Statement

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Space and Environment Subcommittees
Committee on Science, Space, and Technology

Public-private partnerships to support the NASA's Earth observation program

Chairman Babin (Space), Chairman Bridenstine (Environment) and members of the Committee. Thank you for this opportunity to present my views on NASA (and USGS) Earth observation programs, specifically the long-standing **Landsat mission**. These views are my own, which have evolved over more than forty years, from the beginning of my doctoral studies at Indiana State University.

The Landsat observatory was the first land imaging system flown by NASA in the early days of the Space Age[1]. The system was originally designed to produce photography but did not use onboard film-based cameras but rather electronic video cameras and a novel multispectral scanner system. Earth scientists who had used aerial photography for nearly a century prior to the first Landsat launch, considered the Landsat images primitive and a step backward from their well-developed photographic technologies. The Landsat mission visionaries contrarily, viewed the Landsat concept as major new innovation, using space technologies to monitor global land dynamics the same way the weather satellites monitor atmospheric dynamics. The former, aerial photography vision for Landsat has generally dominated widely held impressions of the mission goals and therefore the potential for commercialization. In fact, in 1967 when decision makers met at Woods Hole, MA to discuss Earth observation applications, the land observations satellite was voted most likely to develop commercial potential based on the aerial photography perspective (National Research Council 1969). This conflict between global monitoring and local imaging has colored the dialogue about Landsat's role in the US culture ever since. As a result the Landsat mission has experienced more attempts to commercialize or privatize than any other NASA Earth observation mission

The Landsat mission, now approaching nearly 50 years in durations, experienced at least five different mission eras:

[1] DOD/CIA few earlier space missions under the CORONA but those images were only released recently for public use.

1. Multispectral remote sensing (1960-1970): Supported initially by DOD, particularly the Office of Naval Research, electronic scanning devices originally developed for intelligence gathering were made available to civilian researchers, particularly at the University of Michigan and Purdue University.
2. The Earth Resources Technology Satellite (1970-1973): USGS's William Pecora and Stewart Udall convince the nation and NASA to develop an Earth satellite to monitor land dynamics. Placed in orbit July 1972 ERTS-1 ((cum Landsat-1) it was initially employed to evaluate earth resources such as forests, grasslands, water and geology.
3. Agricultural Application (1973-1982): Russian wheat crop failure undetected by US agencies. The US grain reserves were sold for little profit. Congress and Executive instruct NASA, USDA and NOAA to employ Landsat technology to monitor global agricultural production. Large Area Crop Inventory Experiment (LACIE) followed by AgRISTARS (Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing) dominate Landsat activities for a decade (McDonald and Hall 1980). Remote sensing science developments during this era sets the ground work for later evolution of Earth systems science (Goward 1989).
4. **Commercialization** (1982 - 1992: NASA instructed to stop supporting other Federal Agency applications. Decision made to commercialize the Landsat mission. Landsat transferred to NOAA. EOSAT, a partnership of Hughes Aircraft and RCA, selected to operate Landsat. Cost of purchasing Landsat images balloons by a factor of 10. Legal restrictions prevent data sharing. Earth science use effectively stops, turning instead to NOAA AVHRR images.
5. Government Operations and Earth Systems Science (1992-current): The 1992 Land Remote Sensing Act returns Landsat, beginning with Landsat 7, to government management (DOD and NASA, then NASA and NOAA, then NASA and USGS). Landsats 4 and 5 taken over by USGS in 2001. NASA is directed to seek a **private-public partnership** for Landsat 8. Bids from Digital Globe and Resource21 explored. Digital Globe drops out. Resource21 not selected. Following various diversions NASA finally builds a free-flyer for Landsat 8, some 14 years after Landsat 7 launch. Current efforts to procure Landsat 9 have just begun with the initial profile being a replication of the Landsat 8 procurement.

> The NASA Earth systems science activities provided substantial new opportunities for Landsat (Goward and Williams 1997). In particular, USGS removed COFUR costs in 2008 which caused the use to Landsat observations to skyrocket. Not only was there substantial pent-up demand but also contemporary computer systems, such as the NASA Ames NEX computing facility, can easily handle such data volumes. Not only is our understanding of land dynamics advancing in leaps and bounds but now the commercial potential of a high temporal repeat Landsat observatory is becoming clear.

This tortured Landsat pathway forward served to damage technical advancements and degraded overall mission performance, as the temporal repeat cycle of the system decreased. NASA anticipated replacing the optical-mechanical thematic mapper instrument with sensor array technologies in the 1980's about the same time the French flew a similar system. This ultimately did not occur until Landsat 8 was launched in 2013.

The original designers of the mission knew that a single satellite in sun-synchronous orbit would not be sufficient to accomplish the mission goals. The vision was for at least 4 satellites in orbit at any given time to provide four-day repeat nadir coverage. The initial two-satellite design for ERTS was intended to demonstrate the multiple satellite concept which was expected to further advance into an operational system. A similar logic is found in the simultaneous construction of Landsats 4 and 5, with the advanced thematic mapper sensor. When Landsat 7 is decommissioned in the near future, only Landsat 8 will remain, returning the community 16-day repeat observations. This will not be addressed until Landsat 9 is launched as currently planned in 2023. At which time Landsat 8 will have out lasted its anticipated design life. The 16-day repeat cycle has become the norm when this was never envisioned as suitable to Landsat's global monitoring mission (National Academies of Sciences 2015).

Today, with the maturing of new sensor and satellite technologies, the opportunity exists to fly at least four Landsat observatories at same total cost as a single satellite which uses the traditional using more technology of Landsat 8. . The skeptics claim that these newer technologies have neither the capacity nor the reliability to meet Landsat mission standards. However this claim has never been tested.

A few years ago I served as principal investigator on a proposal developed by Global Science & Technology, Inc., in association with Surry Satellite US to fly a Landsat companion observatory for less than $130 million, to supplement Landsat 8. This "TerEDyn" satellite did not include thermal infrared observations. More recently GST and Surry, with the support of NASA, have shown that fully compatible, including TIR observations, could be flown for less than $250 million, about one quarter the cost anticipated for a more traditional build for a future Landsat mission. Construction of this lower cost system could be completed in 3 years (e.g. 2018 if started now). Certainly GST and Surry are not the only businesses that are capable of taking this step (e.g. the EO-1 mission procured by NASA is the 1990s).

What is needed currently is a push to get NASA and the US private sector moving in the right direction. They need to step away from increasingly expensive single satellite builds toward lower cost, high temporal repeat Landsat class observatories which will better serve the rapidly advancing needs of Earth System scientists and the applied users supported by the private sector.

References

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