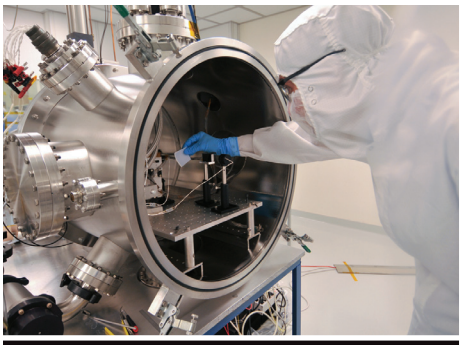
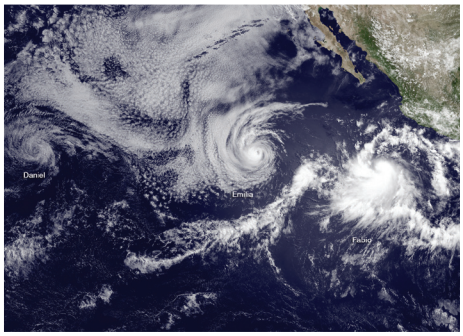
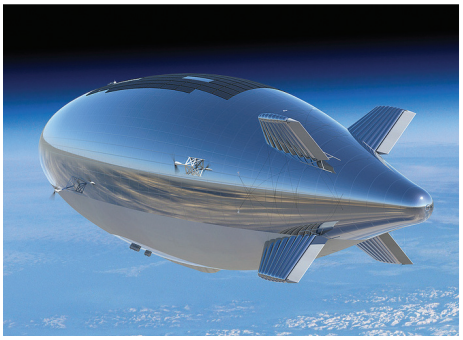


BROOKINGS

COLORADO





BROOKINGS ADVANCED INDUSTRIES PROJECT

LAUNCH!

TAKING COLORADO'S SPACE ECONOMY TO THE NEXT LEVEL

EXECUTIVE SUMMARY

STATE OF COLORADO

OFFICE OF THE GOVERNOR

136 State Capitol
Denver, Colorado 80203
Phone (303) 866-2471
Fax (303) 866-2003

John W. Hickenlooper
Governor

February 5, 2013

Greetings:

Colorado has long been a hub for innovation. Since our state's founding, entrepreneurs have employed Colorado's resources to access new markets and direct new technologies that have contributed greatly to our economic successes.

Today, this spirit maintains Colorado's reputation as a great place to work, live and play. With one of the most educated workforces in the country and an unparalleled quality of life that provides a great place to raise a family, there is no question why Colorado is an attractive place for companies to expand and relocate.

We are grateful that the Brookings Institution, supported by the Rockefeller Foundation, partnered with the Colorado Office of Economic Development and International Trade to craft a forward thinking business strategy to support the Aerospace Industry in Colorado. This report affords us the opportunity to capitalize on the strengths of Colorado's Aerospace sector and develop strategies to collaboratively address the challenges facing the industry.

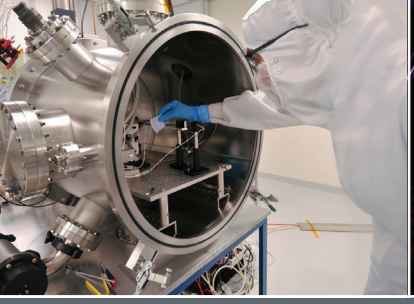
Building on the Colorado Blueprint, a bottom-up economic development strategy, this joint effort has created a platform for communicating directly with industry to develop a strategic plan that demonstrates how Colorado is positioned to confront the challenges we face as a state. The effort will also ensure that Colorado is at the forefront of cultivating a relentlessly pro-business environment in which advanced industries will thrive.

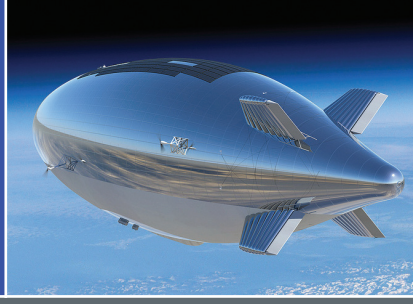
We are optimistic that Colorado, in close collaboration with our partners, can strengthen its competitive standing in the Aerospace Industry and utilize the momentum to build upon our continued efforts to support other important industry networks.

Together, we will make Colorado the best state in the nation for business, while maintaining the highest quality of life.

Sincerely,

John W. Hickenlooper
Governor



BROOKINGS


LAUNCH!

TAKING COLORADO'S SPACE ECONOMY TO THE NEXT LEVEL

EXECUTIVE SUMMARY

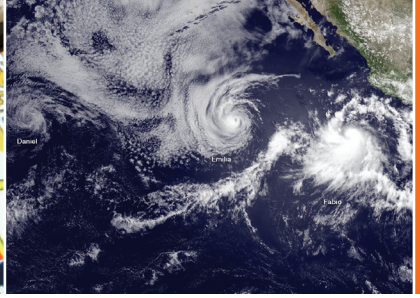
Anchored by critical military installations, glistening clean rooms, and iconic defense and aerospace contractors, the Colorado space industry has been a source of pride and prosperity for Colorado residents for decades.

Now, at a time of testing, interest is rising again.

With the Great Recession receding but disruptive change in the air, the state—like many others—has been moving to reassess its economic positioning and identify the most reliable sources of long-term growth and competitiveness.

Most notably, the administration of Gov. John Hickenlooper—alert to calls that the U.S. must reorient its drifting economy away from consumption activities and imports and more toward high-value innovation, production, and exports—has been carrying out a major economic planning initiative aimed at engaging the state's key industries and regions in a "bottom-up" effort to explore and seize on the best opportunities for economic expansion.

Through this Colorado Blueprint process, the state has come to focus—with support from the Brookings Institution Metropolitan Policy Program—on its extraordinary space / aerospace cluster, which it quickly recognized was a classic "advanced industry."



BROOKINGS
ADVANCED
INDUSTRIES
PROJECT

As defined by Brookings, advanced industries (AIs) like the space industry are the high-value engineering- and R&D-intensive industrial concerns that are the prime movers of regional and national prosperity in the U.S.

AIs matter because large and small companies in the sector—ranging from Lockheed Martin, Ball Aerospace, and DigitalGlobe in space to Ford, Nissan, Siemens, GE, Intel, and Medtronic in other industries—generate 10 percent of the nation's output, 46.5 percent of U.S. goods exports, and over 8 million skilled jobs. Likewise, AIs like aerospace and defense, advanced electronics, automotive design and assembly, semiconductors, and medical devices matter because they encompass a huge piece of the national R&D enterprise that has enabled a steady stream of life-transforming innovations ranging from air flight and GPS to LASIK, MRIs, and clean energy.

Yet like the Colorado space industry AIs are not inevitable. And so—at a moment of economic and policy uncertainty at the national level and disruptive change in the space industry—a confluence of state economic development interest and industry self-reflection has created a juncture of some urgency in Colorado.

Focused by change and the state Blueprint process, the state's space sector finds itself residing at a point of tremendous opportunity and peril as it considers how to navigate massive uncertainties and capture further advantage in the years ahead.

On the one hand, Colorado space activities and space technologies appear well positioned to enable and profit from major expansions of the nation's most critical military, civil, and commercial enterprises. Military actors in the state provide capabilities increasingly important to monitoring potential threats, managing forces, and carrying out combat operations while civil and commercial players remain deeply enmeshed in hot growth industries ranging from earth observation and weather forecasting to GIS and satellite communications.

On the other hand, though, the state's space cluster faces the next five years concerned about threats ranging from its continued dependence on increasingly uncertain government budgets to the rise of new competitors, new business models, and new questions about its competitive underpinnings.

In short, one of the nation's leading space states (and clusters)—aware of both its substantial strengths and disruptive change—is gearing up to defend and expand its long-term competitiveness.

Hence this report: Reflecting extensive consultation with space industry stakeholders convened by the Colorado Blueprint's Key Industry Networks Process and delivered as part of the Brookings Advanced Industries Series, **"Launch! Taking Colorado's Space Economy to the Next Level"** assesses the current competitive position of the Colorado space cluster and suggests private-sector and state government strategies for advancing it.

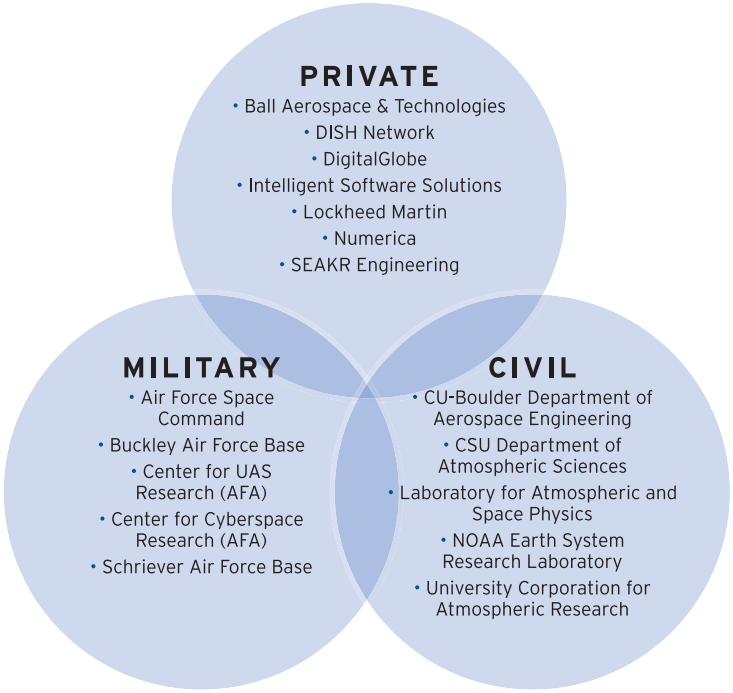
In that vein, the pages that follow advance three major findings about the Colorado space economy:

1. COLORADO POSSESSES ONE OF THE MOST DIVERSIFIED, MULTIDIMENSIONAL, AND HIGH-POTENTIAL SPACE ECONOMIES IN THE NATION

In this respect, a detailed, establishment-level analysis of the state's space cluster furnishes encouraging new intelligence about the cluster's depth, diversity, and growth dynamics. Specifically, the new analysis concludes that:

- **THE SPACE ECONOMY IS AN OUTSIZED DRIVER OF COLORADO'S ECONOMY.** According to the new analysis, space activities, applications, and services pervade the state's industry base—cutting across the public and private sectors and spilling over into telecoms, software, advanced materials, and more. In total, the Colorado space economy directly employs over 66,000 workers across the military, civil, and private domains. Furthermore, the cluster contributes inordinately to the state's overall economic enterprise. In this fashion, the value-added output generated by the private space economy's 2.6 percent of the workforce reached $8.7 billion in 2011, or 3.8 percent of Colorado's private-sector gross domestic product (GDP). All told, space firms generated around $16 billion in sales in 2011. Moreover, space economy firms and establishments have been steady contributors to job growth in the state. From 2008 to 2011, as the national economy fell into and began its climb out of recession, small space establishments added nearly 2,000 jobs and large establishments nearly 1,500 jobs, thereby helping mitigate the effects of the economic downturn on the Colorado economy. Nor are space jobs average jobs. Private sector space economy employees earned an average annual income of $92,500 in 2011, compared to the state private-sector average of just $49,000. Thanks to these high wages, the space economy paid 4.9 percent of all private wage earnings in the state despite employing just a little more than half that share of the private workforce

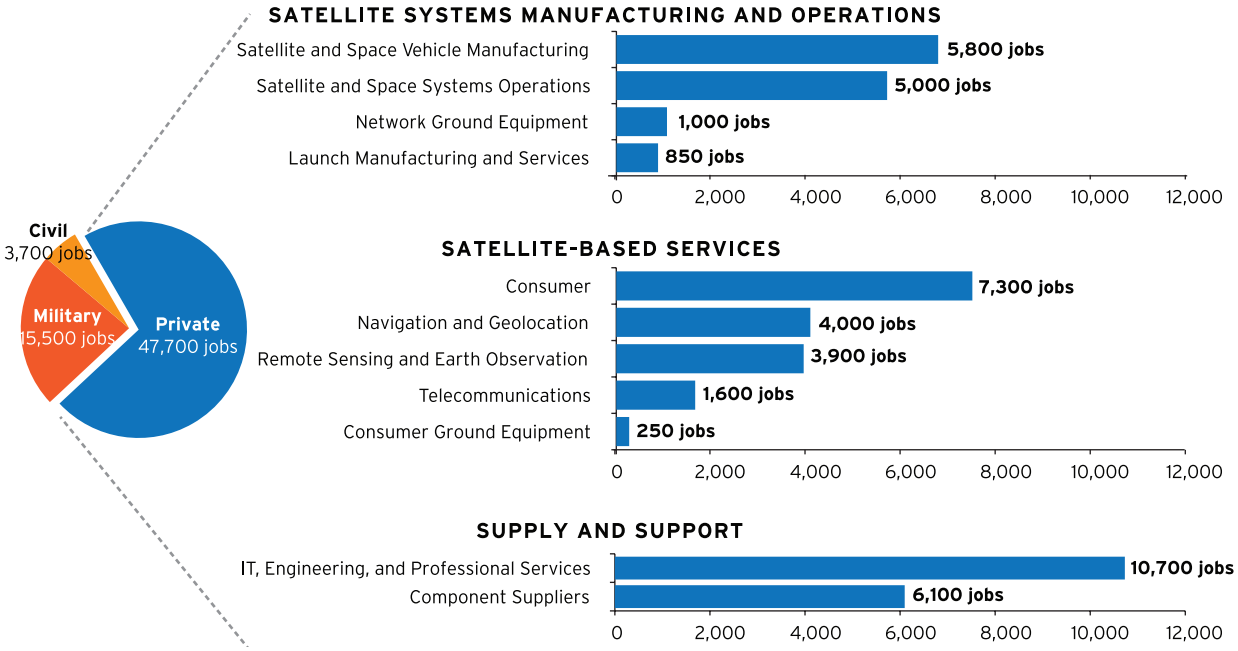
The Colorado space economy comprises three sectors



Source: Brookings analysis

- **COLORADO'S PRIVATE SPACE ECONOMY IS MULTIDIMENSIONAL AND POLYCENTRIC.** The sizable private-sector side of the state's space economy is relatively evenly distributed across three broad categories of space activity: space system manufacturing and operations; satellite-based services; and supply and support. As such, the private space enterprise in Colorado stretches across the full spectrum of space-related activities to comprise a cluster that is diverse, multi-centered, and technology-intensive. The three large categories of activity can be further divided into 11 narrower segments. The traditional core of the industry—*space systems manufacturing and operations*—is the smallest of the three categories, accounting for just under 30 percent of the state's space economy jobs (13,900 in 2011) but a disproportionate share of revenues. This category includes satellite and space systems operations and satellite and space vehicle manufacturing as well as launch manufacturing and services and network ground equipment—and it has been relatively slow growing. Much faster growing has been the *satellite-based services* category which encompasses those segments that use satellites to deliver a service back on earth. This set of industries has been growing by nearly 8 percent a year and now employs 17,000 Coloradans or 35.7 percent of the state's private space economy jobs. Satellite-based services is now the largest category of space economy activity in Colorado in terms of both jobs and revenues. Ranging from consumer services to navigation and geolocation, remote sensing and earth observation to telecommunications, these industry segments generate $6.3 billion in annual revenue—a disproportionate 37.8 percent of the revenue produced by the space economy as a whole. Finally, over one-third of space economy jobs—35.3 percent, or 16,825 positions—fall into the *supply and support* category, which supplies and supports the space manufacturing and services complex with myriad products and services. This category, which encompasses both components and IT, engineering, and professional services, punches slightly below its weight in terms of revenue and output, generating just of 30 percent of net sales and GDP.
In sum, Colorado's space economy consists of a wide and deep assemblage of activities united by a common platform: space-based technology. Taken together, these activities generate exceptionally well-paying jobs and significant sales and growth all unified by increasingly high-tech platforms and content

Within the private sector, the number of space economy jobs varies by category and segment



- **COLORADO'S SPACE ECONOMY IS INCREASINGLY SERVICES-ORIENTED.** The new analysis further reveals that the space enterprise in Colorado is changing. Specifically, the space economy—notwithstanding the size and importance of its manufacturing and operations sector—is increasingly services-oriented as that is where the growth is. This is on balance good news for the Colorado space economy as a whole as these dynamic, often commercial, industry areas play to some of the state cluster's strengths. What is more, demand for services such as direct-to-home satellite television, satellite telecommunications, and satellite-based precision-navigation-timing capabilities helps drive the upstream space systems manufacturing complex. The state now specializes in both activities. Nor is the trend towards services restricted to end-user markets for space-derived capabilities. At the other end of the value chain, IT and engineering services represent an increasingly significant input into the ever-more complex technology systems that enable the space economy in the first place. This strength in advanced services also bolsters manufacturing, which still represents a critical element of the state's space economy. In this respect, the co-location of advanced manufacturing and services constitutes a competitive advantage of increasing importance and positions Colorado for continued growth and innovation in both areas

- **COLORADO'S SPACE ECONOMY SPANS FOUR METRO AREAS AND AT LEAST EIGHT RURAL COUNTIES BUT IS HEAVILY CLUSTERED ALONG THE FRONT RANGE.** Finally, the establishment level analysis concludes that fully 99 percent of jobs in Colorado's private space economy are concentrated in the four metropolitan areas along the Front Range, the megapolitan area that stretches from Fort Collins in the north to Colorado Springs in the south. The remaining space economy jobs are spread across three smaller metropolitan areas—Pueblo, Durango, and Grand Junction—in addition to at least seven further rural counties. In this sense, the Colorado space industry represents a classic innovation and industry cluster, highly concentrated in a single region. Even still, important geographic distinctions emerge at the sub-regional and segment level. Boulder specializes in civilian-oriented space activity with an emphasis on high-value science and engineering, Colorado Springs specializes in military-oriented space activity, and Denver boasts the most diversified segment portfolio in the state and dominates in the satellite-based services category.

The sum-total of these findings: Colorado has amassed a formidable, layered, and diverse space economy that contributes heavily to the state's economic well-being. To be sure, future growth will likely occur outside of the industry's traditional core, representing an important shift from years past. But fortunately, promising growth opportunities exist in a wide variety of industry segments already clustered up and down the Front Range.

2. HOWEVER, WHILE SIGNIFICANT OPPORTUNITIES ARE EMERGING, A SET OF DISRUPTIVE FORCES AT WORK IN THE GLOBAL SPACE MARKET HAVE EXPOSED A NUMBER OF COMPETITIVE CHALLENGES FOR THE COLORADO INDUSTRY

To be sure, numerous trends point to continued growth in Colorado's space economy—especially in promising "adjacent" markets that hold out compelling commercial opportunities. Some in the venture capital community, for example, speak of a coming "Netscape moment" for the industry when major capital market investments set off a wave of fundings of so-called "new space" startups. Likewise, while projections indicate modest top-line global growth for private-sector space revenues, they suggest the cybersecurity / intelligence and unmanned aerial vehicle (UAV) markets will double in next five and 10 years respectively. In short, the global space economy presents a sizable, growing, and attractive opportunity for Colorado. And yet, fundamental changes in the space marketplace are challenging participants to innovate by developing new technologies and business models. At least three mega-trends are redefining the very nature of competition in the U.S. space sector:

- **THE CUSTOMER BASE IS CHANGING.** To begin with, global demand is shifting away from its historic, relatively simple, concentration in space infrastructure for a few governments (particularly America's). Federal government spending is flatlining, on the one hand, while growing international demand is difficult to access—and contested. More fundamentally, the space industry has shifted from one dominated by the manufacture and build-out of space infrastructure (satellites, launch systems, and ground-based control systems) to one driven primarily by the provision of space-based services—including communications such as fixed and mobile satellite services and entertainment such as direct-to-home television and satellite radio. Service-provision often to commercial customers is the new reality

- **CUSTOMERS ARE DRIVING A NEW INDUSTRY EMPHASIS ON VALUE, SERVICE, AND CAPABILITY.** At the same time, changes in the customer base are requiring space actors to change how they operate to improve their responsiveness. Changing government preferences and the growth of commercial space-based services markets are amplifying the need for the adoption of more commercial business models—i.e., fixed-price, product-based, and customer-focused approaches. These dynamics are forcing both business and technological change in the industry. Companies deeply rooted in big-government or military-oriented cultures are being forced to become more entrepreneurial and collaborative. And meanwhile firms must seek out new sources of research and development (R&D) to develop and commercialize new technologies, which in turn will require new financing mechanisms to fund the critical space economy innovation process

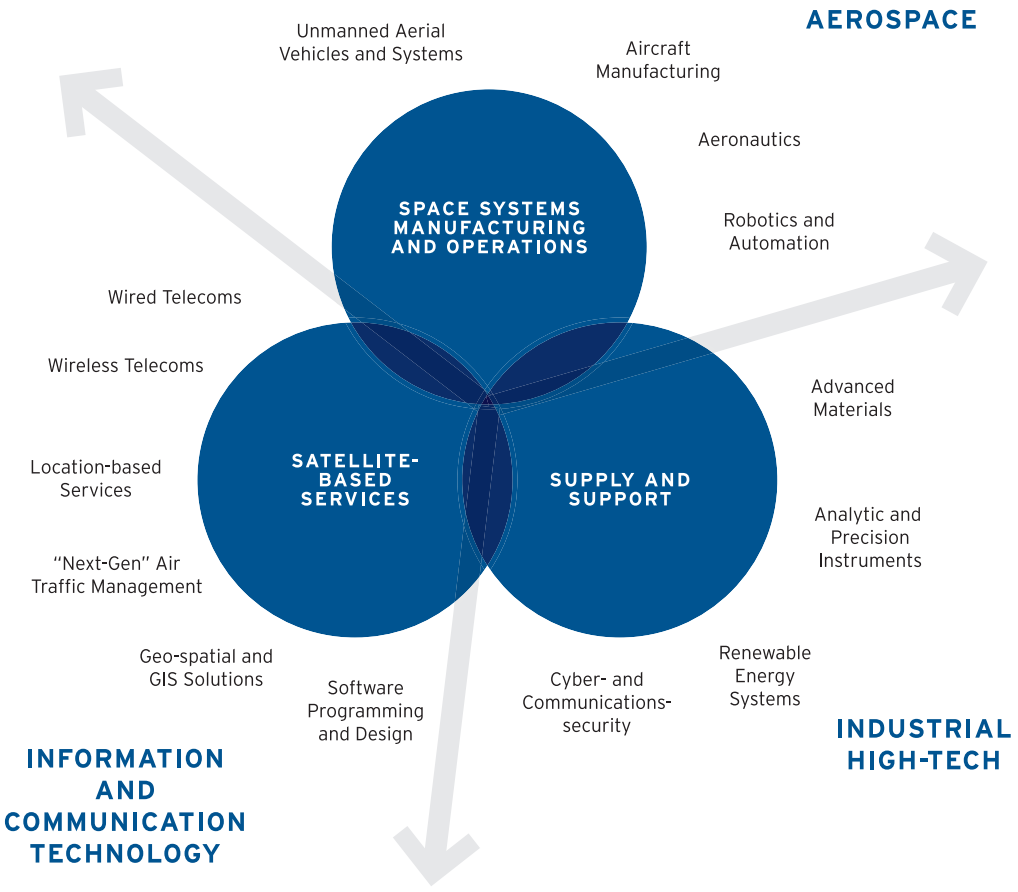
- **THE INDUSTRY'S COMPETITIVE UNDERPINNINGS ARE UNDER STRESS.** Finally, a looming skills gap due to an aging workforce and a growing imperative to innovate are challenging the very origins of the space industry's competitive standing. On the skills front, a potential wave of retirements in the next five years will severely test the ability of the space industry to maintain a high-quality technical workforce. As to technological advancement, the imperative to maintain competitiveness in a world with more players, shorter product lifecycles, and more complex products is ratcheting up the need to strengthen the space economy innovation system and the collaborations that make it work best. Along these lines, space companies are increasingly finding that they need to reshape themselves to maintain world-class technical staffs and innovate at the needed rates

In light of these trends, a systematic SWOT (strengths, weaknesses, opportunities, and threats) assessment reveals that Colorado's space economy approaches the future with tremendous assets but also a number of vulnerabilities. In terms of its assets, Colorado seems well situated to flourish. A strong entrepreneurial bent, low to moderate costs of doing business, a strong innovation system, and a large base of skilled STEM talent provide the prerequisites for success. Yet the state's strengths go far beyond business basics to encompass more specialized sector-specific attributes. An enviable complex of military and civil institutions anchors the cluster. A dense assemblage of organizations and networks such as the Colorado Space Coalition (CSC), the Space Foundation, eSpace: The Center for Space Entrepreneurship, and the Space Business Roundtable provide intellectual infrastructure for a well-organized, geographically concentrated space ecosystem. And of course, the state enjoys a strong position in government space, secured in large part by its proven ability to win federal contracts.

At the same time, ongoing trends expose a number of deficiencies that could imperil the ability of the Colorado space economy to maintain its momentum. In this respect, at least six challenges raise questions about the near- to medium-term competitive position of this "crown jewel" industry:

- **A HEAVY DEPENDENCE ON GOVERNMENT SPACE MAKES THE COLORADO SPACE ECONOMY VULNERABLE TO FEDERAL FUNDING PULLBACKS.** Ironically, what makes the state strong also makes it vulnerable. The predominance of military and intelligence activities in the space sector and the state's heavy reliance on federal government contracting make the state susceptible to federal budget drawdowns and fiscal uncertainties

The future shape of Colorado's space economy will be defined by both familiar segments and new opportunities in emerging and adjacent ones



Source: Brookings analysis in consultation with McKinsey & Co.

- **THE STATE HAS YET TO GAIN A SIGNIFICANT TOEHOLD IN NEW SPACE, ADJACENT, AND GLOBAL MARKETS.** Although Colorado firms badly need to pivot into emerging new markets that are less dependent on federal support, the state space industry has not moved aggressively in this direction as yet and actually lags on some indices of competitiveness when compared to its peer states

- **THE STATE'S INNOVATION SYSTEM IS STRUGGLING WITH THE CHALLENGES INHERENT IN TECHNOLOGY TRANSFER AND COMMERCIALIZATION WITHIN THE AEROSPACE AND SPACE SECTORS.** Very little matters for the future competitiveness of the Colorado space economy as much as the efficiency and speed of the state's innovation ecosystem, which will increasingly depend on effective collaboration, especially between the state's universities and industry. And yet here, too, shortcomings in the state's space-related innovation activities—particularly with regard to university-industry collaboration and technology transfer—raise questions about Colorado's ability to achieve and defend global leadership in this industry

- **INSUFFICIENT ACCESS TO RISK CAPITAL STYMIES STARTUPS.** Innovation and commercialization in the space economy also require adequate flows of patient, risk-tolerant capital. And yet, investment capital has remained scarce in the aerospace and space sector. With venture capital (VC) funding in the state heavily skewed toward the energy, software, IT services, and biotech sectors, Colorado's space economy entrepreneurs find themselves at a disadvantage when compared to competitors in other states. Furthermore, because VC funds typically prefer to invest in local companies, fewer Colorado-based VC funds effectively translates into less VC for Colorado startups

- **AN AGING SCIENCE AND ENGINEERING WORKFORCE AND OTHER WORKFORCE-RELATED CHALLENGES COULD ADVERSELY IMPACT THE INDUSTRY'S FUTURE GROWTH.** The national STEM workforce challenge appears especially acute for Colorado. In this regard, three workforce-related challenges must be addressed in order to ensure the future growth of Colorado's space sector: an aging science and engineering workforce; a looming shortage of STEM graduates in the next five to 10 years paired with increasing demand for skilled workers; and very low state spending for higher education as a proportion of GDP

- **SUBOPTIMAL CLUSTER DYNAMICS—ESPECIALLY THOSE INVOLVING COLLABORATION—MAY BE HINDERING GROWTH.** With collaboration increasingly central to the innovation and growth process, the state's complicated cluster dynamics may not be functioning at optimal levels. Qualitative analysis suggests that a number of institutional, geographical, sectoral, and cultural challenges may well be depressing the collaborative vibrancy of the state's extraordinary assemblage of space actors

3. GIVEN THESE CHALLENGES AS WELL AS ITS MANY STRENGTHS, COLORADO SHOULD COMMIT ITSELF TO PREEMINENCE IN SPACE THROUGH A COLLABORATIVE PARTNERSHIP OF INDUSTRY AND GOVERNMENT ALONG SIX DIMENSIONS

In this respect, Colorado's strong overall competitive standing amid disruptive megatrends licenses an ambitious vision of the state's future in the space economy. Colorado's goal over the next five to 10 years should therefore be simple and bold: **"Colorado becomes the center of innovation for the global space economy."** As to how to get there, Colorado's industry leaders and government should embrace a new, more aggressive, creative, and collaborative mindset focused on addressing specific cluster deficiencies in the light of global dynamics by creating a supportive environment in which competitive and innovative space firms can flourish. Implied by the six major challenges the state faces, six strategies for advancing the Colorado space economy suggest themselves:

- **CONSOLIDATE AND MAXIMIZE THE STATE'S POSITION IN THE SPACE ECONOMY EVEN AS GOVERNMENT SPACE CONTRACTS.** As federal funding declines, big projects are dwindling, government customers are moving toward lower-priced solutions, and commercial contracting methods are on the rise. Colorado and its space firms will need at once to "defend the base" of its present civilian and military activity even as they adapt to the changing landscape of government space

- **SEIZE COMMERCIAL OPPORTUNITIES IN EMERGING NEW SPACE, ADJACENT, AND GLOBAL MARKETS.** With growth prospects modest in conventional government space, a strong and strategic pivot to embrace emerging opportunities in new commercial, adjacent, and global markets is the most important thing that Colorado and its space firms can do to assure continued preeminence in the future space economy. Pivoting in this way will require all parties to master new technologies and new ways of doing business

- **COMMIT TO INNOVATION AND OWNING THE NEXT GREAT SPACE TECHNOLOGIES.** Amid disruptive change Colorado's space competitiveness will hinge on how well its innovation ecosystem functions. The state should put a new emphasis on R&D; collaboration among companies and between industry and research institutions; and the commercialization of innovation. Innovation is not everything, but it is almost everything

- **IMPROVE THE AVAILABILITY OF RISK CAPITAL.** Colorado companies—working with the state—will need to adopt more of an investment mindset and seek out and experiment with broader sources of finance to scale up their products

- **BOLSTER THE WORKFORCE PIPELINE TO SECURE COLORADO'S HUMAN CAPITAL ADVANTAGE.** A long-term commitment to and strategy for developing, attracting, and retaining a skilled, flexible, and technically competent workforce will be critical in the coming half-decade

- **INTENSIFY CLUSTER DYNAMICS.** A strong cluster-based development strategy that emphasizes breaking down silos and increasing collaboration among the state's myriad industry stakeholders and cluster organizations will help to diversify and increase the competitiveness of Colorado's space economy. In this respect, the centrality of collaboration to innovation makes it imperative to foster the collaborative exchanges of the state's rich cluster

* * *

In terms of moving forward, both industry and government should organize an array of actions along the lines of these six strategies. In this vein, this report recommends the following division of labor among industry and government actors to take the Colorado space economy to the next level:

- **THE PRIVATE SECTOR MUST LEAD THE WAY IN MAKING COLORADO THE UNDISPUTED CENTER OF INNOVATION FOR THE GLOBAL SPACE ECONOMY.** In this respect, though military and civil sector organizations will continue to anchor the state's space cluster, the private sector alone possesses both the self-interest and ability to grow its share of current markets and pursue new growth opportunities. To that end, Colorado space firms should embrace the six growth strategy themes to simultaneously improve their individual performance and advance the collaborative power of the cluster.

  To consolidate and maximize their position in space, firms should (among other things): **Focus on affordability to secure competitive positions in core government markets,** which will increase an individual contractor's probability of winning and help ensure that programs remain fully funded. To achieve greater affordability, companies will need to drive a step change in efficiency and productivity and institutionalize a more commercial approach to business. In addition, firms should aggressively develop, seek out, or acquire distinctive capabilities

  To seize commercial opportunities in new markets, firms should: **Build on product and technology knowledge in R&D to develop new products or take products to new markets.** Likewise, companies can leverage existing customer relationships to expand their offerings or expand into new areas of the value chain

  To commit to innovation, firms should: **Increase internal R&D investment in next-generation technologies.** Companies should set a goal of "owning" the technologies that will enable the next generation of space-based systems and space-enabled services. In addition, industry should actively **support the development of a Colorado AI innovation hub**, which will strengthen the state's innovation ecosystem, foster collaboration, and help build the industrial commons that will nurture Colorado's advanced industries for its next growth period

  To improve the availability of risk capital larger, companies should: **Reinvigorate corporate venture capital** efforts, which will afford larger firms improved access to cutting-edge capabilities while also helping small companies break into established space markets. Such a way of identifying, scaling, and bringing to market innovative new products and capabilities will benefit both large and small companies in the state

  To bolster the workforce pipeline, all firms should: **Better model future skill requirements,** which will enhance both how industry attracts and retains new talent as well as how it develops its existing workforce. Sharpening the process

THE FEDERAL GOVERNMENT MUST DO ITS PART

The state of Colorado is rededicating itself to a collaborative partnership with industry and other governments to advance the state's extraordinary space cluster. So should the state's congressional delegation. Members should organize their work around the six strategy agendas this report has identified along the lines of the actions presented below:

- To consolidate and maximize Colorado's position in the space economy, the federal government must **circumvent sequestration** and provide a more predictable path to budgetary and programmatic stability in the near- and long-terms. The federal government should also **recommit itself to the nation's space program** and endow it with a clear vision and mission.

- To help Colorado's space economy seize commercial opportunities in new markets, the federal government should **implement export control reform** as quickly as possible and **set the regulatory parameters for integrating UAVs / UASs into national air space.**

- To commit to innovation, the federal government should **invest in R&D, make the research and experimentation tax credit permanent** and move to **create and scale up a national network of AI innovation hubs**, beginning with the proposed National Network for Manufacturing Innovation.

- To improve access to capital, the federal government should **maintain its commitment to the SBIR / STTR grant program** and consider tax incentives for startup operating capital.

- To bolster the workforce pipeline, the federal government should **create and fund portable manufacturing skills certifications, reinvigorate the workforce development system** with a "Race to the Shop" competition, and reform the immigration system for growth.

- Finally, to intensify cluster dynamics, the federal government should **support and expand existing cluster grant programs** and, in addition, **seek ways to boost federal laboratories' involvement in economic development.**

by which firms and industry identify and fill critical skills gaps will be essential. **In addition, stronger partnerships with educational and training institutions** will help ensure that workers are well prepared for current and projected job opportunities

To intensify cluster dynamics, the private sector should: **Encourage and engage with state efforts to improve how the space cluster functions.** Advocacy for and active engagement with a new state space cluster champion, support for state-led marketing initiatives, and contributions to the state's industry mapping efforts will help improve coordination and collaboration within the state's space cluster

- **MEANWHILE, THE PUBLIC SECTOR MUST CREATE A SUPPORTIVE ENVIRONMENT IN WHICH COMPETITIVE AND INNOVATIVE SPACE FIRMS CAN FLOURISH.** For its part, the state—in collaboration with industry and in close partnership with Colorado's congressional delegation—should work in focused, strategic ways to ameliorate the sorts of governance, institutional, and market challenges this report has identified. In this respect, the state should lead on a number of fronts while at the same time maintaining a supportive and collaborative stance in dealings with industry, the delegation, and the state's critical cluster organizations.

To consolidate and maximize the state's position, the governor should: **Take the lead in convening both Colorado's congressional delegation and other aerospace states** so that together they can defend and advocate for growth in the space economy. The state government should also **brand and relentlessly market Colorado's space economy** in order to raise awareness of the many space-economy strengths that Colorado offers. **A dedicated "sector champion"** can further these marking efforts while at the same time spearheading space cluster development and ensuring regular dialogue with stakeholders

To seize commercial opportunities in new markets, the state should: **Position the state to lead on next-generation system platforms** such as UAV/UASs. In addition, **establishing a governor's prize for new space business plans** would direct attention toward new commercial opportunities, build buzz, and open the door to follow-on investment, and encourage further innovation

To commit to innovation, state government should: **Create a targeted matching grants program** similar to the Bioscience Discovery Evaluation Grant Program that would help researchers and companies bridge the AI technology development gap more efficiently and effectively. The state should also **establish a statewide AI innovation hub**, which would further bolster Colorado's innovation capacity by taking on the cross-cutting technology challenges that are most critical to the state's advanced industries. **A state-run innovation vouchers program** for smaller firms seeking innovation expertise would encourage industry-university collaboration on pressing concerns, and **a SWAT team of innovation "site miners"** would expedite technology transfer by helping participating universities actively seek out commercial opportunities

To improve the availability of risk capital, the state should: **Establish an annual space economy investor's conference** at which top-quality opportunities could be presented, deals discussed, and networking accelerated. In addition, **matching grants to SBIR/STTR award recipients and a Phase 0 Fund for prospective SBIR/STTR applicants** would help maximize Colorado firms' access to federal resources. Meanwhile, as the state takes steps to **improve its existing state-run venture capital fund**, it should also consider working to **create university-based venture capital funds**, which would greatly expand the availability of risk capital

To bolster the workforce pipeline, state government should: **Create a dedicated STEM education initiative or entity** in order to ensure that the many great STEM education resources and programs already in place become more than the sum of their parts. **An "Intern in Colorado" initiative**, meanwhile, would better connect students to various AI internship opportunities across the state. And a push to **create industry skills panels** (including in aerospace) would foster a robust workforce and economic development ecosystem by bringing together representatives from the private sector, labor, and the state's educational and training system to devise solutions to common workforce and skills challenges in the space industry and elsewhere

To intensify cluster dynamics, it should: **Leverage existing cluster partnerships** to increase the levels of collaboration, inclusivity, and exchange within the cluster. **A state-run competitive grant program** would reinforce such efforts by building the networking capacity of the state's cluster organizations. And **a collaborative R&D tax credit** would reward collaboration between industry and academia

* * *

In the end, the aspirations and actions for industry development urged here are bold—but only as bold as is required given the potential for decline posed by the disruptive forces at work. In that sense, the potential for success seems high—and the opportunity for gains large—should industry and government together focus together now: and execute. ■

INDUSTRY AGENDA

$** = Little to no cost | **$$** = Low cost | **$$$** = Moderate cost | **$$$$ = High cost

Consolidate and maximize the state's position in the space economy even as U.S. government space contracts

Focus on affordability to secure competitive positions in core government markets	**$-$$$**

Seize commercial opportunities in emerging new space, adjacent, and global markets

Build on product and technology knowledge in R&D to develop new products or take products to new markets	**$$-$$$**
Leverage existing customer relationships and familiarity with customers' requirements to expand offerings	**$**

Commit to innovation and owning the next great space technologies

Increase internal R&D investment in next generation technologies	**$$$$**
Actively support and help shape the state's efforts to establish a statewide advanced industries innovation hub	**$$-$$$**

Facilitate the availability of risk capital for small and medium-sized entrepreneurial firms

Reinvigorate corporate venture capital	**$$$$**

Bolster the workforce pipeline to secure Colorado's human capital advantage

Model future skill requirements	**$**
Develop a greater number of leaders conversant in commercial and international markets	**$**
Develop stronger partnerships with educational and training institutions	**$-$$**

Intensify cluster dynamics

Advocate for and actively engage with a new state space cluster champion	**$**
Support state-led marketing and industry mapping efforts	**$$**
Foster more effective collaboration	**$**

STATE AGENDA

$** = Little to no cost | **$$** = Low cost | **$$$** = Moderate cost | **$$$$ = High cost

Consolidate and maximize the state's position in the space economy even as U.S. government space contracts

Produce and annually or biannually update a sophisticated strategy for bolstering Colorado's space economy preeminence	**$**
Lead in convening Colorado's congressional delegation to defend and advocate for the expansion of the state's space economy	**$**
Lead in convening the leading aerospace states	**$**
Brand Colorado's unique space economy and market it relentlessly	**$$**
Name a dedicated "sector champion" to spearhead cluster development	**$$**
Ensure that Colorado remains a business and military friendly state by engaging in regular dialogue with stakeholders	**$**

Seize commercial opportunities in emerging new space, adjacent, and global markets

Survey the competitive landscape in additional detail	**$**
Promote the new opportunities and celebrate the companies seizing them	**$**
Position the state for leadership in next-generation aerospace / space platforms	**$$-$$$**
Offer modest "deal closers" or small relocation incentives for innovative small firms	**$$$**
Launch a governor's prize for new space business plans	**$-$$$**
Facilitate the convening of technology "boot camps" around opportunities for innovation	**$**
Spearhead a space and new space trade mission	**$$**
Solicit foreign direct investment	**$**

Commit to innovation and owning the next great space technologies

Create a program that bridges the advanced industries technology development gap	**$$$$**
Establish a statewide advanced industries innovation hub	**$$$$**
Bolster the Colorado Higher Education Competitive Research Authority	**$$$**
Create an innovation vouchers program	**$$$**
Launch a matching grants program for collaborative R&D projects	**$$$**
Appoint a SWAT team of innovation "site miners"	**$$**
Develop more industry-friendly university-to-business technology licensing agreements	**$**

Improve the availability of risk capital

Establish an annual space economy investor's conference	**$**
Provide matching grants to SBIR / STTR award recipients	**$$-$$$**
Create a "Phase 0" Fund	**$$**
Improve the existing state-run venture capital fund	**$**
Create university-based venture capital funds	**$$$$**
Create an advanced industries fund of funds	**$$$$**

Bolster the workforce pipeline to secure Colorado's human capital advantage

Create a dedicated statewide STEM education entity or initiative	**$-$$**
Create a set of focused high school advanced industries career academies	**$$-$$$$**
Expand and strengthen advanced industries apprenticeship opportunities	**$$**
Provide far more opportunities for work-based learning including cooperative education	**$**
Launch an "Intern in Colorado" initiative	**$$**
Launch an advanced industries fellows program	**$$**
Create industry skills panels	**$**

Intensify cluster dynamics

Leverage existing cluster partnerships	**$**
Build the capacity of the state's cluster organizations through a competitive grant program	**$-$$$**
Launch a multi-sectoral, multidisciplinary road-mapping and collaboration forum	**$-$$**
Create a collaborative R&D tax credit	**$$$**
Prioritize or provide incentives for multi-actor applications to state funding programs	**$**
Sponsor or provide matching grants for an "entrepreneurial leave" program	**$$-$$$**

FEDERAL AGENDA

$ = Little to no cost	**$$** = Low cost	**$$$** = Moderate cost	**$$$$** = High cost

Consolidate and maximize the state's position in the space economy even as U.S. government space contracts

Circumvent sequestration	**$**
Maintain commitment to the nation's civil space program	**$-$$**
Support the National Space Policy's priorities	**$$**
Move to reduce recent uncertainty in budgeting and programming	**$**

Seize commercial opportunities in emerging new space, adjacent, and global markets

Implement export control reform	**$**
Accelerate spectrum sharing initiatives	**$-$$**
Accelerate the integration of UAV / UASs into national air space	**$-$$**
Assure and expand commercial access to space	**$-$$$**
Embrace the spirit of frugal innovation throughout the procurement process	**$**
Pursue multilateral trade agreements	**$**

Commit to innovation and owning the next great space technologies

Boost investment in advanced R&D	**$$$$**
Move to create and scale up a national network of advanced industries innovation hubs	**$$$$**
Expand and make permanent the research and experimentation tax credit	**$$$**
Institute a collaborative R&D tax credit	**$$$**
Scale up mission-oriented, outside-the-box innovation initiatives	**$$-$$$$**
Expand the focus of the nation's research enterprise	**$**

Improve the availability of risk capital

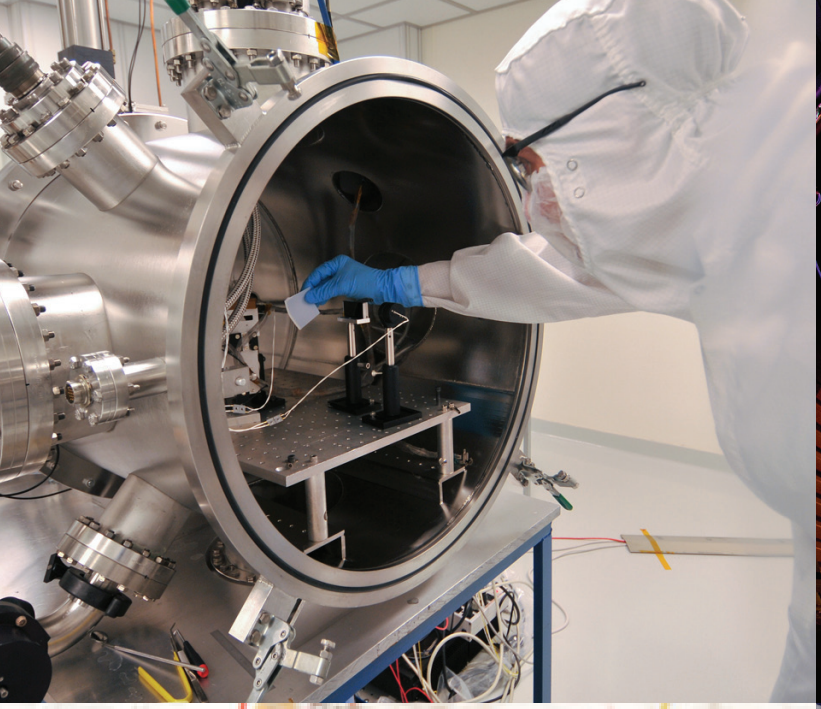
Support continued or expanded funding of SBIR and STTR programs	**$-$$$**
Leverage the Export-Import Bank of the United States	**$**
Create tax incentives for startup operating capital	**$$$**

Bolster the workforce pipeline to secure Colorado's human capital advantage

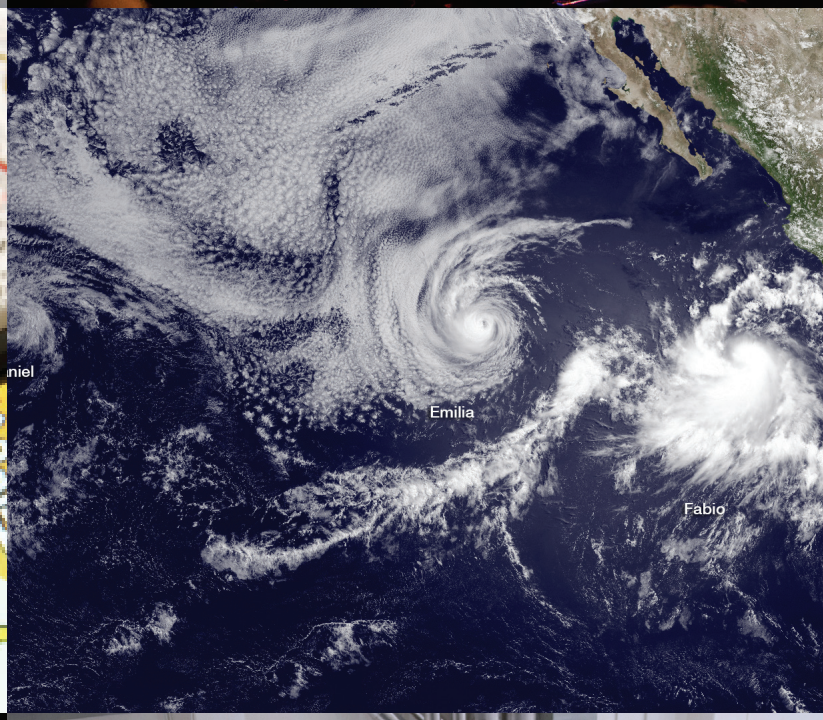
Create and fund a nationwide manufacturing skills standards initiative	**$$**
Promote the creation of STEM-focused elementary, middle, and high schools	**$$$**
Create a "Race to the Shop" competition	**$$$$**
Reform the immigration regime for growth	**$**

Intensify cluster dynamics

Support maintenance or expansion of bottom-up competitive grant programs	**$-$$$**
Explore avenues for intensifying federal laboratories' engagement in regional economic development	**$$**




224 yd


Emilia
Fabio


9
11

ABOUT THE AUTHORS

Mark Muro is a senior fellow and policy director at the Brookings Metropolitan Policy Program. Devashree Saha is a senior policy analyst and associate fellow, Kenan Fikri a research analyst, Jessica Lee a senior policy analyst and associate fellow, and Nick Marchio a research assistant at the program.

ADVANCED INDUSTRIES SERIES

This paper is part of the Brookings Metropolitan Policy Program's Advanced Industries series. This series calls attention to the critical role that advanced industries—characterized by high-value engineering- and R&D-intensive industrial concerns—play in building and sustaining regional and national economic competitiveness. By working intensively with two emblematic state AI clusters to develop actionable economic development strategies to advance the clusters the series seeks to highlight the value of AIs to national policymakers and so further regional and national prosperity in the United States. Ultimately a high-level national framing paper will build on the state analyses to assert the importance of AIs—and federal, state, and regional action to foster them.

IN THE SERIES

- *Launch! Taking Colorado's Space Economy to the Next Level*

ABOUT THE METROPOLITAN POLICY PROGRAM AT THE BROOKINGS INSTITUTION

Created in 1996, the Brookings Institution's Metropolitan Policy Program provides decision makers with cutting-edge research and policy ideas for improving the health and prosperity of cities and metropolitan areas including their component cities, suburbs, and rural areas. To learn more visit: **www.brookings.edu/metro**

ACKNOWLEDGMENTS

Authors accrue many debts in a project like this. The authors would therefore like to thank the following Coloradans for special contributions to this work: Noah Aptekar, Penina Axelrad, Tom Bugnitz, Robert Cleave, Mike Dickey, Diane Dimeff, Steve Eisenhart, Lt. Governor Joe Garcia, Michelle Hadwiger, James Hague, Todd Headley, Henry Hertzfeld, Suzanne Hultin, Jay Jesse, Allan Lockheed, Ed Locher, Kenneth Lund, Dave Lung, Sean McClung, Amy Minnick, Michael Pierson, Elliot Pulham, Naseem Qussar, Walter Scott, Rick Silva, Phillip Singerman, Sarah Sloan, Tom Smerdon, Alan Stern, Norman Stucker, Simon Tafoya, Karla Tartz, Mark Wdowik, Dave White, Laurence Williams, Trent Yang, Rachel Yates. In addition, we would like express a special measure of gratitude to Tom Clark, Vicky Lea, and Edgar Johansson.

The Brookings team would also like to thank McKinsey & Co. for contributing fact based research and analysis on advanced industries and the role they play in innovation and economic growth.

Closer to home sincere thanks go to: Alan Berube, Alex Boucher, David Jackson, Rachel Harvey, Bruce Katz, Brad McDearman, Ellen Ochs, Maria Sese Paul, Ben Slowik, Richard Shearer, Karen Slachetka, Taylor Stewart, and Linda Zhang.

The Metropolitan Policy Program at Brookings would like to thank the Rockefeller Foundation for its support of the Brookings-Rockefeller Project on State and Metropolitan Innovation, which presents fiscally responsible ideas state and metropolitan leaders can use to create an economy that is driven by exports, powered by low carbon, fueled by innovation, rich with opportunity and led by metropolitan areas.

The Program would also like to thank the John D. and Catherine T. MacArthur Foundation, the Heinz Endowments, the George Gund Foundation, the Kresge Foundation, and the Surdna Foundation for their general support of the program's research and policy efforts. We would also like to thank the Metropolitan Leadership Council, a network of individual, corporate, and philanthropic investors that provide us financial support but, more importantly, are true intellectual and strategic partners.

FOR GENERAL INFORMATION

Metropolitan Policy Program at Brookings
202.797.6139
www.brookings.edu/metro

1775 Massachusetts Avenue NW
Washington, D.C. 20036-2188
telephone 202.797.6139
fax 202.797.2965

BROOKINGS

Metropolitan Policy Program at BROOKINGS