong></td>
<td><strong>Longer shelf life of pharmaceuticals</strong></td>
<td><strong>ESA:</strong> None <strong>JAXA:</strong> Share information on the devices used for stress monitoring <strong>JAXA:</strong> 24-hour ECG for biological or circadian rhythms and heart rate variability in frequency domain <strong>JAXA:</strong> Actigraphy to monitor physical activity, e.g. for assessing sleep quality <strong>NASA:</strong> Long-term efficacy tests across a basic medical kit of about 80 major medicines <strong>ROSCOSMOS:</strong> CARDIOSON contact-less recording of physiological signals during sleeping and ECOSAN-TM with the translation of physiological signals to a doctor</td>
<td></td>
</tr>
</tbody>
</table>
Ultimately, technology needs to help solve health problems.
Example applications of space science and technologies to public health
WHO Polio eradication project: Locating sample sites on the satellite images and tracking over time using JAXA’s 5-m resolution DEM data

Kano Environmental Surveillance Sites

Slide courtesy: Jason Hutton, ESA, 2018
B-Life (Light Fieldable laboratory for Emergencies)  
Developed through ESA’s Integrated Applications Programme

Integrates Satellite Telecoms, Earth Observation and GNSS Capabilities with field laboratory  
Deployed in Guinea during 2014-2015 Ebola outbreak

Slide courtesy: Jason Hutton, ESA, 2018
AMAZON Project (TEMPUS)
Developed through ESA’s Integrated Applications Programme

Field diagnostic device, enhanced with telemedicine and GNSS locatisation. Commercially available as Tempus device

Slide courtesy: Jason Hutton, ESA, 2018
Health Information System Landscape

A Set of Complex Sub Systems

HIS Sub Systems

Extract, transform and load data into warehouse

Data Collection

Forms & Methods

Census

Vital Event Registry

Surveys

Health Events & Risks

Health Service Records

Resource Tracking

Data Warehouse

Information Services

Policy

Resources

Processes

Statistical Systems

Financial Systems

Common health-relevant data sources

- Censuses
- Civil Registration
- Population Surveys
- Health system data generally found at Health Ministries

- Earth Observation Data
- Health-relevant earth observation data generally found outside Health Ministries

- Resource Records
- Service Records
- Individual Records

Population-based → Institution-based
# Examples of earth observation data

*Near-real-time health-relevant earth observation data obtained from satellites*

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>375 m Active Fire</td>
<td>Nitrous Oxide</td>
</tr>
<tr>
<td>Aerosols</td>
<td>Ocean Wind Speed</td>
</tr>
<tr>
<td>Brightness Temperature</td>
<td>Ozone Profile</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>Ozone</td>
</tr>
<tr>
<td>Cloud motion vectors (Winds)</td>
<td>Precipitation</td>
</tr>
<tr>
<td>Cloud Top Pressure</td>
<td>Radiances</td>
</tr>
<tr>
<td>Clouds and Trace Gases</td>
<td>Retrieved Carbon Monoxide</td>
</tr>
<tr>
<td>Clouds/Aerosols</td>
<td><em>(Thermal Infrared Radiances)</em></td>
</tr>
<tr>
<td>Columnar Cloud Liquid Water over ocean</td>
<td>Sea Ice Concentration</td>
</tr>
<tr>
<td>Columnar Water Vapor over ocean</td>
<td>Sea Ice</td>
</tr>
<tr>
<td>Corrected Reflectance Imagery</td>
<td>Snow Cover</td>
</tr>
<tr>
<td>Dust</td>
<td>Snow Water Equivalent</td>
</tr>
<tr>
<td>Fire</td>
<td>Soil Moisture</td>
</tr>
<tr>
<td>Global Rainfall</td>
<td>Sulfur Dioxide</td>
</tr>
<tr>
<td>Global Total Precipitation</td>
<td>Temperature</td>
</tr>
<tr>
<td>Land Surface Reflectance</td>
<td>Total Column Ozone and Aerosol Index</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>Total Precipitable Water</td>
</tr>
<tr>
<td>Moisture Profiles</td>
<td>Water Vapor</td>
</tr>
<tr>
<td>Nitric Acid</td>
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Examples of potential focus areas identified as part of the ESA-WHO Cooperation
Earth Observation Data and Products

ESA Space Capability
Earth observation data from a wide range of ESA Developed Earth Observation Satellite Missions
- Scientific (Earth Explorers),
- Sentinels (EU Copernicus)
- MetOp (Eumetsat)

EO for SDG
Use of EO data in implementation of Official Development Assistance (ODA) projects, source of environmental information for environmental safeguard, monitoring and evaluation

Integration of EO data in measuring and monitoring of SDG targets with UN Statistical Offices and National Statistical Offices

Health SDG Relevant Focus areas;
- Water mapping => Accessibility, quality, disease vectors
- Climate change and determinants of health
- Disaster / epidemic response (link with IDC)
Operations Planning and Big Data Analytics

ESA Space Capability

- Spacecraft Operations: Tracking & Control of Spacecraft, planning of operations
- Innovative Technology solutions for decision making

Potential Applications to Health

- Predictive Analytics, data driven modelling and forecasting
  - Early detection of disease outbreaks, models of evolution of epidemics, “what if” analysis of different scenarios & preventative measures
- Artificial Intelligence Planning & Scheduling of Health services delivery
  - Optimal allocation of resources & sequences for service delivery
  - Simulated feasibility analysis of (what-if) scenarios of new services
  - Health Emergency process management & decision support

WHO 13th GPW
Space Technology and Services

ESA Space Capability
- Supporting development of projects which utilise space technologies and capabilities for terrestrial applications
- Transfer of technology developed for space applications for terrestrial use

Example Health Applications

- eHealth & Telemedicine (50% of ESA’s Health Projects)
- Deployable lab / midi lab on table technology
- Environment – water & air monitoring
- Water treatment technologies
Human Spaceflight Research, Applications and Technology

**Space Capability**
- Health relevant research in space and analogue platforms
- Living & working in hostile environments and development of countermeasures
- Diagnostic technology and emergency / autonomous medical care for space crew

**Terrestrial Health Application of Human Spaceflight research findings & technology**
- Medical and biology research – applicants to terrestrial health
- Water treatment, food production in compact environment / limited resources

**Technology & Knowledge Spin in / Spin out for Human Space Exploration**
- Emergency medical care, Monitoring of persons in isolated environments, with remote or autonomous decision making for medical care
- Medical diagnostics technologies and processes

Healthy Living / Optimizing use of Physical Exercise

WHO 13th GPW
Education and Capacity Building

Space Capability
- Full portfolio of ESA space activities
- Broad range of education activities at many different levels associated with projects and programme
- Inspiration and fostering cooperation

Education Activities linked to Health relevant SDG’s

SDG 3 - Ensure healthy lives and promote well-being for all at all ages  Mission X – train like an astronaut

SDG 4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all --> ESA Education runs a continuous teacher training programme at school level and student training programme at university level

SDG 5 - Achieve gender equity and empower all women and girls; Gender equity/breaking of stereotypes is a cultural aspect we promote through all ESA Education initiatives

SDG 6 - Ensure availability and sustainable management of water and sanitation for all; new European school initiative about Exploration, including water recycling

SDG 13 - Take urgent action to combat climate change and its impacts new European school initiative about Climate Change
Countries need a framework to strengthen national capacities for utilizing space science and technologies to advance national health-related SDG 3 targets.
Components of the Framework

1. **National readiness** for using earth observation data in conjunction with routine health systems data

2. **Multi-sectoral engagement** for establishing earth observation data utilization environment in the national context

3. **Alignment** of stakeholders, strategies, and efforts
Conceptual Framework for Country Capacity Development
For utilizing Satellite-based Earth Observation Data in advancing health-related SDG targets

Established EO data utilization environment

Emerging enabling environment for big data analytics

Level 3
Experimentation

Level 2
Early adoption

Level 1

Level 4
Mainstreaming

Established digital health infrastructure, governance, policy, standards, resources

Established enabiling environment for big data analytics

Beginning of penetration of digital health infrastructure and computing environment

Level = National Readiness for utilizing Earth Observation Data in combination with routine health systems data

Level 1

Level 2

Level 3

Level 4

Strengthening digital health enabled environment for big data analytics

Emerging enabling environment for big data analytics

Strengthening infrastructure, make the case for digital health environment

Developing and building up capacity

Scaling up routine use

Scaling-up and integration, cost-effectiveness, policies for privacy, security and innovation

World Space Forum | Vienna International Centre
18 – 22 November 2019 | Vienna, Austria
Align Stakeholders

Activities related to SDG 3 targets
(stakeholder’s positions vary depending on the model)

Conceptual Framework for Country Capacity Development
For utilizing Satellite-based Earth Observation Data in advancing health-related SDG targets

Value Chain of Solutions
driven by Public Private Partnerships

Better Health Outcomes
Conceptual Framework for Country Capacity Development
For utilizing Satellite-based Earth Observation Data in advancing health-related SDG targets

Align Strategies

Health Innovation Activities
(stakeholder’s positions vary depending on the model)

Value Chain of Solutions
driven by Public Private Partnerships
Conceptual Framework for Country Capacity Development
For utilizing Satellite-based Earth Observation Data in advancing health-related SDG targets

Align efforts to reduce gaps

- Health Data Science
- Appropriate Informatics Approach
- Human Capacity

Desired Impact
Reliable Data to Results
Sustainable Approach
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Thank you