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The Rise of the Commercial Space Industry

Early Space Age to the Present

Edited by
Brian C. Odom

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Foreword: Promoting Innovation in the Space Sector

Our goal as a community in the space sector should be to develop more innovative goods and services—for use in space science and exploration, national security, and economic development—at a rapid clip and cost-effectively. The *Rise of the Commercial Space Industry* volume is a key marker in exploring pervious experiences to help NASA think about approaches that make the sector speedier, more innovative, and cost-conscious.

As many of the authors in the anthology discuss, bringing more private sector companies that take financial and other risks is certainly one way of promoting innovation in the space sector. These companies are driven by their investors' interests in larger returns on investment (ROI) and are therefore incentivized to prioritize speed and lower cost.

But as other authors discuss, the government's role in incentivizing innovation should not be underestimated. When the government focuses simply on solutions ("give me a hole that is x meters deep") without dictating process ("use instrument y with reliability z to dig"), it can incentivize faster-paced lower-cost innovation, as it has done with the commercial style contracts COTS and CRS to deliver cargo to the International Space Station, and hopes to do with the HLS and CLPS contracts for the Moon. Research has shown that government purchases of products and services from companies—using these "solutions-based" approaches—have the twin benefit of reducing costs *and* accelerating the development of many government space systems, as well as fostering the growth of the space sector and promoting the industrialization of space. To use an analogy, *commercial approaches provide no incentive to build a Ferrari if a Ford*

Focus would do. And in the process can help build more Ford Focuses that can increase the number of exciting things in space.

Commercial approaches and commercial companies, working together, prioritize risk-taking, rapid development, and a focus on cost reduction (often but not always over performance and reliability). As a result, the most important benefit this ecosystem (jointly referred to as "commercial space") brings to the space sector is speed and lower costs. In some cases, as a result of these approaches, commercial capabilities have surpassed or are complementary to government ones.

Today, commercial approaches in the space sector are incentivizing a balance between performance, risk-taking, and cost in diverse sectors from launch to space situational awareness to space nuclear power and even deep space exploration. There is tremendous excitement in the community about the prospects of the use of commercial approaches not only in accelerating our presence on the Moon and Mars but also in promoting activities such as on-orbit servicing (which includes services such as de-orbiting or repairing malfunctioning satellites), in-space assembly of structures, and manufacturing industrial products in space for use on Earth or in space.

It is becoming increasingly evident that we must consider commercial approaches when purchasing space goods and services *as norm rather than exceptions or one-off approaches.* In some cases, such as developing transportation to Mars, a cost-plus contract may be necessary and appropriate. But more often than not, solutions-based approaches suffice, allowing for innovative solutions at a faster timeline and lower cost. Integrating commercial approaches in our current architecture has proven to be a difficult transition in a risk-averse government culture that values performance over speed and cost. And that is the challenge NASA and the broader space community must address.

NASA Bhavya Lal
Washington, DC, USA

Preface

As President Dwight Eisenhower closed out his last year in office, the issue of commercial space remained one of many last-minute concerns. Companies including AT&T, RCA, and GE continued to push the president toward supporting a plan to allow commercial firms control over something they believed lay clearly in the domain of the private sector, communication satellites. On December 30, 1960, Eisenhower made public a final statement on the matter. There, the president called for the government to "aggressively encourage private enterprise in the establishment and operation of satellite relay for revenue-producing purposes."[1]

Success in this national objective of commercializing satellite communications would require the "concerted capabilities and funds of both the government and private enterprise" as well as the "cooperative participation of communications organizations in foreign countries."[2] As with many of his decisions related to space, Eisenhower sought a balanced approach that established a strong government engagement with private enterprise but also looked to invite international collaboration wherever possible. As historian Walter McDougall argues, Eisenhower left the delicate issue of crafting national policy (a choice seemingly between state ownership and

[1] White House Press Secretary, "Statement by the President," December 30, 1960. In John Logsdon, ed. *Selected Documents in the History of the U.S. Civil Space Program, Volume III: Using Space*. (Washington, D.C., NASA, 1998), 42. https://www.nasa.gov/wp-content/uploads/2023/04/sp-4407-etuv3.pdf?emrc=fe2581 Accessed on May 16, 2023.

[2] Ibid.

private monopoly) to the Kennedy Administration—ultimately decided by a slightly hybrid approach in the Communications Satellite Act of 1962.[3]

Over the intervening decades from 1962 to the present, as the aerospace landscape underwent vast changes in direction and composition, the US government, international community, and private industry all vacillated among various positions on commercial space. Today, the commercial space industry is unquestionably taking on an increased leadership role in space—positioning itself as an innovator in space access, research, and exploration. This growth of commercial space over the past decades offers the potential for a new paradigm for space exploration—one in which industry transitions from supplier to partner. Still, many questions remain spanning from the most seemingly consequential "How will humanity explore the Moon and Mars?" to the more basic, "What is Commercial Space?"

In March 2021, the NASA History Office hosted a three-day virtual symposium to explore the issue and offer a workable definition of the term "commercial space." The objective of the current volume, the outcome of that event, is to advance an effective definition of and practical historical context for commercial space. The historians, legal experts, practitioners, executives, and academics who authored the chapter were challenged to examine historical developments in the field of commercial space, in both governmental and non-governmental sectors, and offer conclusions that could inform policymakers moving forward.

The chapters in Part I of this volume all highlight important foundational elements of this history including commercial space definitions, historiography, and public history methodologies for engaging with the public. In his introduction, Ken Davidian provides a brief history of commercial activities, unpacks the murky context surrounding past embedded meanings of "commercial space," and some early theorizing about the definition before considering why we need to define it in the first place. In Chap. 2, Roger Launius provides a historiographical investigation of the rise of the commercial space era while working to define the fundamental differences between "old" and "new" space and what impact those differences might mean. Launius explores the manner in which early efforts in the commercial space arena laid the groundwork for what has come to pass dating back to the communications satellite debates of the 1960s, the

[3] Walter McDougall, … *The Heavens and the Earth: A Political History of the Space Age*, second edition (Baltimore: Johns Hopkins University Press, 1997) 352–357.

efforts to stimulate commercial activities in the latter 25 years of the twentieth century, and the plethora of space launch endeavors that emerged near the turn of the new millennium.

Turning to public history, Matthew Shindell explores the challenges of presenting the history of commercial space by highlighting the experience of the Smithsonian Institution's National Air and Space Museum. One new installation at the Museum, the *Futures in Space* gallery, is dedicated to the evolving relationship between government space agencies and the commercial space sector. Tied to the complexity of defining commercial space, Shindell notes that the gallery is designed explicitly not to predict the future of spaceflight, but to act as a forum that invites visitors to engage with a set of "enduring questions" about the who, what, and why of spaceflight.

Part II of the volume examines relevant histories, analogues, and perspectives that provide a useful frame of reference for the experience of commercial space. Wendy N. Whitman Cobb uses the framework of the initial development of commercial air policy in the 1910s and 1920s to explore how history might provide a sustainable balance in the relationship between government and commercial interests in spaceflight.

Surveying post-Apollo forays into commercialization, Jonathan Coopersmith surveys how from the late 1960s through the 1980s, various attempts at commercialization emerged, spurred by optimistic studies predicting huge markets and growing federal support, only to run aground on unforgiving technological and financial reefs. Coopersmith argues that although failure was a typical outcome of those attempts, the paradigm of commercialization created numerous opportunities in and outside the government that created an environment favorable to the concept. Bringing her experience as journalist in the early/mid-1980s to bear on the topic, Linda Billings provides a critical perspective on commercial efforts in those years. Billings provides a sampling of proposals and developments reported in SBN from July 1983 to July 1985, and much of the information in this chapter is anecdotal. The author focuses on areas of commercial space development that were hot topics at the time and avoids delving into the politics of space commercialization during those years.

Matthew Hersch examines the experience of the space shuttle to offer a "cautionary tale" for those seeking profits in low Earth orbit. Those in government who believed the shuttle would quickly "pay for itself" soon found themselves with an unworkable paradigm. The *Challenger* accident

in January 1986 ended all hopes at commercialization for that program. Hersch argues that the lessons of the shuttle should serve as a critical warning for anyone looking for safe profits in space. From the field of remote sensing, Brian Jirout explores commercialization efforts of Landsat and civil remote sensing programs in the United States during the Jimmy Carter and George H.W. Bush presidential administrations to underscore how attempts to commercialize Landsat, and more broadly, civil remote sensing, was a politically charged activity that failed to develop clear lines between public goods and private commodities leading to effective policy implementation both across government agencies and with commercial interests.

Turning to the international commercialization scene, Marco Ferrazzani and Teresa Wendel of the European Space Agency (ESA) explore how, in recent decades, European space efforts have also progressively ceased to be the sole domain of governmental actors. Ferrazzani and Wendel argue that new technologies and continuous advancements in space-based end-to-end services fuel the development of space applications have created new business opportunities—a shift that has led public actors to begin making room for commercial undertakings. The authors provide a useful overview of European commercialization efforts currently supported by ESA as well as the outlook and immediate plans for the upcoming years.

Part III shifts the focus from the policy front to considerations of legal infrastructures for commercial space. In his chapter, PJ Blount addresses the historical development of US commercial space activities, showing how the development of the law led to the current state of fragmentation. Blount then discusses the current state of play in the regulation of space activities and the various attempts at smoothing the authorization and licensing procedures for commercial companies. Finally, Blount points to potential actions the United States might take to address the issue of fragmentation in the current and future eras of space innovation.

In his chapter, Steven Freeland turns to international commercial law to examine the development of commercial space activities within the context of the fundamental international legal principles that regulate the exploration and use of space. Freeland suggests some overarching considerations that should inform how we continue to develop appropriate and practical frameworks to shape behavior so as to best assure the ongoing safety, security, and sustainability of space.

Michelle L.D. Hanlon argues that the context which produced the Outer Space Treaty of 1967, a world dominated by two lone superpowers, has passed and dramatically shifting the international regulatory paradigm. Hanlon addresses the primary issue of individual state liability for its non-governmental actors in all aspects of space activity while also exploring how these issues intersect with geopolitical considerations and potential conflicts.

Finally, Part IV turns to the critical issues of national space security and policy. Rick Sturdevant charts the evolution of the relationship between commercial space and the US military. With a primary focus on the US Air Force, but including examples from the Army, Navy, and other DOD organizations, Sturdevant surveys how military reliance on commercial companies has expanded chronologically and dimensionally across key areas of space-related activity. These developments, Sturdevant argues, have created an increasingly integrated military-commercial space enterprise. Turning to the dual use nature of space technology, Deganit Paikowsky explores the evolution of space security beyond the Cold War that impacted the movement toward commercialization in the United States. Paikowsky argues that during the Cold War, the US government mainly perceived the dual use characteristic of space technology as a threat to national security, leading it to keep a close hold on space technology diffusion. But as the end of the Cold War brought diminished budgets, closer cooperation with commercial partners became more an opportunity than a threat.

In concluding the volume, Alexander MacDonald explores pathways for how we might begin engaging with the difficult question of "What we should make of the rise of commercial space in the twenty-first century?" As MacDonald makes clear, our answers to this question will necessarily involve a variety of new frameworks, interdisciplinary methodologies, and a willingness to consider various perspectives and possible outcomes.

This volume is not intended as an endpoint to understanding the history of commercial space or its evolving place in our discourse on space history. In truth, it is not even a comprehensive beginning. However, it is a useful application of history to a contemporary debate that has become, at times, convoluted, error-ridden, and misdirected. The demand is for a thoughtful, informed debate and a clear understanding of why it is absolutely critical that we have it in the first place. I hope future scholars will continue to push this investigation forward into new directions and pose

new questions from additional perspectives and frameworks. Like Eisenhower, we must strive toward establishing some semblance of equilibrium in both our cooperative and competitive affairs in outer space by gaining an equitable balance among government, private enterprise, and international cooperation. Only by doing so will we make that audacious venture worthwhile.

Huntsville, AL Brian C. Odom

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Notes on Contributors

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P. J. Blount is Lecturer in Law in the School of Law and Politics at Cardiff University, UK. He serves as the executive secretary of the International Institute of Space Law.

Jonathan Coopersmith is a Professor Emeritus at Texas A&M University, USA, where he taught the history of technology and science and technology policy. His publications include *The Electrification of Russia, 1880*–1926 and *FAXED: The Rise and Fall of the Fax Machin*e. His current interests focus on the importance of froth, fraud, and fear in emerging technologies and how to learn from failure.

Ken Davidian spent 14 years working for the FAA's Office of Commercial Space Transportation, 20 years at NASA (Lewis/Glenn Headquarters), and 5 years in private industry/academia. Davidian is also the editor-in-chief of the *New Space Journal* and serves as an adjunct professor at Pamplin College of Business, Virginia Tech.

Marco Ferrazzani is a senior legal counsel, having served as an attorney-advisor for 35 years at the European Space Agency, based at its

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Steven Freeland is Emeritus Professor at Western Sydney University, Professorial Fellow at Bond University, and a co-principal of specialized space law firm Azimuth Advisory. Among other appointments, he is a member of the Australian delegation at COPUOS Meetings and in 2021 was appointed by COPUOS as vice-chair of the 5-year COPUOS Working Group on Legal Aspects of Space Resource Activities.

Michelle L. D. Hanlon is the executive director of the Center for Air and Space Law at the University of Mississippi School of Law and Professor of Practice of Aviation and Space Law. Michelle received her B.A. in Political Science from Yale College, her J.D. from the Georgetown University Law Center, and her LL.M. in Air and Space Law from McGill University. Michelle is the editor-in-chief of the *Journal of Space Law* and the *Journal of Drone Law and Policy.*

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Brian Jirout is a tenure-track librarian at the State University of New York, Cortland, USA. He has previously been Adjunct Professor of History at University of South Carolina and taught at Georgia Institute of Technology. He has held research fellowships from the Smithsonian National Air and Space Museum and NASA and is a certified archivist.

Brian received his Ph.D. in History of Science and Technology from Georgia Tech and his MLIS from Simmons University.

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Roger D. Launius is former chief historian of the National Aeronautics and Space Administration and most recently associate director for Collections and Curatorial Affairs at the Smithsonian Institution's National Air and Space Museum. He is the author, most recently, of *NACA to NASA to Now: The Frontiers of Air and Space in the American Century* (2023) and *Apollo's Legacy: The Space Race in Perspective* (2019), among many others.

Alexander MacDonald is the chief economist at NASA. He was previously the senior economic advisor in the Office of the Administrator, program executive for the International Space Station National Laboratory, and was the founding program executive of NASA's Emerging Space Office. He is the author of *The Long Space Age: The Economic Origins of Space Exploration from Colonial America to the Cold War.*

Brian C. Odom is chief historian of the National Aeronautics and Space Administration where he leads the programs responsible for capturing, preserving, and disseminating the agency's history. Odom is the co-editor of *NASA and the 'Long' Civil Rights Movement* (2019) and *NASA and the American South* (2024).

Deganit Paikowsky is a lecturer in the Department of International Relations at the Hebrew University of Jerusalem, and a non-resident scholar in the Elliott School for Foreign Affairs at the Space Policy Institute, George Washington University, USA. Paikowsky's research expertise is at the intersection of international relations and security studies, with a unique focus on the politics of science and technology, accompanied by extensive hands-on experience in policymaking.

Daniel J. Rasky is a NASA senior scientist, was a co-founder of the Space Portal in 2005, and is the current chief of the Space Portal Office. Rasky was the primary inventor or significant contributor to flight hardware for ten NASA and US flights systems, which includes the Space Shuttle, the DC-XA, SHARP-B1&B2, Mars/Pathfinder, DS-II, Mars Exploration Rovers, Stardust Mission, the Re-entry Breakup Recorder, the Mars Science Laboratory, and the X-37.

Matthew Shindell is a historian of science whose work focuses on the history of Earth and planetary science and exploration. He curates the Smithsonian National Air and Space Museum's collection of spacecraft, instruments, and other artifacts related to the exploration and study of our Earth and solar system, as well as exoplanets. Shindell is the author of *For the Love of Mars: A Human History of the Red Planet* (2023) and *The Life and Science of Harold C. Urey* (2019).

Rick W. Sturdevant received his Ph.D. from the University of California, Santa Barbara, USA, in June 1982. He began researching and writing US Department of the Air Force official space organizational history in April 1985 and currently serves as command historian, Space Training and Readiness Command.

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PART I

Frameworks

CHAPTER 1

What Is Commercial Space?

Ken Davidian

Introduction

In thinking about the question, "what is commercial space?" it is useful to consider a methodology based on a story entitled "The American Claimant," by Mark Twain. In that story, Twain describes an event called the "Mechanics' Club Debate," a way of discussing a topic that I always thought was interesting. In front of a gathered audience, an essayist reads a prepared text on a topic for public debate. The subject is not immediately discussed, but audience members who wish to offer counter points, rebuttals, or additional observations can put their thoughts in writing, and present them by reading their essays at a subsequent meeting. This method gives people time to think about what they heard, gives them the opportunity to formulate their words, and results in a concise presentation that reflects clarity of logic and depth of discussion. I imagine myself as this volume's essayist, reading my prepared text of ideas on the definition of the word commercial. I will consider this with respect to space activities to you, an interested audience of space community members. It is my hope that some of you will hear my ideas and feel sufficiently compelled to

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compose counter points, rebuttals, or additional observations on the topic, for presentation at a future opportunity.

Normally, I would start this discussion with an explanation of why we need a definition for the term "commercial," but I want to hold that part of the discussion until the end of this chapter. Instead, I'll start with a quick history of commercial activities, before talking about the cognitive construct surrounding the word, the different ways the word has been defined in the past, and then some early theorizing about the definition before actually talking about why we need to define it in the first place.

Historical Perspectives

Historically, different social groups define the word "commercial" in different ways, and the social status of people engaged in commercial activities varies over time, too. For example, historians have described the perception of any commercial enterprise during the early Greco-Roman times as demeaning, corrupting, and money-grubbing.[1] In medieval Europe, historians explain that "one of the oldest stereotypes in European history is the leisured aristocrat who abhors commerce as derogatory and beneath his social status. Being 'in trade' was considered ignoble, and in some European countries before the eighteenth century, notably France, titled aristocrats were legally barred from any business but farming, government … service, and warfare."[2]

It may be these perceptions still exist today to some extent, in the remnants of the Roman Empire. Under the Islamic Empire, however, commercial activities were encouraged by institutions in the fields of science and technology, but never received formal approval from other institutions, such as religion.[3] The point of these examples is that regardless of

[1] Michael Hudson, "Entrepreneurs: From the Near Eastern Takeoff to the Roman Collapse." In David S. Landes, Joel Mokyr, & William J. Baumol, eds., *The Invention of Enterprise: Entrepreneurship from Ancient Mesopotamia to Modern Times* (pp. 8–39). (Princeton: Princeton University Press, 2010).

[2] James M. Murray. "Entrepreneurs and entrepreneurship in Medieval Europe. In David S. Landes, Joel Mokyr, & William J. Baumol, eds., *The Invention of Enterprise: Entrepreneurship from Ancient Mesopotamia to Modern Times*, 88–107, (Princeton: Princeton University Press, 2010) 101.

[3] Timur Kuran, "The scale of entrepreneurship in Middle Eastern history: Inhibitive roles of Islamic institutions." In David S. Landes, Joel Mokyr, & William J. Baumol, eds., *The Invention of Enterprise: Entrepreneurship from Ancient Mesopotamia to Modern Times*, 62–87, (Princeton: Princeton University Press, 2010).

what we think the definition of commercial is, it may only be relevant to our particular social group in this particular time period.

Although defining the word "commercial" has long been recognized as being a hard thing to do, the real trick is to come up with a definition that transcends different social groups and times.

Cognitive Constructs

Next, any discussion about the definition of the word "commercial" can be problematic, so before defining the word, it is beneficial to define how we define the word. As is the case of historians' use of the word "civilization," there is the implication of a bifurcation: some societal groups were characterized as civilized, and by doing that, there was an implication that other groups were not civilized. Similarly, by calling some activities commercial, there is an implication that some activities are not commercial, and the impact of this delineation can be significant or not. In any case, these are all cognitive or intellectual constructs, meaning they are not an intrinsic property of the group or activity under investigation: they are properties we invent to describe them. So, for the word civilization, historians abandoned using the word as an absolute label, and adopted an approach that is similar to that used by the medical community when diagnosing an illness. In the historical context, social groupings possess different characteristics of civilizations to some degree. A societal group can possess some level of these characteristics, and each characteristic is like a dial that can be turned to some value from zero to one hundred percent. The overall characteristic of civilization is ambiguous and vague, primarily because each dimension is a non-linear combination of multiple sub-factors, and they all have non-linear co-dependencies, as in any complicated system of systems. The ultimate conclusion of this discussion about civilization, as applied to the concept of commercial, is that space activities are neither commercial nor non-commercial, but they are all commercial to some degree, given they possess some level of the many defining characteristics.

Attempted Definitions

So, what are those characteristics? This is where we need to start defining the word itself, and to do that, we'll look at how this was attempted in three different professional arenas. First, the legal profession has grappled

with the question of how to define the word commercial for a long time. Despite attempts starting in the 1970s, multiple courts have not been able to define what constitutes "commercial speech." The two primarily reasons for needing a definition of the word was, first, to determine when the immunity afforded to foreign states could be withheld in cases when they engaged in commercial activity on U.S. soil and second, to identify the boundaries of First Amendment protections.[4] Efforts by the courts to define discrete boundaries around commercial speech have been described as "fumbling." Eventually, there was a realization that the concept of "commercial" requires "a more nuanced approach based on smaller, discrete categories." This is consistent with the historical preference for a listing of characteristics rather than a single, discrete definition.

Second, many individuals in the space industry, including myself, have written papers attempting to list the characteristics that define the concept of "commercial."[5] The sources used to identify these characteristics

[4] A. L. McCarthy, "The Commercial Activity Exception—Justice Demands Congress Define a Line in the Shifting Sands of Sovereign Immunity," *Marquette Law Review*, 77(4):1994, 893–923 and N. Stern, "In Defense of the Imprecise Definition of Commercial Speech," *Maryland Law Review*, 58(1):1999, 55–149.

[5] See Greg Autry, "Exploring New Space: Governmental Roles in the Emergence of New Communities of High-Technology Organizations," (PhD Thesis), 2013, J. F. Bell, C. Nickerson, M. Lopez-Alegria, T.D. Jones, and W. J. Pomerantz, "Leveraging the Academic–Commercial Partnership for NewSpace," *New Space*, 2(3):2014, 131–138, L. Culver, L. Escudero, A. Grindle, M. Hamilton, and J. Sowell, "Policies, Incentives, and Growth in the Newspace Industry," Cambridge, MA: Massachusetts Institute of Technology, Working Paper, 2007, Ken J. Davidian, "Do "Commercial" Space Companies Exist?" *New Space*, 4(4):2016, 269–285, S. di Ciaccio, A. Cramarossa, and M. Fatica, (2018). "New Space: A Glance at Italy." *New Space*, 6(4), 254–261, Flytkjaer, R., Oswald, N., Sadlier, G., & Stanbrough, L, "NewSpace: Bringing the New Frontier Closer to Home," 2019, Frischauf, N., Horn, R., Kauerhoff, T., Wittig, M., Baumann, I., Pellander, E., & Koudelka, O. (2017). NewSpace: New Business Models at the Interface of Space and Digital Economy: Chances in an Interconnected World. New Space, 6(2), space.2017.0028, Lal, B., & Wei, R. (2019). What is commercial space? And why does it matter? *Proceedings of the 2019 IAF International Astronautical Congress*, N.P. Nagendra, "Traditional Space and New Space Industry in India." *Observer Research Foundation*, 2017, Nagendra, N. P., & Segert, T. (2017). Challenges for NewSpace Commercial Earth Observation Small Satellites. New Space, 5(4), 238–243, Onuki, M. (2012). "Space Entrepreneurship Challenges to Create Commercial Space Projects in Japan Engineering and Ideas to Open New Space Markets." *Proceedings of the 2012 IAF International Astronautical Congress*, D. Paikowsky, "What Is New Space? The Changing Ecosystem of Global Space Activity," *New Space*, 5(2):2017, 84–88, W. Peeters, "Toward a Definition of New Space?: The Entrepreneurial Perspective." *New Space*, 6(3):2018, 187–190, S. Schmidt, "The Hybrid NewSpace Approach," *New Space*, 2(4):2014, 178–183, and *Review*, 58(1):2014, 55–149, M. N. Sweeting, "Modern Small Satellites—Changing the Economics of Space," *Proceedings of the IEEE*, 106(3):2018, 343–361.

include governmental documents, policies, reports, and sometimes, the author's personal observations and experiences. The list of characteristics includes a broad and untamed collection of concepts and phrases. Many of these concepts are consistent with the 2010 U.S. National Space Policy:

> *The term 'commercial,' for the purposes of this policy, refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers.*[6]

An interesting assertion of this definition is that an activity can be considered commercial even if the only customer is the government, as long as the potential for a nongovernmental customer exists. This portion of the definition seems rather forgiving, especially if there's no clear way to determine how real the existence is of a potential non-government customer.

Our last example of attempts to define the word commercial is in the field of management. Some management scholars identified "commercial" activities as "characterized by the private appropriation of the surplus and private investment decisions" (Mizruchi, 1992).[7] "Private investment decisions" implies the existence of a capitalist system, and this leads us down an entirely different rabbit hole. Like "civilization" and "commercial," "capitalism" is a cognitive construct, and similarly cannot be defined in a bifurcated fashion. Economic systems are neither capitalist nor non-capitalist. Economic systems possess a degree of capitalism, determined by the specific number of capitalistic characteristics that exist. I'm not sure the two terms are perfectly synonymous, but it seems that commercialism and capitalism are linked in some way, based on the characteristic of

[6] Executive Office of the President, National Space Policy of the United States of America, 2010. https://history.nasa.gov/national_space_policy_6-28-10.pdf, accessed December 10, 2023.

[7] M.S. Mizruchi, *The Structure of Corporate Political Action: Interfirm Relations and Their Consequences*, (Cambridge: Harvard University Press, 1992).

private ownership of capital. Unfortunately, we don't have time to talk about this topic today, but I'd be happy to engage in this discussion at a later time.

Levels of Analysis

Up to this point I have examined attempts to define the word "commercial" from different perspectives in the past, and now it is time to introduce my recent thoughts on the topic. I tend to think about commercial space activities at the level of markets. Levels of analysis are ways that management scientists think about different social structures within organizations, at the intra-organizational levels, at the organizational level, and at inter-organizational levels, including multiple organizations, and sometimes called market levels. Each level is part of a nested and embedded hierarchy. The lowest market level is made up of many similar firms grouped into what might be called an industry segment. An example of an industry segment could be firms producing liquid rocket engines. Multiple industry segments are nested together within a level called an industry. Continuing our example, the liquid rocket engine and solid rocket motor industry segments are combined into the propulsion industry. Finally, multiple industries are nested together within the level called a field, a market, or an ecosystem. It is at these three market levels, industry segments, industries, and fields, that I work to define the word commercial.

Organizational Change Motors

One way organization theory frames the discussion of innovation is a set of models describing how organizations change. Organizational change at market levels of analysis, after all, is a major part of the innovation process that characterizes new, emerging, and evolving markets. Organization theory identifies four ideal organizational change "motors" describing how innovation is induced. These motors are categorized in a two-by-two matrix, based on different units of analysis, referring to one organization or multiple organizations, and modes of change, whether the motor follows a prescribed series of steps, or the change is externally constructed or

directed. The four organizational change models are teleology, life cycle, dialectic, and evolution.[8]

Two of these models, life cycle and dialectic, do not describe the past or present state of space activities very well. The life cycle model of organizational change is characteristic of highly regulated environments or standardized and controlled markets, where organizations proceed through well-defined stages in a prescribed sequence. Developing and bringing a new pharmaceutical or medical device to market is an example of life cycle organizational change because drug companies follow specific steps to gain technical, regulatory, and market approvals of a new drug. The dialectic model of organizational change is a process mechanism between two organizations, deliberately constructing a novel result, a synthesis, from an established, "status quo" organization, representing the thesis, and a conflicting or confronting organization, representing the antithesis. The resulting organization is not one or the other of the two original organizations, but something new and different. Neither of these two models, life cycle or dialectic, describe commercial space activities very well.

The third model of organizational change, the teleologic model, describes a process of deliberate and purposeful innovation as directed or constructed by a single entity, such as a central committee or agency. Organizational members in the teleologic model do not set their own goals but follow directions from the single guiding authority, who decides between competing ideas. This model is a good fit for space activities during the space race era of the 1960s, and it is also applicable to many governmental space activities today. It is not, however, a good description for what we think of as commercial space activities.

The final model, the evolution motor of organizational change, involves multiple organizations following a prescribed set of forces: variation, selection, and retention. All three forces are always present, and the strength of any one force may be dominant over the other two at different times of industry emergence, and organizations progress through them in a serial fashion. For many reasons, I think this model best represents what we commonly call "commercial" markets. One reason is that a defining

[8] Marshall S. Poole, Andrew H. Van de Ven, Kevin Dooley, and Michael E. Holmes, *Organizational change and Innovation Processes: Theory and Methods for Research*. (Oxford: Oxford University Press, 2000).