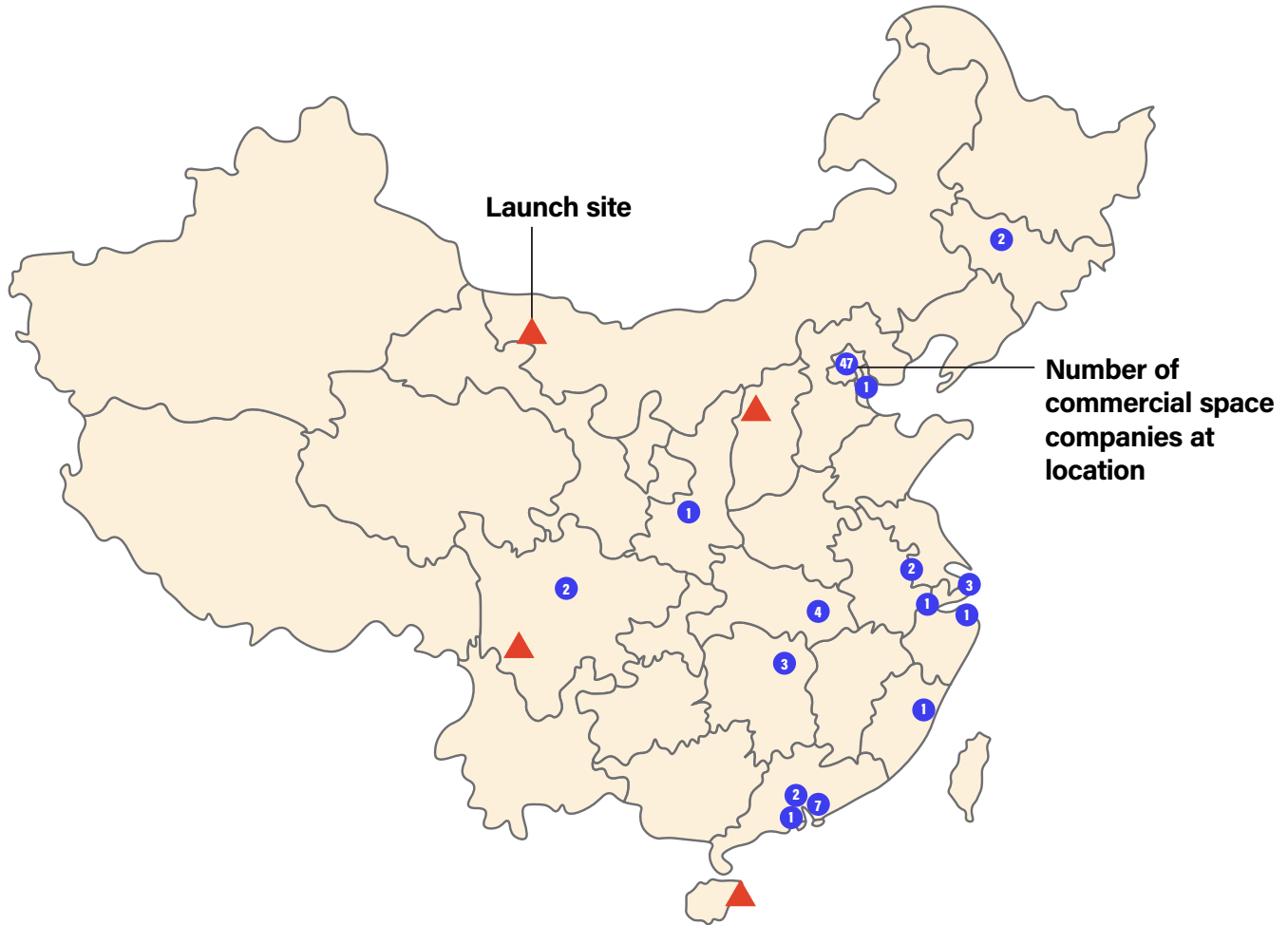




China's Commercial Space Sector



Guests: Bhavya Lal, Irina Liu, Shirley Han, Thomas J. Colvin

Host: Rhett A. Moeller

April 2020

IDA Document NS D-13128

Approved for public release;
distribution is unlimited.

Institute for Defense Analyses
4850 Mark Center Drive
Alexandria, VA 22311-1822



The Institute for Defense Analyses is a nonprofit corporation that operates three Federally Funded Research and Development Centers. Its mission is to answer the most challenging U.S. security and science policy questions with objective analysis, leveraging extraordinary scientific, technical, and analytic expertise.

About This Publication

This work was conducted by the IDA Science and Technology Policy Institute under contract NSF-OIA-0408601, Project ET-20-4515, "Evaluation of China's Commercial Space Sector Objective." The views, opinions, and findings should not be construed as representing the official position of either the National Science Foundation or the sponsoring organization.

For More Information

Bhavya Lal, Project Leader
blal@ida.org, (202) 419-3724

Mark S. Taylor, Acting Director, Science and Technology Policy Institute
mtaylor@ida.org, (703) 578-2864

Copyright Notice

© 2020 Institute for Defense Analyses
4850 Mark Center Drive, Alexandria, Virginia 22311-1882 • (703) 845-2000.

This material may be reproduced by or for the U.S. Government pursuant to the copyright license under the clause at FAR 52.227-14 (May 2014).

Executive Summary

IDA Ideas host Rhett Moeller talks to researchers from the IDA Science and Technology Policy Institute (STPI) about China’s commercial space sector. Joining him are STPI researchers Bhavya Lal, who leads STPI’s space portfolio and directed the project being discussed; Irina Liu, who studies science and technology policy, planning, and strategy; Shirley Han, who focuses on China’s science and technology policy, global talent migration, and statistical analysis; and Tom Colvin, whose expertise includes the effects of space launch and re-entry on national air space. Highlights of their discussions follow.

Research Overview

The motivation for STPI’s project on China’s commercial space sector was the prevalence of unsubstantiated hyperbolic claims about China’s commercial space sector—what it is, the extent of its integration with the Chinese state, and its expenditures and achievements. What STPI tried to do was to use facts to inform U.S. Government policy in space, something that IDA does very well. STPI had four study questions:

1. What factors are motivating the development of China’s commercial space sector?
2. What are the key characteristics of the companies in this sector?
3. What are the strengths and weaknesses of this commercial space sector?
4. Where do we expect them to be in the next 10 to 15 years?

Discussions with Chinese Space Experts

Because STPI is a Federally Funded Research and Development Center (FFRDC), the Chinese experts that STPI researchers spoke with sensed that STPI didn’t have an agenda other than data collection. Asking local experts to be guides and consultants helped open doors that otherwise would not have been possible. Further, having Chinese language speakers on the project was a critical strength. They visited six cities in China and spoke with staff from over twenty companies from space launch and satellite communications to data analytics and space education. Most were open and willing to share their reality of being a commercial space company in China. One of the major findings was that their definition of “commercial” is different from ours. Commercial subsidiaries under the state-owned enterprises in China operate with profit in mind, and these subsidiaries are similar to what we think of as private startups. Many employees of the state-owned enterprises have been inspired by Western space companies to leave their careers in

state-owned companies to start their own companies. SpaceX, Jeff Bezos, Blue Origin, and Iridium came up a lot in these discussions.

Because STPI promised anonymity for all of the people they spoke with, they believe the information received from the Chinese companies was generally truthful. The same challenges and barriers came up repeatedly in discussions across the companies involved. Interviewees felt that that U.S. researchers were doing an objective analysis of what is happening with China commercial space, and found themselves having a voice that they didn't have before. Most importantly, STPI validated the information from interviews to the extent possible with Chinese language literature and other literature.

Technological Advancements of Interest

Although China is making advancements in space technology, all have already been demonstrated at a technological level by the United State, so they are not ahead of us on that axis.

The pulse detonation engine being developed by TWR Engine is interesting in that it is being pursued by China's commercial sector. The U.S. Government has looked at this technology as well. This type of liquid rocket motor would need to produce hundreds of supersonic shockwaves per second to produce enough thrust to launch or fly, making for a jarring ride.

Another interesting technology is a dual-pulse motor, which is a type of solid rocket that puts a physical barrier inside the solid fuel so that, instead of having multiple stages, you light it, it burns until it hits the barrier, it stops, and you can coast. When you want to burn again, you light the next part of the propellant grain, thus reducing mission complexity. This technology is generally used for anti-aircraft missiles, so the development company may be positioning to mature a technology to sell for defense purposes.

In terms of developments to watch, LinkSpace, LandSpace, and iSpace are developing liquid rocket motors with reusable flight architectures. Those companies are the ones to watch because they might present some competition to Western companies. In terms of the technology, they're not doing anything that hasn't been done in the West, and the Western companies are further ahead. However, they may be able to provide services at a lower price point.

Strengths and Weaknesses

One of the greatest strengths of the commercial Chinese space sector is support from the government. They can draw on the government's broader, more sophisticated manufacturing capability. These companies also have access to a large workforce of trained young people and a lot of capital from investors. The space commercial entities in China are highly entrepreneurial and have a potentially large domestic market unencumbered by foreign competitors.

In terms of weaknesses, it appears that state-owned enterprises, such as the China Aerospace Science and Technology Corporation (CASC) and the China Aerospace Science and Industry

Corporation (CASIC), may not want to see some of these commercial companies grow and compete with them. While there is a venture capital sector, it lacks business acumen, deals with smaller amounts of funding, and requires shorter turnaround times compared to the United States. Workforce challenges include the increasing cost of labor.

In the long term, some things seen now as strengths may become weaknesses, while things seen now as weaknesses may become strengths.

Looking to the Future

It's difficult to say definitively where the commercial space sector in China is going. These companies are embryonic; however, they are gaining footing and should be able to develop globally competitive products and services in the next 5 to 10 years. Factors external to the companies themselves that will affect how quickly these developments take place include:

- Extent of support of Chinese government policies,
- Growth in the global market for small satellites and small launchers,
- Ability to access customers internationally,
- Upstream developments, and
- Downstream demand.

Contents

Introduction.....	1
Research Overview	1
Discussions with Chinese Space Experts.....	2
Technological Advancements of Interest.....	4
Strengths and Weaknesses	6
Looking to the Future.....	7

The following is a transcript of “China’s Commercial Space Sector,” the first episode of the podcast IDA Ideas. Speakers’ comments have been edited for length and clarity.

Introduction

Rhett Moeller: Hello listeners, I’m Rhett Moeller and I’m the host of *IDA Ideas*, a podcast sponsored by the Institute for Defense Analyses. Through the course of this series we’ll bring in some of our top experts to share their perspectives on cutting-edge research and issues of importance to the U.S national security community. Today we’re going to examine China’s commercial space sector. China’s space program has been around for decades, but only recently has the country started building up its commercial space capabilities. To help explore this topic I have with me several experts who are here from IDA’s Science and Technology Policy Institute, or STPI. Located in DC, this is a Federally Funded Research and Development Center that IDA operates. STPI provides technical and analytical support in a range of critical areas to the Office of Science and Technology Policy, the White House National Space Council, and other executive branch agencies. In recent months, STPI has conducted some high-profile evaluations of our Nation’s space program, including the prospects of commercial space stations, NASA’s plans to go to Mars, and the potential and payoff from asteroid mining—lots of fascinating work and a great deal of intense work going on in this field.

Joining me today are Dr. Bhavya Lal, the lead researcher whose fields of expertise include space technology and policy analysis, research and development policy analysis, technology assessment, scientometrics, and more. In particular, Bhavya leads STPI’s space portfolio and directed the research conducted in the project we’ll discuss today. Welcome Bhavya.

And Bhavya has brought with her several of her team. Also with us today is Irina Liu, a research fellow with a background in science and technology policy and planning and strategy and Dr. Shirley Han, a researcher with a focus on China’s science and technology policy, global talent migration, and statistical analysis. And joining us shortly will be Dr. Tom Colvin, a researcher with expertise in the effects of space launch and re-entry on national air space, commercial space, and China space.

Welcome everyone to this inaugural episode.

Research Overview

Rhett: Let’s jump right in. Bhavya, your team recently conducted a study. Tell us about the study and what you were trying to do.

Bhavya Lal: Of course, Rhett, glad to be here. We were asked by a Federal sponsor to look at and evaluate China’s commercial space sector, and the motivation was pretty straightforward. There’s a lot of hype about what China’s commercial space sector is, how closely integrated it is with the state development, and there’s a lot of hype in the system. For example, there’s a new article which incorrectly notes that China is spending eight billion dollars on its commercial industry, and there’s

really no evidence for where that funding source is coming from. Another one notes that Chinese startups are undercutting U.S. companies by eighty percent. Again, we have no idea where that number is coming from. Even authoritative U.S. Government publications are citing sources that—where it seems it’s unclear what the source is. What we tried to do was to use facts to drive U.S. Government’s policy in space, something IDA, of course, does very well. We embarked and we had four study questions. The first one was, what are the factors that are motivating the development of China’s commercial space sector? Second, what are the key characteristics of this sector? What are the companies we’re talking about, what are they doing, who are they working with, where are their customers, what sorts of funds they’re raising? Third, what are the strengths and weaknesses of this commercial space sector? And, last but not least, where do we expect them to be in the next ten to fifteen years?

Discussions with Chinese Space Experts

Rhett: Bhavya, it’s notoriously difficult to talk with experts in China, especially about a field as sensitive as this. How were you able to collect reliable data? I know you mentioned some things already, but is there anything else that you did?

Bhavya: I think, coming from an FFRDC [*Federally Funded Research and Development Center*], we didn’t have an agenda; we were purely on a data collection quest, and I think the experts we spoke to could sense that. Information about STPI and IDA is very publicly available; they could tell how authoritative and reliable our reports are. We’re not trying to push one opinion or another, and that really does make a difference. We also asked some local experts to be guides and consultants to us and they were able to open doors that otherwise is not possible if you are conducting government-sponsored studies, and again, as I said, having Chinese-language speakers on the project was our critical strength here.

Rhett: Irina, you visited many of the companies and talked to experts in China. Also, together with Shirley Han, you are a native Mandarin speaker. What were some of your most notable findings?

Irina Liu: Shirley and I visited six cities in China, including Shanghai, Beijing, and Wuhan. And we spoke with probably over twenty companies, spanning from the launch sector to satellite communications to remote sensing data analytics and even a space education company, and it was amazing to see how excited some of these companies were to speak with us. They were extremely open and willing to share what their reality of being a commercial space company was in China. Some of them gave us tours of their facilities and [*others*] chatted with us over coffee. It was really interesting to see how some of them were extremely developed, had their own manufacturing facilities, and, obviously, had products on the market, and then others were just large empty office spaces and still kind of figuring out what they were trying to do and recruit people and hire people.

I think one of the major findings was that commercial and the definition of commercial in China is very different from the definition of commercial in America, so what we think of as a state-owned enterprise in America I think we...most of the time think that it’s not commercial, but there

are actually subsidiaries under the state-owned enterprises in China that operate with a very commercial intent, which is they're motivated by the pursuit of profit, and if they don't make enough profit their parent company most likely will not support them and will also get rid of that division. These commercial subsidiaries of the state-owned enterprises are actually very similar to what we think of with the private startups and whatnot, so that is a distinction that is different from, I would say, Western commercial space companies. And then there [are] a lot of employees of the state-owned enterprises from CASC [*China Aerospace Science and Technology Corporation*] and the Chinese Academy of Sciences that actually left their bureaucratic jobs in their mid-career to start their own startups, most of the time because they were inspired by Western space companies, which was super cool to see the influence of just commercial space in the West inspiring these people to leave their red tape jobs and start their own companies.

Rhett: In your discussions did you have any indication of specific companies, like SpaceX or anything, did any of those names come up.

Irina: Oh yes, SpaceX came up a bunch of times. Jeff Bezos and Blue Origin came up a lot, and then Iridium. I think the coolest part was learning what these...these American companies or Western companies...what their names were in Chinese, because going in I had no idea what Iridium's name was in Chinese. It was "yī xīng," which sounds like "one star," so the whole time I was asking Blaine and Shirley, "What the heck is yī xīng? What is it?" And afterwards we realized oh they're talking about Iridium. Yeah.

Rhett: Shirley, in Irina's discussion just now, she mentioned the openness that the companies exhibited in their time with you. Can you talk a little bit more about that and maybe did you feel like you were getting reliable information; did you feel like it was quality information that you were getting?

Shirley Han: Absolutely, so I think that's a great question. One of the major concerns a lot of people have when we do research in China is...kind of getting at whether the information that we're receiving is actually truthful or forthcoming or if they're only saying things that they think we want to hear or things that they would not be hesitant to say. Because this was such a sensitive area, we wanted to make sure that we promised anonymity for all of the people that we spoke with. And yes, I believe that the information that we received from all of the companies was very truthful and mainly because they were very open about the challenges and barriers that they were facing. And one of the ways that we know that is true is because when we spoke across the different sectors, as Irina indicated, from launch to satellites to data analytics, it was the same challenges and barriers that were coming up over and over again. Some of the companies also indicated that, "please do not indicate our names or our sectors," because these areas are very sensitive should they get out and get linked to their particular names.

One of the other things that has echoed from my previous research in China is a lot of the companies noted that they wanted to speak with us because these are things that they have spoken out about in China; however, having an outside voice, an external voice, from Chinese commercial

space companies saying these things gives them a little bit more voice, so the fact that we are U.S. researchers doing this completely independently, having no agenda, having our own objective analysis to what is happening with China commercial space really gave them a voice that they didn't have before.

Bhavya: Rhett, if I could add a couple things to what Shirley said. One, Shirley is actually an outstanding qualitative data research analyst, so I think she has a really good sense of asking questions in a way that you get to have more of what they are actually thinking. And the second piece is we didn't just rely on interviews; we also looked at literature in Chinese language; we did validate somewhat with literature in the United States as well. So, we use this triangulating approach to make sure that the information that we were collecting is as good as can be, given [*that*] people are people.

Rhett: Excellent, and Shirley, you mentioned a growing voice; is this voice taking shape in different ways, such as conferences or public exhibitions of what kinds of things they're capable of doing?

Shirley: Yes, so back in 2018, in the fall, my other colleague Evan Link and I were able to attend the fourth annual conference on China commercial space in Wuhan, and so this was something that they had indicated in the conference that had been growing every single year. It was an international conference, so they also invited individuals from the U.S. and Europe, and it was very well attended. This is something that at least within the China commercial space sector itself there is a lot of growing interest and people are very excited to see where this is going to go.

Rhett: Shirley thank you very much for your comments, your insights. I know you've got things you need to be doing. Thank you for joining us, and replacing you will be Dr. Tom Colvin.

Shirley: Great! Thank you for having me.

Rhett: Sure.

Technological Advancements of Interest

Rhett: Tom, thank you for joining us this morning, and welcome to *IDA Ideas*.

Tom Colvin: Thanks for having me.

Rhett: You are the team's aerospace expert, and in this study you looked at the technologies being developed by these companies. Did you find any companies that are pursuing technologies that are unusual or may be further ahead than where U.S. commercial companies are? And are there any technologies you found that we should be paying particular attention to?

Tom: I'm going to key in on three things you said, which are unusual—yes, they have a few unusual technologies—further ahead, and the ones that we should be watching. In terms of further ahead, as Bhavya mentioned before, there's a lot of hype even with the government space program, so I look more at the civil and the commercial but I want to make a distinction, and we'll use, say,

the Chang'e, like their lunar program, as an example. They've landed a rover on the far side, they have a comm satellite at L2 that allows them to relay back and forth; many people say "Oh my God, China's ahead!" Well, hold on. They've done something that we haven't done but they didn't do something that we couldn't do; we could have done that decades ago if we'd chosen. When it comes to China's commercial space sector maybe we see a few things where they're doing things that we haven't done, but I would say technologically they aren't...I have seen nothing that they are doing that we have not already demonstrated at a technological level, so I wouldn't say they're ahead of us on that axis.

When it comes to unusual technologies, there are two that I found especially interesting. This is in the commercial companies. One is called a pulse detonation engine. It's being developed by TWR Engine, so it's a type of liquid rocket motor where instead of having a long continuous burn that produces a continuous amount of thrust, you have this really long tube as your new combustion chamber, and when you burn the fuel it burns so quickly that it sets up supersonic shockwaves that travel through the tube and get kicked out the back, and it produces thrust, but only for like a second. This is a far more efficient way of burning fuel than our normal way, but if you try to do this, like I said, you only get that thrust for a second so you've got to have hundreds of these detonations per second at least, and that winds up making for a very jarring ride. DARPA [*Defense Advanced Research Projects Agency*] has looked at this, the U.S. Government has looked at this. It's really interesting to me that a commercial company is trying to pursue it, but I mentioned it because it's unusual and interesting, but I think that's probably not flying in the next decades, so I'm not worried about that.

Another technology that I thought was really interesting that we don't see much in commercial companies is called a dual-pulse motor. And so this is a type of solid rocket where—normally when you light a solid rocket, that's it; the fuel burns and then you can't stop it. If you want to have a coast phase, you have to have stages where stage one burns [and] falls away, then stage two burns [and] falls away; that introduces a lot of complexity and can increase your chance of mission failure. The dual-pulse motor actually puts a physical barrier inside the solid fuel so that way you can light it, it burns until it hits the barrier, and then it stops and you can coast. Then when you want to burn again, you just burn the next part of the grain, so this reduces your mission mass, your mission complexity, because you're always just lighting the same motor again instead of having all these stages. That's an interesting technology. They're going to be using it for small payloads to sun-synchronous orbits, which are very useful for trying to do Earth observations. But the thing that I found extra interesting about it is that generally we only see this technology used in anti-aircraft missiles. So S Motor—I think that they have a potentially valid civil and commercial use for it, but they may also be positioning themselves to mature a technology that they could then sell to CASIC [*China Aerospace Science and Industry Corporation*] for defense uses.

Those are the two interesting and unusual technologies. To the last point about what we should watch, the early companies that we've seen have some launch successes and make it to orbit have been using solid rocket motors, which, from my perspective, serve a somewhat limited niche. I

don't think that that's really the way of the future, especially because [*they are*] very hard to reuse. The companies, like LinkSpace, LandSpace, and iSpace, who are developing liquid rocket motors with reusable flight architectures, where, sort of like you see with SpaceX or Blue Origin, they'll bring it back and reuse it. I would say those are the ones to watch because those are the most near-term viable and might present some sort of competition to Western companies, but, in terms of the technology, they're not doing anything that we haven't already seen our Western counterparts do and the Western companies are further ahead. Ultimately, I'm not really worried...yet.

Rhett: You mentioned CASIC as an acronym—can you describe what that is?

Tom: Yes, so without defining it, it's their large defense contractor, so, would it be fair to say that's analogous to like a Boeing or a Lockheed?

Irina: And they're a state-owned enterprise, too.

Tom: Yeah.

Irina: Along with CASC, which is their more civilian state-owned enterprise space contractor.

Bhavya: I think it might be more analogous to say that they are a Lockheed or a Boeing and NASA, so they are much more integrated with the government than in the United States—defense contractors are.

Rhett: Gotcha. Understood, thank you.

Strengths and Weaknesses

Rhett: Bhavya, we're coming close to the end of our time, so I'll just ask you to wrap things up. What do you see as the strengths and weaknesses of the Chinese commercial space sector?

Bhavya: Sure, so the devil's in the details, so I hope your viewers and listeners will actually read our report, but at the top level, one of the strengths of the commercial Chinese space sector, as Shirley, Irina, and Tom mentioned, is that there is some support from the government; there's policy support; there is in-kind support, such as facilities and launch access—those sorts of things. There's access to the government's deep space capabilities that these companies have. They can draw on a broader manufacturing base, and as you know, China has a pretty sophisticated manufacturing capability. These companies have an access to a large young and trained workforce, and it's pretty important. Availability of capital—there's a lot of money and, there's investors looking for the next big thing after IT. In fact, a really good quote I have is by the founder of the company MinoSpace, Wu Shufan, who said, “Chinese economic growth has been so fast, and in the past two years space has gotten into what we called a ‘wind window,’ and if you are in the wind window, even a pig can fly.” A little colorful, but I think it hits the mark.

Moving on to some of the other capabilities, the space commercial entities are as entrepreneurial as anywhere else, in fact, more so. They certainly have a potentially large domestic market, which is unencumbered by foreign competitors, which is a case we may not see in the United States. The

Belt and Road initiative is seen as a potential growth avenue for some of these smaller companies, but on the other hand, both...Shirley and Irina mentioned the state-owned enterprises (SOEs). SOEs aren't really that keen to see some of these commercial companies grow, so there is a chance, from a weakness perspective, that these companies may not be allowed to grow because SOEs would prefer to have some of those market shares. While there is a VC [*venture capital*] sector, as compared to the United States, it lacks a business acumen as well as the U.S. sector does, it's also smaller amounts of funding, and they have a shorter turnaround time compared to U.S. VCs, so there's more pressure on companies to produce. China really has a problematic brand image problem, which will hurt these companies.

Last but not least on the weakness front, there is, as with other sectors, increasing cost of labor and workforce challenges. There's some things in China we see as strengths, but in the long term they may be weaknesses. For example, not having regulations and strong policies may make the sector move forward faster, but in the long term, it may hurt growth. Insulation from market forces, again, may allow companies that are not as good to move forward and that may, in the big picture, hurt the Chinese space sector, but on the other hand, things that may be seen as weaknesses now could be strengths in the long term. An example would be the fact that Chinese companies don't have access to the most cutting-edge technology that they could import from the United States or Western countries under ITAR [*International Traffic in Arms Regulations*] or export controls. In the near term, yes, they are limited, but in the long term, they are developing an indigenous technology base, which would be good for them.

Rhett: Thank you for that analysis, Bhavya.

Looking to the Future

Rhett: It sounds like there [*are*] a lot of factors, both internal and external, are affecting this. Where do you see this going?

Bhavya: It's a difficult question to answer as to where the commercial space sector in China is going. We know that these companies are embryonic; however, they are slowly gaining footing, and they should be able to develop globally competitive product and service in the next five to ten years. However, what will affect how quickly they develop are factors that are external to the companies themselves.

Our study identified four or five such factors. The first is the extent to which the Chinese government's policies will continue to support these commercial entities, so its funding, minimizing competition with SOEs, and others. Second, growth in the global market for small satellites and small launchers. The more demand there is of products that the Chinese companies are producing, the more likely that they would be successful. The third is these companies' ability to access customers internationally. As I said earlier, it is limited because of policies of certain governments and other external factors. Fourth, upstream developments. For example, if we develop additive manufacturing techniques that would lower the cost of producing satellites, that

may benefit these companies because the Chinese commercial space sector is very quick at picking up new technologies and running with them. And last but not least, a downstream demand, so, if for example, every Chinese home has multiple IOT [*internet of things*] devices, it will really make the case for providing some of the services from space. Those are some of the factors that will affect how fast it develops, and it is something that we will have to watch, carefully.

Rhett: I want to thank you all for joining us, taking the time to share your experience and your findings in this big project. Listeners, if you want more information on STIPI and the important work done there, feel free to visit ida.org and check them out there. This show is sponsored by the Institute for Defense Analyses, a nonprofit based in the Washington, DC, area. Once again, you can find out more about us and the work we do by visiting ida.org. Thanks for tuning in, and we hope you'll join us again next time as we discuss another big idea here at *IDA Ideas*.