Space Technology to Address Possible Future Pandemics

Tecnología espacial para hacer frente a una posible pandemia en el futuro

Carlos Duarte
General Coordinator of Human Capital Training
in the Field of Space–Mexican Space Agency
duarte.carlos@aem.gob.mx

■

Abstract:
Space technology can help prevent, manage, and mitigate the effects of a pandemic by providing telemedicine services to people in remote, marginalized zones, tracking the affected population, preventing more infections and predicting new outbreaks of disease. It is therefore important to promote its development and dissemination, as well as international cooperation, so we are better prepared to deal with future pandemics.

■

Resumen:
La tecnología espacial puede ayudar en la prevención, el manejo y la mitigación de los efectos de una pandemia. A través de la tecnología espacial se pueden proporcionar servicios de telemedicina a la población en zonas remotas y marginadas, rastrear a la población afectada, prevenir nuevos contagios y predecir nuevos brotes de una enfermedad. Por lo tanto, es importante fomentar su desarrollo y difusión, así como la cooperación internacional en la materia, a fin de estar mejor preparados para enfrentar los efectos de una próxima pandemia.

■

Key Words:
Pandemic, space technology, remote sensing, satellite communications, satellite positioning.

■

Palabras clave:
Pandemia, tecnología espacial, percepción remota, comunicaciones satelitales, posicionamiento satelital.

Space Technology to Address Possible Future Pandemics

Carlos Duarte

Introduction

Although the use of space technologies in the health sector is not a new development,[1] their capacity to help address health emergencies like the one caused by COVID-19 has not been fully exploited. This is because most countries have not adopted these technologies as public health tools, be it because they are unaware of their potential, because of a lack of communication between space scientists and the health community, or due to a lack of resources for their acquisition and exploitation.

However, when properly employed, their global nature means space technologies could be extremely useful in combatting future pandemics, due to their capacity to alert health systems of possible outbreaks, regardless of the region where these originate, track their spread and help mitigate their impact.

Hence the importance of gaining a better understanding of the potential role space technologies have to play in addressing pandemics and their various applications, which are described below.

---

1 S. Joseph Sirintrapun and Ana María López, "Telemedicine in Cancer Care", in American Society of Clinical Oncology (ASCO), *American Society of Clinical Oncology Educational Book: Delivering Discoveries: Expanding the Reach of Precision Medicine*, Alexandria, ASCO, 2018, 540-545.

Space technologies

Space technologies can be divided into three main categories: satellite communications, satellite navigation and remote sensing satellites. Each of these technologies has a role to play in combatting disease, and especially in the event of a global health emergency.

Satellite communications

Satellite communications employ geostationary satellites or, more recently, constellations of low-orbit satellites, to retransmit radio signals and communicate extensive regions. Geostationary satellites orbit the Earth in a roughly circular orbit at an altitude of approximately 36 000 kilometers above the equator, in what is called the *geostationary belt*. The orbital period of satellites in such an orbit is equal to the Earth's rotational period, which is why, to a ground observer, they appear to be in a fixed position in the sky, and the antennae used to transmit and receive signals from them have a fixed direction. These kinds of satellites are used by commercial satellite television services. The advantage of geostationary satellites is that they can cover very extensive regions of the Earth's surface and have been very successfully used to provide communications like fixed telephone, mobile and Internet services. For example, the Bicentenario satellite provides fixed public security communications services for all of Mexico. The drawbacks of geostationary satellites are that they need relatively higher power transmitters to work, due to the distance the signals have to travel. This same distance causes a delay in the transmission of information, which can be a disadvantage for some applications. Low-orbit satellites, however, orbit at altitudes relatively close to Earth (500 to 1000 kilometers). They are faster moving, taking around 90 minutes to orbit the Earth, meaning that, unlike geostationary satellites, they are only visible to observers on the ground for a short period each time they pass overhead and cover a given region for only a few minutes. This is why a single low-orbit satellite is not sufficient to provide communications services for a given region. This requires many sat-

ellites working in coordination in what is called a *constellation*. Constellations of low-orbit satellites are a relatively new phenomenon that has the potential to provide global broad-band communications services, and because they function at a lower altitude than geostationary satellites, constellations of low-orbit satellites can use less powerful amplifiers and signal transmission delay is much lower. SpaceX has developed a communications system based on a constellation of thousands of low-orbit satellites called Starlink that promises to provide global broad-band services at affordable prices.

During a pandemic, satellite communications could help improve connectivity in regions where ground communications are insufficient, as frequently occurs in remote, marginalized parts of the planet, where the impact of a pandemic could potentially be much more severe than in regions with better communications and health services. In scenarios such as these, satellite communications services are even more critical.

Satellite communications can be used to provide telemedicine services to diagnose patients remotely, follow up on them and obtain second opinions on patients in remote areas, without the need to transport them to second-level hospitals for consultations with specialists. They can also be used to remotely train health personnel in techniques to combat and mitigate disease, and provide psychological support for people in quarantine.

In the event of a health emergency, telemedicine services could be rendered using mobile units dispatched to where they are needed. These would be equipped with the necessary instruments and lab equipment to make diagnoses remotely, although their utility would not be restricted to pandemics; they could also be used to perform routine operations and administer treatments under normal circumstances.

Satellite positioning

Satellite positioning is a technique that uses constellations of satellites to accurately determine the position of objects on the Earth's surface via the transmission of very precise time signals. There are several satellite navigation networks—Navstar (also known as GPS), BeiDou Glonass and Galileo, owned and operated by the United States, China, Russia

and Europe, respectively—that provide free global positioning services via mobile devices like cell phones.[2]

In a pandemic, satellite positioning could serve to record the location of sick people, monitor their movements and those of the people they have come into contact with in a given period of time. This information could then be used to predict the spread of the disease and alert others to the possible risk of contagion or zones with high rates of infection. It could also be used to guide patients to the most suitable healthcare center, depending on their condition and geographical location.

During the COVID-19 pandemic, countries like China and South Korea[3] used the satellite positioning technology installed on mobile phones with very positive results. The total number of people infected and mortality indices reported by these two countries are among the lowest in the world, even though the outbreak started in China. As such, it is surprising that satellite positioning has not been more widely used by other countries, especially since it employs mature technology that is easily deployed, given the extensive use of mobile phones equipped with GPS technology.

In the event of another pandemic, satellite positioning technology could be used globally like China did to quickly check the spread of the disease. One objection to the use of positioning technologies to keep track of people's movements is that it invades their privacy. There is also the risk this information will be misused by governments and other organizations.[4] It therefore behooves governments the world over to agree on clear regulations for the use of personal information so as to prevent such abuses.

---

[2] G. Manoj Someswar, T. P. Surya Chandra Rao and Dhanunjayarao Chigurukota, "Global Navigation Satellite Systems and Their Applications", in *International Journal of Software and Web Sciences,* vol. 3, no. 1, December 2012-February 2013, 18.

[3] Jung Won Sonn and Jae Kwang Lee "The Smart City as Time-Space Cartographer in COVID-19 Control: The South Korean Strategy and Democratic Control of Surveillance Technology", in *Eurasian Geography and Economics*, vol. 61, no. 4-5, May 25, 2020, 482-492, at *https://doi.org/10.1080/15387216.2020.1768423* (date of reference: December 3, 2020).

[4] Rob Kitchin, "Civil Liberties or Public Health, or Civil Liberties and Public Health? Using Surveillance Technologies to Tackle the Spread of COVID-19", in *Space and Polity*, vol. 24, no. 3, June 3, 2020, 362-382, at *https://doi.org/10.1080/13562576.2020.1770587* (date of reference: December 3, 2020).

Remote sensing

Remote sensing provides information on the properties of the Earth's surface or atmosphere based on the radiation captured by satellites on different bands of the electromagnetic spectrum, including the visible region.[5] By estimating these properties, we can detect atmospheric and environmental anomalies like differences in temperature and humidity, and other factors that could be associated with possible sources of disease.

This technique is usually combined with a geographic information system to facilitate the analysis and interpretation of the data obtained by satellites, with the data being presented in the form of georeferenced images that can be more easily manipulated. In a pandemic, satellite data could be mapped to regions affected by the disease, with a view to establishing correlations between environmental factors and its spread in both time and space.

Combined with other techniques, like automatic learning, remote sensing could help predict regions where new outbreaks are likely to occur, so the population can be alerted in advance.

And because remote sensing has the capacity to monitor extensive regions over long periods of time, it could also be used to verify that the population is complying with the quarantine measures implemented by the health authorities to prevent the spread of the disease. For example, Planet has developed analysis tools that incorporate artificial intelligence and that can automatically identify objects like automobiles, highways and buildings using satellite images. By recording indicators of the population's movements, like the number of cars in parking lots or on the streets, these tools can help predict the spread of a disease based on human behavior, such as how many shoppers are at commercial centers and other places where people tend to gather.

---

5 P. R. Pisharoty, "Introduction to Remote Sensing", in *Proceedings of the Indian Academy of Sciences Section C: Engineering Sciences,* vol. 6, no. 2, June, 1993, 97.

Similarly, remote sensing can help locate and track the building of health facilities, mobilization centers, new hospitals and other public health infrastructure required to respond to an outbreak.

Another application consists of determining the effects of climate change on the transmission of diseases. For example, it has recently been discovered that, in Mexico, dengue has spread from regions where it was habitually endemic to regions further north. This is because, to the extent that the Earth's temperature rises, conditions in more regions become favorable to the mosquitos that transmit the disease.[6] Remote sensing can serve to monitor climate change and help identify places where there is increased risk of the outbreak of a disease associated with environmental factors, such as temperature, humidity or a concentration of certain types of gases in the atmosphere.

Utility of satellite images

Zoonotic diseases

Once the dynamics of a disease have been modeled and understood, satellite images can be used to look for risk factors and identify places where an outbreak is most likely to occur. For example, many new viral diseases like COVID-19 are zoonotic,[7] which means they have jumped from animals to humans. Approximately 60% of all human diseases are zoonotic. Likewise, more than 30 new human pathogens have been

[6] Sara Cecilia Díaz Castro, Manuel Moreno Legorreta, Alfredo Ortega Rubio and Vania Verónica Serrano Pinto, "Relation between Dengue and Climate Trends in the Northwest of Mexico", in *Tropical Biomedicine*, vol. 34, no. 1, March 2017, 158.

[7] Lori Cuthbert, "How Infections like the Coronavirus Jump from Animals to People", in *National Geographic*, April 1, 2020, at *https://www.nationalgeographic.com/science/health-and-human-body/human-diseases/how-do-animals-pass-dangerous-zoonotic-diseases-to-humans-zoonoses-coronavirus/* (date of reference: December 3, 2020).

identified in the last three decades, 75% of which have been found to originate in animals.[8]

One way of predicting where new zoonotic diseases might emerge is by monitoring regions where human beings are in contact with wildlife, either directly or indirectly. To the extent that we infringe on pristine regions like forests and transform these ecosystems into artificial ones like farmlands or cities, so the risk of a virus found in wild animals infecting us increases. Satellite images can be extremely useful in this regard by detecting changes in the landscape that could, in turn, point to changes in the use the land is being put to and, based on this information, provide early warnings of possible outbreaks.[9]

Response to infectious diseases

Another use of satellite images is related to how we respond to infectious diseases. For example, Chagas disease, a health problem endemic to Mexico and that affects the poorest of communities, is transmitted by a bug that inhabits certain types of palm tree and that thrives under certain environmental conditions.[10] The application of automatic learning techniques to satellite images makes it possible to detect the species of trees and conditions preferred by the Chagas bug, so areas where there is the greatest risk of transmission can be identified and assistance and health workers sent where needed.

As can be seen, there are many ways in which remote sensing can help health authorities take preventive and control measures in the event of a

---

8 WHO Regional Office for Eastern Mediterranean, "Zoonotic Disease: Emerging Public Health Threats in the Region", October 2014, at *http://www.emro.who.int/about-who/rc61/zoonotic-diseases.html* (date of reference: December 3, 2020).

9 Andrew Zolli, "How Satellite Data Can Help with COVID-19 and Beyond", in Planet, April 14, 2020, at *https://www.planet.com/pulse/how-satellite-data-can-help-with-covid-19-and-beyond/* (date of reference: December 2, 2020).

10 C. A. Romaña, J. C. N. Pizarro, E. Rodas and E. Guilbert, "Palm Trees as Indicators of Risk Areas of Chagas Disease", in *Transactions of the Royal Society of Tropical Medicine & Hygiene*, vol. 93, no. 6, November-December, 1999, 594-595, at *https://doi.org/10.1016/s0035-9203(99)90059-7* (date of reference: February 26, 2021).

pandemic. Many of our Earth observation satellites have the capacity to provide relevant information and models have been created based on this information; what we need to do now is promote more widespread use of these tools.

The path ahead

If anything, the COVID-19 health emergency has taught us a valuable lesson: pandemics put the world population at risk because they have the potential to kill thousands and paralyze the global economy. Consequently, it is important we make use of all the technologies at our disposal to address these problems and, as we have seen, there are many advantages to space technologies. These, used in combination with other tools like mobile phones equipped with global positioning receivers, high-resolution screens and large processing capacity, could be of enormous utility in future health crises.

But the use of space technology to combat future pandemics is not going to happen all by itself. We need to promote the application of these technologies in the health sector and governments need to start preparing as of now. There are many actions that can be taken. On the one hand, space technologies need to be incorporated into health systems via the creation of multidisciplinary teams comprised of doctors specialized in different fields, engineers, geographers and other professionals, so that information systems for the early detection of diseases and their subsequent treatment and mitigation can be developed. And on the other, training programs need to be revised so the doctors, nurses and other health professionals of the future are familiar with space technologies and feel comfortable using them on a daily basis.

It is also vital we foster the creation of new tech companies for the application of space technologies to health problems. This, however, will require steering new generations in the direction of successful entrepreneurship in the space sector, so they can come up with their own health-related innovations. There are many scenarios in which space technologies can be applied to health or used to mitigate the effects of a pandemic and not all require space infrastructure. A great deal of space data is freely

accessible; all that is needed is a little creativity by technological entrepreneurs to put this data to use on, for example, mobile phone apps that could be used to record the geographic distribution of infected people and the correlation to environmental variables, so as to alert users and get a better understanding of the dynamics of a given disease. One example is the Radar COVID app developed by the Spanish government, which notifies users of risk contacts.[11]

Crucial: international cooperation

Not all countries have access to high-resolution satellite images, the necessary software and personnel trained to address a pandemic using space technologies. Hence the importance of promoting international cooperation for the transferal of data, software and know-how in support of countries at a disadvantage in this respect, so as to level the playing field.

Another type of cooperation—perhaps more important than the transferal of technology—is the sharing of experiences on how countries have addressed health emergencies using space technologies. These exchanges should not be limited to strategies employed to mitigate health impacts, but should extend to the economic, social and psychological repercussions of such crises.

In Mexico, such an exchange took place during the COVID-19 pandemic when the Mexican Space Agency organized remote meetings with its peers around the world, including NASA, the European Space Agency (ESA), France's National Center for Space Studies (CNES) and the Italian Space Agency (ASI). At these meetings, different approaches, technologies and best practices *vis-à-vis* the use of space technologies to address the impact of the COVID-19 pandemic were shared. Aside from strengthening ties of international cooperation, these experiences will serve to better prepare us for

[11] Iván Linares, "Radar Covid ya disponible, la app oficial para controlar el coronavirus ya se puede descargar", in Xataka Android, June 30, 2020, at *https://www.xatakandroid.com/aplicaciones-android/radar-covid-disponible-app-oficial-para-controlar-coronavirus-se-puede-descargar* (date of reference: February 2, 2021).

the future. In a health emergency like the current one, no country has all the solutions and international cooperation is crucial to boosting global resilience and mitigating adverse effects.

Latin America and the Caribbean are making leaps and bounds in this direction. The recently announced Latin American and Caribbean Space Agency (ALCE) will coordinate space activities, foster academic collaboration and unify other space agencies in the region like its counterpart, the ESA.[12] This collaboration will encourage the exchange of data, equipment and software, while fostering transfers of technology, experiences and best practices, and the training of human capital among the countries of the region. One possibility that holds enormous promise is the development of shared infrastructure, both in the form of communications and Earth observation satellites and ground infrastructure. ALCE will indubitably play a key role in addressing the next pandemic and the hope is that the initiative will pan out, for the good of the region.

[12] Javier López Casarín, "Agencia Latinoamericana y del Caribe del Espacio, una nueva etapa en la búsqueda del conocimiento en pro de la humanidad", in Nodal, Noticias de América Latina y del Caribe, October 16, 2020, at *https://www.nodal.am/2020/10/agencia-latinoamericana-y-caribena-del-espacio-una-nueva-etapa-en-la-busqueda-del-conocimiento-en-pro-de-la-humanidad/* (date of reference: December 11, 2020).