Revisiting the Land Remote Sensing Policy Act of 1992

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Landsat Advisory Group
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1.0 Introduction

The Land Remote Sensing Policy Act of 1992 (PL 102-555)[1] repealed the Land Remote-Sensing Commercialization Act of 1984 and established the function of the National Satellite Land Remote Sensing Data Archive at the Department of Interior's United States Geological Survey (USGS). Nearly thirty years later, the 1992 statute remains in place although there have been significant technological advancements across the disciplines associated with remote sensing for Earth observation.

In early 2020, the USGS requested that the Landsat Advisory Group (LAG), a subcommittee of the National Geospatial Advisory Committee (NGAC), review the Land Remote Sensing Policy Act and develop a modernized interpretation of the Act in a manner that remains consistent with the spirit of the existing language. The intent of this review is to inform future Land Remote Sensing policy formulation. USGS requested that the LAG study team specifically factor in: the consideration of technology trends in space and ground mission segments, public-private partnering opportunities, and evolving user needs across a broad range of applications.

2.0 Sustained Value of Land Remote Sensing Goals

The purpose of the Land Remote Sensing Policy Act was "to enable the United States to maintain its leadership in land remote sensing by providing data continuity for the Landsat program, to establish a new national land remote sensing policy, and for other purposes." Many of the specific objectives of the Act, including program continuity, data sharing, and the emergence of the commercial industry have been realized to a significant degree. These goals, along with those emphasizing the need for global leadership and clear, sustainable policy continue to be important for the United States (U.S.). This paper reexamines the Act in light of the myriad advancements in the satellite remote sensing sector over the past three decades.

3.0 Changes from 1992 to 2021

Much has changed in the nearly 30 years since the Land Remote Sensing Policy Act was passed in terms of technology, economic conditions, international environment, and applications. While the underlying values and priorities in the Act remain important, taking these changes into account leads to better understanding of how these values and priorities can be interpreted and applied today.

- **Satellite technology has evolved.** By 1992, satellite remote sensing had been in operation for more than three decades, but it was still fairly limited. In the subsequent three decades, the capabilities of Landsat systems have steadily improved. The ability of the most recent Landsat system to provide detailed, spatially and spectrally accurate imagery far surpasses that of earlier systems. Of course, it is not solely the Landsat series that has benefited from rapidly advancing technologies. Multiple countries now operate land remote sensing satellites, and the breadth of these programs and their

[1] Public Law No: 102-555. https://www.congress.gov/bill/102nd-congress/house-bill/6133)

associated capabilities has increased significantly over the past three decades. These satellites utilize a wide array of technologies to focus on parameters of interest spanning the atmosphere, oceans, and land.

- **Industry has grown and diversified.** Ventures into remote sensing technology have grown well beyond the realm of governments. Emergent commercial ventures have grown to maturity over the last three decades. A robust global commercial satellite remote sensing sector has developed. This sector includes well-established companies with constellations of highly capable satellite platforms with significant advances in both spatial and temporal resolution. The expanding sector also includes new companies using new techniques and phenomenologies – particularly large constellations of small satellites – providing new sources and vast amounts of data. The industry has begun to expand beyond visual imagery to include synthetic aperture radar, multispectral, hyperspectral, radio frequency, and radio occultation. Several billion dollars of private capital have been invested in these companies – both new and established – and billions in revenue has been produced over the years.

- **Capabilities to use remote sensing data have grown.** As capabilities for collecting data have improved, so have the technologies for analyzing and using that data. The rise of broadband internet, cloud computing, data analytics, data fusion, machine learning, artificial intelligence, and data visualization capabilities and applications have greatly increased the ability to move, store, access, and analyze data. Consider that in 1992 the GPS constellation was still not fully operational; it was subject to selective availability and its receivers were costly. Today, the ubiquitous availability of precision location data due to mobile devices with embedded GPS receivers has greatly increased the use of Geographic Information Systems of all levels of complexity. This has facilitated the proliferation and integration of these tools into myriad sectors of the economy and indeed into daily life.

- **Users have expanded.** As technologies have evolved to improve access and capabilities for analysis, the number of users of this data has increased significantly. More people are trained to work with minimally processed satellite data just as many data providers have taken responsibility to deliver those satellite data resources as "analysis-ready." This emerging data delivery model allows even those without specific remote sensing expertise to get involved in this sector. Use of satellite remote sensing data has increased among scientists, practitioners, entrepreneurs, and even the general public. In 1992, the Landsat program distributed about 4,500 images, mostly to users in the Federal government. In 2019, millions of Landsat images were distributed to users all over the world.[2] The satellite remote sensing value-added sector has grown steadily and is projected to grow even more rapidly over the next decade.[3] Many of the ways in which Landsat and other remotely-sensed data are being used today were not foreseen

[2] USGS Landsat Annual Sales Report 1992
[3] https://www.nsr.com/the-future-of-satellite-based-earth-observation/

thirty years ago, especially in an era when GPS positioning had limited use. As one example, think of precision agriculture.

4.0 What Has Stayed the Same

While many things have changed, particularly with respect to technological capabilities and the breadth of participation by data collectors, producers, distributors, and users, the key goals of the Land Remote Sensing Policy Act remain intact. As discussed in the following sections, while fully acknowledging the technology advances and the use changes discussed above, the U.S. should continue to focus on:

- Ensuring global leadership;
- Engaging with users;
- Making useful and reliable data readily available; and
- Ensuring continuity.

5.0 Key Themes

This section explores a number of key themes in the Land Remote Sensing Policy Act that would benefit from a re-examination in light of these significant trends.

5.1 Importance of Land Remote Sensing Data and Expanding Users

The Act states: “The continuous collection and utilization of land remote sensing data from space are of major benefit in studying and understanding human impacts on the global environment, in managing the Earth's natural resources, in carrying out national security functions, and in planning and conducting many other activities of scientific, economic, and social importance.” The Act explains that the Landsat system should be “responsive to the broad interests of civilian, national security, commercial, and foreign users.” (Title 1, Section 101(c) 2)

These elements of the program remain critically important today. In fact, the benefits of Land Remote Sensing have grown immensely since 1992. There has been significant expansion of the use of remote sensing in multiple economic verticals well beyond what was envisioned in 1992 (including retail, marketing, insurance/risk, minerals exploration, oil & gas, and precision agriculture). Regarding the Landsat Program alone, there were an average of 400 publications per year between 1986 and 1999 that included “Landsat” in the title, abstract, or keyword. By 2017 that number had risen to 1600 publications. (That remarkable growth in publication also reflects the impact of free and open access to Landsat imagery in 2008.) Numerous studies have chronicled the economic benefits derived from the broad use of Landsat data.[4]

[4] Zhu, Zhe, et al. "Benefits of the free and open Landsat data policy." Remote Sensing of Environment 224 (2019): 382-385.

The Act encourages continued Federal research and development "in cooperation with other U.S. Government agencies and with public and private research entities (including private industry, universities, non-profit organizations, State and local governments, foreign governments, and international organizations)" to develop applications and basic research. It specifically calls out the importance of working with agencies such as the Department of the Interior and the Department of Agriculture in order to use data to enhance the ability of the U.S. to manage and utilize its renewable and nonrenewable resources. (Title 3, Section 301) As noted above, efforts to encourage the use of Landsat data in research and applications have been successful and continue to grow as new data and advanced analysis techniques create expanded opportunities. Landsat data is used to create maps, monitor crop health, monitor forest fires, and to enable a wide variety of other applications by government agencies and non-profit organizations. A survey in 2014 showed that Landsat had tens of thousands of active users spread across academic institutions, private businesses, Federal agencies, State and local governments, and nonprofit organizations.[5]

5.2 Global Leadership

Section 2 of the Act states: "The Federal Government's Landsat system established the United States as the world leader in land remote sensing technology. The national interest of the United States lies in maintaining international leadership in satellite land remote sensing and in broadly promoting the beneficial use of remote sensing data." Once again, the LAG emphasizes the continued importance of these statements.

The Landsat system is unparalleled in its provision of continuous data over nearly five decades. The program was a leader in embracing an open data policy and continues to lead in making high-quality data available in formats and on platforms that will reach a diverse set of users. While no other nation can match the longevity of the Landsat program, others have recognized the value of openly-shared land remote sensing data. Notably, the Europe Union Copernicus program, and particularly its Sentinel-2 satellite, have begun to provide high-quality land remote sensing data to users around the globe. The U.S. has taken steps to ensure compatibility between Landsat and Sentinel-2 data, increasing the value of both satellite systems. "Harmonization" of the two systems is a high-priority effort.[6] China has also greatly expanded its Earth observation capabilities.[7]

Both Europe and China continue to develop and expand their Earth observation programs, and continued U.S. global leadership in land remote sensing is not guaranteed. The U.S. must remain committed to data continuity – preserving the continuous collection of data that makes Landsat a uniquely valuable global resource. The issue of continuity of coverage cannot be overemphasized especially as appreciation grows for the climate and environmental change that the visual history of land observing reveals to Earth's scientists. The U.S. must also remain

[5] https://pubs.er.usgs.gov/publication/ofr20161032
[6] https://hls.gsfc.nasa.gov/
[7] https://www.chinacenter.net/2020/china_currents/19-1/earth-observing-satellites-and-open-data-sharing-in-china/

committed to making data available to all users in the most effective ways, recognizing and adapting to changing technologies for data dissemination, data processing, and data analysis. The U.S. must also look for opportunities to increase its capabilities in land remote sensing. This can be done through improvements in capabilities for future Landsat systems or through partnerships with private and/or international entities which increase the benefits of the Landsat system.

The Copernicus program has also drawn attention to the growing importance of monitoring climate change.[8] The Landsat program, as well as other federally funded Earth observing satellites, makes important contributions in this area, but a careful review of the identified needs and wants of many users, recently collected through the Requirements, Capabilities, and Analysis – Earth Observation survey[9], may present opportunities for the program to increase its capabilities in this area and inform planning for future Landsat missions.

5.3 Data Sharing

The Act recognizes that "the cost of Landsat data has impeded the use of such data for scientific purposes, such as for global environmental change research, as well as for other public sector applications." One of the key purposes of the Act was to expand access to Landsat data to a broad array of users. The Act calls for data to be released at no more than the cost of fulfilling user requests. [Title 1, Section 103, 105] With the advent and expansion of the internet, these costs are near zero. Beginning with a pilot program in 2007, the Landsat system moved to a free and open data policy, under which data is provided for free to all users. This policy resulted in dramatic increases in the use of Landsat data and associated societal benefits. In 1992, the program distributed fewer than 5,000 images. This increased following the changes in the Land Remote Sensing Act, but distribution remained below 50,000 scenes per year. In 2009, with the free and open policy well-established, the program distributed over a million scenes. The one hundred millionth Landsat scene was downloaded in 2020.[10] The Landsat Advisory Group recently reviewed and re-affirmed the importance of maintaining a free and open data sharing policy.[11]

5.4 Data Archiving

The Act states: "It is in the best interest of the United States to maintain a permanent, comprehensive Government archive of global Landsat and other land remote sensing data for long-term monitoring and study of the changing global environment." (Section 2 (16) and Title 5, Section 502) Once again, the value of this archive has proven to be much more significant than many originally anticipated. The nearly 50-year history of Landsat data allows studies of change over time that are simply not possible with any other data set.

[8] https://land.copernicus.eu/
[9] https://www.usgs.gov/core-science-systems/nli/rca-eo
[10] https://www.usgs.gov/core-science-systems/nli/landsat/march-11-2020-landsat-downloads-top-100-million
[11] https://www.sciencemag.org/news/2019/06/keep-landsat-data-free-panel-urges-interior-department

Starting in 2010, the U.S. demonstrated an important commitment to this idea with the advent of the Landsat Global Archive Consolidation program. This effort brought in millions of images from Landsat ground stations around the world, more than doubling the size of the Landsat archive. The project resulted in an enhanced capability for global mapping and analysis.[12] Continued commitment to maintaining the Landsat archive is essential.

5.5 Commercialization and Public Private Partnerships

While the Act found that commercialization of the Landsat system was not feasible at that time, it states that "commercialization of land remote sensing should remain a long-term goal of United States policy." It also stated that the U.S. should "support the development of the commercial market for remote sensing data." In 1992, there were no commercial firms operating remote sensing satellites in the U.S., although the WorldView Imaging Corporation and Orbital Imaging Corporation were founded in that year, in anticipation of the forthcoming Act. In 1993, WorldView was granted the first license to operate an imaging satellite. By late 1999, the first commercial remote sensing satellite, IKONOS-2 had been successfully launched by Space Imaging, Inc. Over time, via a number of mergers and acquisitions, the successor company Maxar continues to be a world leader in the provision of commercial remote sensing data. In recent years, a variety of new commercial remote sensing firms have been established, often prioritizing new features – such as very high revisit times or hyperspectral imagery. In retrospect, it wasn't possible to foresee the rapid and diverse proliferation of expanded spatial, temporal, and spectral resolution that has come to pass yet in the early 2000's several studies pointed to continued healthy expansion of the industry.

While some worried that free Landsat data would interfere with the private sector, the opposite has often been the case. Free availability of Landsat data has allowed the number of users and applications for land remote sensing to increase significantly, thus massively expanding the potential market for commercial remote sensing data. Users may experiment with relatively low-resolution Landsat data before turning to commercial providers for more precise imagery. Commercial entities use Landsat data to calibrate their own instruments and sometimes offer products that fuse their commercial data with free government data.[13] Through these mechanisms, the existence of commercial remote sensing capabilities also helps to drive increased use of Landsat data. Access to large amounts of data for academic research and education has strengthened the Earth science credentials of emerging professionals, in turn enabling improved understanding to further extract more information from the source data.

The U.S. should continue to develop the Landsat system as a government-owned system providing free and open data. Additionally, government system developers and operators must actively encourage and pursue strong partnerships with commercial entities and encourage synergistic interaction with commercial products, increasing the value of all systems and benefitting a broad array of users. The government should also consider imaginative public -

[12] https://www.usgs.gov/core-science-systems/nli/landsat/landsat-global-archive-consolidation?qt-science_support_page_related_con=3#qt-science_support_page_related_con
[13] https://www.fgdc.gov/ngac/meetings/october-2020/ngac-paper-landsat-data-community-standard-for.pdf

private partnerships that contribute to the goals of the Landsat program while preserving free and open data sharing.

The U.S. should also consider regulatory reform with regard to commercial remote sensing, as international competition in this area has increased significantly since 1992. The 1992 commercial regulatory environment was conceived in an era where there were many unknowns and where international competition was largely nonexistent. Today, the U.S. government has decades of experience working with the commercial industry. The perceived potential risks to national security posed by widespread availability of commercial remote sensing to national security have not materialized, while international competition has. Because of restrictive policy decisions, the U.S. is only at the threshold for commercial satellite radar, while other countries are addressing the needs of increasingly sophisticated users. Commercial capabilities have the potential to complement the Landsat program in multiple ways, especially as the Landsat Next system is being designed. Commercial capabilities can augment additional demand for the use of Landsat data, especially in the area of "analysis-ready," while improving distribution approaches. Cross-calibration can enhance the value of both commercial and Landsat data sets as demonstrated in current scenarios.[14] A robust commercial remote sensing industry can also help to support the technology base, which ultimately creates more and more diverse opportunities for the government while driving down cost.

5.6 Stable Funding

The Land Remote Sensing Policy Act was stimulated by programmatic funding shortfalls and organizational uncertainty, as noted in Section 2, part 7 of the Act. Unfortunately, funding uncertainties have continued to plague the Landsat program. Recent Congressional support for a funding profile that includes Landsat 9 and Landsat Next has been a productive step in addressing this issue. It is important that continuous, stable funding be provided to ensure the continuity of the program, and for the most efficient, effective use of resources by the program office. (Title 1. Section 105(a) 4) The Congressional Research Office published an important analysis of these funding needs in October 2020.[15]

5.7 Technology Demonstration Program

The Act calls for a technology demonstration program that would examine the ability of evolving remote sensing technology to contribute to increasing capabilities and/or lowering the cost of future Landsat systems. (Section 2, part 12; Title 1, Section 101(4) and Title 3, Section 303). This is currently accomplished through funding for the Sustainable Land Imaging technology development program, as well as by joint NASA-USGS funding within NASA's Earth Science Technology Office.

Continued technological innovation will strengthen the Landsat program. For example, robust cross-calibration could enable more sources of remotely sensed data to contribute to the land

[14] *Ibid*.
[15] crsreports.congress.gov/product/pdf/R/R46560

remote sensing base and make it easier for the Landsat program to take advantage of new technologies and capabilities without negatively impacting the continuity of the Landsat record. In looking at the areas to focus research and development, the U.S. should not replicate what is being done elsewhere (commercial, international) but rather look at (a) opportunities to materially reduce the cost of Landsat systems, and (b) opportunities to incorporate types of land remote sensing data that are currently being collected by NASA science programs into Landsat and the Sustainable Land Imaging program, where those data have broad utility and where a long term record going forward would be of societal value. Collection of new types of data would logically remain a NASA science focus, complementing the Landsat program.

5.8 Data Continuity

The Act emphasizes the importance of data continuity, defined as data that "are, from the point of view of the user-- (A) sufficiently consistent (in terms of acquisition geometry, coverage characteristics, and spectral characteristics) with previous Landsat data to allow comparisons for global and regional change detection and characterization; and (B) compatible with such data and with methods used to receive and process such data." With respect to Landsat 7, the Act notes that program management should seek to incorporate into Landsat 7 "any performance improvements required to meet United States Government needs that would not jeopardize data continuity." (Title 1, Section 102, (b) 3)

NASA and DOI entered into an Interagency Agreement in September 2016 to collaborate on the Sustainable Land Imaging (SLI) program. This effort aims to enable the development of a multi-decade, spaceborne system that will provide users worldwide with high-quality, global, land-imaging measurements that are compatible with the existing record. The agreement specifically aims to address near- and long-term issues of continuity risk while evolving flexibly and responsibly through investment in, and introduction of, new sensor and system technologies.

5.9 Program Management

At the time of the Act, program management was assigned to NASA and the Department of Defense. Shortly after the Act was passed, management of the program was passed to the USGS. USGS has proven over time to be the appropriate home for the Landsat program. Through close cooperation with NASA, the program has demonstrated technical excellence, great research value, and significant practical application. This is actually a superb example of a cross-agency initiative in terms of its operational effectiveness.

<u>NASA</u>
Under the Sustainable Land Imaging Program, NASA is responsible for, among other things:

- Leading and managing the overall system architecture design and development;
- Developing and executing agreements with potential international partners;
- Developing and executing agreements for flight hardware development with potential external partners;

- Supporting ground system development and leading and managing mission operational readiness;
- Developing, integrating, and testing spacecraft, instruments, and launch vehicle services for the program;
- Launching the mission, performing on-orbit checkout and commissioning, and transitioning Landsat to DOI for operations; and
- Supporting the calibration, validation, and characterization of the instruments throughout the remaining mission life cycle.

USGS

Under the Sustainable Land Imaging Program, DOI, through the USGS, is responsible for, among other things:

- Defining the needs of national and international users for a land imaging system and providing technical, managerial, and scientific support to NASA related to those needs throughout the space system development life cycle;
- Supporting, under NASA leadership, the overall land imaging system architecture design and development;
- Leading and managing ground system development, including all pre- and post-launch activities related to development of the ground-based component of the land imaging system;
- Leading and managing the calibration, validation, and characterization of the instruments after reaching orbit;
- Operating Landsat, as well as the downlink, archiving, processing, and distribution of Landsat data;
- Establishing cooperation in land imaging system data acquisition, data sharing product development, and distribution with potential external partners;
- Defining and representing to NASA the needs and desires of user communities, as well as providing unique expertise and guidance in the design of spacecraft and data operations, processing, and distribution methodologies and management approaches;
- Developing a common set of land imaging data products and data dissemination; and
- Maintaining the national archive of land imaging system data.

6.0 Summary and Recommendations

There have indeed been massive technology and application advances in the remote sensing sector since the enactment of the Land Remote Sensing Policy Act of 1992, particularly in terms of the proliferation of collection platforms and sensors (and sensor types) on orbit and technologies on the ground facilitating the storage, dissemination, analysis, and display of the data from those platforms and sensors. There has generally been a vast increase in the

availability of remotely sensed information, services, data, and applications beyond anything that might reasonably have been predicted in 1992.

Recognizing this, we find that many of the foundational precepts of the Act endure. Enhanced applicability to myriad economic sectors calls for ongoing support for making data widely available to facilitate knowledge of and access to Earth observation data and to attend to the pragmatic needs of the continually expanding user community. The U.S. maintains a mandate for global leadership, especially as it relates to ensuring the unique opportunity for data continuity, the value of which has never been greater. Along with continuous data collection, data sharing and archiving are at the core of the Landsat program and must remain so to facilitate the broad and varied use cases that have blossomed from the open availability of Landsat data. Landsat's joint program management represents a success story, and that team is perfectly poised to take advantage of the tremendous potential for public-private partnerships as it looks to the future of the program. Finally, as with any long-term acquisition program, a stable funding profile and competent administrators will support the most effective, efficient use of government and contracted resources over time.

Based on the observations documented in this paper, we find several policy areas which the Landsat program office might find beneficial for further examination, reflecting the underlying guidance of the Land Remote Sensing Policy Act and the influence of great technological change:

1) Looking forward, precisely what does 'continuity' for the Landsat program require, and what combination of approaches to accomplishing 'continuity' hold the most promise?

2) Should Landsat continue to be optimized for medium resolution earth observation or should there be a broader set of objectives considered, to include diverse phenomenologies (as in the European Copernicus program)? For example, should Sustainable Land Imaging be expanded to Sustainable Earth Imaging, so as to include the collection of data regarding water and atmospheric resources?

3) How do the Earth observation capabilities of the U.S. compare to other countries and regions, particularly China and Europe? What is Landsat's role in maintaining the 'global leadership' mandate set forth in the Land Remote Sensing Act?

4) How can or should the Landsat program leverage existing international Earth observing capabilities, such as the Copernicus program in Europe? What is the relative importance of each country / continent maintaining and enhancing its own robust independent capabilities, and how could these efforts support more robust partnership and harmonization efforts that increase benefits to users within these countries, in the U.S., and elsewhere in the world? How do free, full, and open data policies play a role in these efforts?

5) One could assert that the goal of "establishing a new national land remote sensing policy" hasn't been fully realized over the years. There have been some excellent ad hoc developments (such as adopting the Landsat "free and open" data policy), and providing land remote sensing portions of other national policies/plans (i.e., National Space Policy, two National Plans for Civil Earth Observations, etc.), but there has been no new policy dedicated exclusively to land remote sensing since 1992. What principles should be considered for inclusion in a new national land remote sensing policy that would "enable the United States to maintain its leadership in land remote sensing"? These principles should be in full conformity with the law, and could emphasize issues pertaining to data continuity, data sharing, technology infusion, analysis-ready formats, external partnerships, connections to other types of geospatial data as part of a 21st century public information infrastructure, and other important considerations.

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