

Landsat’s History: The story behind nearly a half-century of monitoring the Earth’s surface with Landsat

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Abstract

Spanning a period of more than 15 years, the Landsat Legacy Project Team researched, compiled and published, in late 2017, Landsat’s Enduring Legacy that describes the myriad of factors that surround the nearly half-century of monitoring the Earth’s surface with Landsat. Born of technologies that evolved from the World War II, Landsat not only pioneered global land monitoring but, in the process, drove innovation in digital imaging technologies and encouraged development of global imagery archives. Access to this imagery led to early breakthroughs in natural resources assessments, particularly for agriculture, forestry, and geology. The technical and political aspects of the remote sensing revolution led by Landsat were not simple or straightforward. Early conflicts between civilian and defense satellite remote sensing users gave way to disagreements over whether the Landsat system should be a public service or a private enterprise. Only the combined engagement of civilian and defense organizations ultimately saved this pioneer satellite land monitoring program from termination. With the emergence of 21st century Earth system science research, coupled with greatly enhanced data computing, storage and transfer capabilities, the full value of the Landsat concept and its continuous, calibrated nearly half-century global archive has been recognized and embraced. The attempts to privatize Landsat had dramatic negative impacts on the collection, availability, and use of the data. These impacts should inform deliberations on the future of the Landsat program moving toward a Sustained Land Imaging program following Landsat 9. Discussion of Landsat’s future continues, but its heritage will not be forgotten.

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Background / Motivation

As a result of the Congressional 1992 Land Remote Sensing Policy Act, the National Satellite Land Remote Sensing Data Archive (NSLRSDA) was established at the US Geological Survey EROS Center. A NSLRSDA Federal Advisory Committee (FACA) was soon formed, including two co-authors of this poster -- Drs. Goward and Williams. Early EROS reports to the FACA regarding the EROS Landsat archive contents were numerical, and it was impossible to grasp the global distribution or seasonal and annual variability of available imagery. Goward and Williams requested that geographical / visual summaries of the archive contents be assembled.

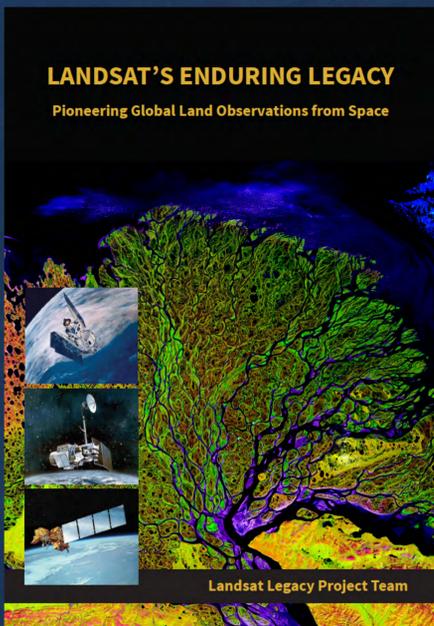
Soon thereafter visual summaries of the Landsat holdings were presented to the NSLRSDA FACA and these summaries raised many questions concerning variations in geographical distribution and year-to-year variability. Goward and Williams quickly realized that a serious endeavor was needed to document the technical history of the Landsat program to determine what were the drivers behind these image acquisition variations before critical veteran insight was lost due to retirements, death and/or document disposal. With funding from the NASA History Office, coupled with additional funding from Williams' Landsat Project

Science Office, the Landsat Legacy team was assembled to research and compile this technical history. Over the next ~15 years, the team conducted extensive research activities including document retrieval/salvage and recordation of video interviews with Landsat veterans to document the first ~50 years of the Landsat program. Sadly, many of the interviewees have now passed away, but this effort culminated in **Landsat's Enduring Legacy**, a history book published in late 2017 by the American Society of Photogrammetry and Remote Sensing (ASPRS) under a Space Act Agreement with the NASA History Office.

Landsat's Enduring Legacy has received excellent reviews -- "this is the great American story of innovation – not that of a single inventor, but of teams of brilliant men and women dedicated to furthering science, engineering and space technology for the good of humankind" – and it is considered a 'must read' for those in the quantitative remote sensing community.

Copies of the Landsat Enduring Legacy can be ordered from www.asprs.org or from Amazon.

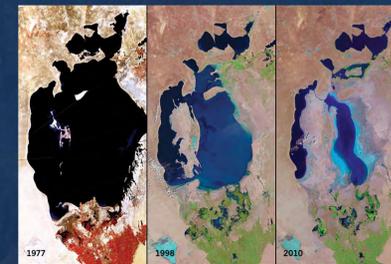
[NOTE: the co-authors receive no royalties from book sales.]



Landsat's Enduring Legacy

Introduction

Herein we present the overarching themes of *Landsat's Enduring Legacy*, a book that reviewer Russell G. Congalton asserts could have been titled "Everything You Might Ever Want to Know About Landsat."



Landsat imagery of the Aral Sea in Central Asia. The sea began to shrink after two of its feeder rivers were diverted in the 1960s for agriculture. (USGS EROS)

Chapter 1

"The Vision – Earth Rising" chronicles how early remote sensing science, WWII technology, and the Gemini and Apollo space missions coalesced into a vision for the Landsat mission.



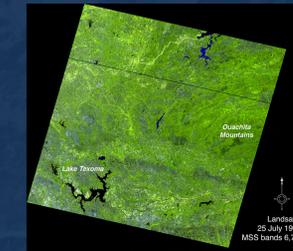
Virginia Norwood during Landsat Legacy interviews at the Pecora Symposium, Denver, March 2009



The integrated ERTS payload and Nimbus satellite bus undergoing testing at the GE facility in Valley Forge, PA.

Chapter 2

"Beyond Expectations" explains how the secondary "ride along" sensor, the Multispectral Scanner System (MSS), became the defining success of the early Landsat missions, as it explores the new Earth science done with the data acquired by the first civilian land-focused satellite.



First cloud-free band image acquired by the Landsat 1 multispectral scanner system (MSS), 25 July 1972, including the Ouachita Mountains in south-eastern Oklahoma. "I looked at that image and tears came to my eyes" (Chuck Robinove, USGS) "Gentleman, that's a map" (Alden Colvocoresses, USGS cartographer)

Chapter 3

"Landsat in Transition" documents the technological advances and design challenges of the second-generation Thematic Mapper (TM) sensor—a sensor that has defined much of modern passive remote sensing. The travails of the 1980s Landsat commercialization period are explained in tandem with the advent of Earth System Science that would sow the seed for Landsat data democratization.



Landsat 5's thematic mapper (TM) sensor under construction at the Hughes Santa Barbara Research Center in 1982. (Hughes SBRC)

Chapter 4

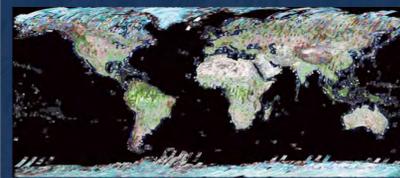
"Light on the Horizon" covers the period from 1992 to 1999, from when Congress returned control of the Landsat program to the public sector, through the set-back of the privately-owned Landsat 6 launch failure, to the successful build and launch of Landsat 7 that happened despite shifting agency management and funding. The re-emergence of a Landsat science team helped shape the global data acquisition strategy leading to the realization of the original mission.



Backing the trailer with the Landsat 7 satellite into the C-5 aircraft ramp into a snag. Note the wood shims in the middle of the ramp. (Lockheed Martin)

Chapter 5

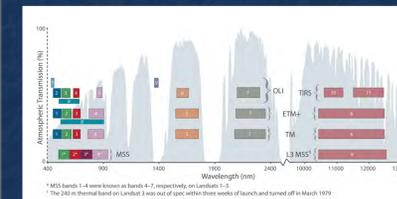
"Approaching the Vision" recounts the interval between the Landsat 7 and 8 launches, and describes the return of Landsat 4 and 5 operations to the federal government; it chronicles the recovery of unique data from International Cooperators, and the landmark decision by USGS to make Landsat data available for free.



Mosaic of lowest-cloud-cover-per-Path-Row ETM+ browse images for the year 2000, demonstrating the substantial impact of the long-term acquisition plan and solid-state recorder on global extent and coverage quality for Landsat 7's first full year in orbit.

Chapter 6

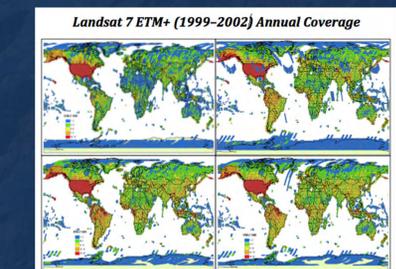
The final chapter outlines the ways in which the Landsat program history has influenced the current state of Earth observation from space, while the **Epilogue** provides final thoughts and some updates about the current Landsat 8 mission.



Evolution of spectral bands on the Landsat sensors. Numbered color boxes indicate bands. Gray background curve shows atmospheric transmission. MSS: Landsats 1–5; TM: Landsats 4–5; ETM+: Landsat 7; OLI and TIRS: Landsat 8. (L. Rocchio and J. Barsi)

Appendices

It's rare when an appendix is not to be missed, but this is where all of the historical Landsat data acquisition maps from 1972-2007 can be found. The historical challenges of the program are in many ways "etched" into these maps—maps that were themselves an impetus for the book to be written.



Acknowledgments

For a work of this scope and subject, we owe many thanks to many people. Nearly fifteen years have elapsed since the idea for this book was conceived by the Landsat Project Science Office (LPSO) at NASA Goddard Space Flight Center, and subsequently grew into a collaborative effort involving the NASA History Office, the Goddard Library, and the USGS EROS Center. We are grateful to all who shared their recollections of working on various aspects of Landsat. Given the timespan to research, write, and edit the manuscript, some of the Landsat veterans we engaged during this process have passed away – we regret they did not get to see the published tome. A number of people associated with the Landsat program, and several libraries and offices, have donated documents to the Landsat Legacy archive. In the ASPRS, we could not have a more fitting publisher. We thank the Board of Directors for their commitment to this book, and ASPRS publications staff members Rae Kelley and Matthew Austin who assisted us with the many details required to submit a manuscript and publish a book.