

# Drone Services in Construction

**Jennifer Powell**

## Abstract

The use of unmanned aerial vehicles (UAVs), or drones, has grown briskly in recent years. This paper presents evidence of the growth in drone use in the construction industry, outlines the uses of drones in the construction industry (including the benefits and risks associated with drone use), examines factors affecting the provision of drone services, identifies major U.S. and foreign providers of drone services, and concludes with a brief discussion on industry prospects.

# U.S. international Trade Commission

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## Introduction

The use of unmanned aerial vehicles (UAVs), or drones, has grown briskly in recent years. While military and consumer applications are expected to account for the largest shares of the world drone market in the near future,<sup>1</sup> commercial users comprise a sizeable and particularly rapidly growing segment of this market.<sup>2</sup> A number of factors—including falling hardware prices, the opportunity to reduce project costs, low barriers to market entry, and lower-than-expected demand among hobbyists—are contributing to the expansion of the commercial drone market.<sup>3</sup> In the United States, new regulations that allow the commercial use of drones under specific conditions have prompted market growth. Further, domination of the drone hardware market by Chinese-owned firm DJI has given rise to a market that focuses on supplying commercial drone users with complementary services and software.<sup>4</sup>

The construction industry has traditionally been slow to incorporate technology into its operations, and this low technological intensity has been associated with the industry's lagging productivity growth.<sup>5</sup> During 1995-2014, labor productivity increased at an average annual rate of 1 percent in the world construction industry, as compared to 3.6 percent and 2.8 percent respectively in the manufacturing sector and the global economy as a whole.<sup>6</sup> McKinsey Global Institute estimates that value added in the construction industry would increase by about \$1.6 trillion if labor productivity in the industry rose to a level on par with the overall economy, and identifies innovation and technology as factors that could contribute to productivity growth.<sup>7</sup> High-technology tools—such as drones—could address the extreme shortage of workers in the construction industry.<sup>8</sup> Such tools may also enhance accuracy and precision during the construction process, which may lessen the possibility of budget overruns and legal problems at the end of a project.<sup>9</sup>

Among the advanced technology tools used by construction firms, drones are particularly popular, and the construction industry has reportedly become the fastest-growing and largest user of commercial drones.<sup>10</sup> In a 2017 survey of professionals at small- and medium-sized construction firms, 18 percent of respondents indicated that they used drones in their business. This exceeded adoption rates for autonomous equipment (16 percent), augmented and virtual reality (6 percent), and 3D printing

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<sup>1</sup> Specifically, military applications are expected to account for \$70 billion of the projected \$100 billion global market for drones during 2016–2020, while consumer applications (including drone use by hobbyists) are expected to account for \$17 billion.

<sup>2</sup> Goldman Sachs, “Drones: Reporting for Work,” accessed April 10, 2019.

<sup>3</sup> Black, “Drone Pilots’ \$2,000 Paydays,” May 18, 2018; The Economist, “Taking Flight,” June 2017; Somerville, “Analysis: Consumer Drone Business Stumbles” November 14, 2016.

<sup>4</sup> The Economist, “Taking Flight,” June 2017.

<sup>5</sup> Holt et al., “Emerging Technology in the Construction Industry,” June 2015; Glaser and Molla, “The Construction Industry is Short on Human Workers,” June 6, 2017.

<sup>6</sup> McKinsey Global Institute, *Reinventing Construction*, February 2017, 2.

<sup>7</sup> McKinsey Global Institute, *Reinventing Construction*, February 2017, vii, 4.

<sup>8</sup> Glaser and Molla, “The Construction Industry is Short on Human Workers,” June 6, 2017.

<sup>9</sup> The Economist, “Taking Flight,” June 2017.

<sup>10</sup> Scott Seltz, “Leveraging Drones on the Job Site: Why UAVs are Transforming the Construction Industry,” ENR Webinar, May 22, 2018, <https://www.enr.com/events/519-leveraging-drones-on-the-job-site-why-uavs-are-transforming-the-construction-industry>.

(4 percent).<sup>11</sup> A 2016 survey of construction and engineering executives and large project owners also suggests that drones are a popular innovation in the industry, as 42 percent of respondents reported that they monitored projects with drones. This placed drones firmly in the middle of those technologies assessed in the survey, with remote monitoring ranking as the most widely used technology (65 percent of respondents reported its use) and smart sensors ranking as the least used technology (17 percent of respondents employed this tool).<sup>12</sup>

This paper presents evidence of the growth in drone use in the construction industry, outlines the uses of drones in the construction industry (including the benefits and risks associated with drone use), examines factors affecting the provision of drone services, identifies major U.S. and foreign providers of drone services, and concludes with a brief discussion on industry prospects.

## The Growth of Drone Use in the Construction Industry

Data on the commercial use of drones are extremely limited, and comparable and discrete data on the size of the U.S. and global markets for drone services and on trade in such services do not exist. However, available information suggests that drone use in the commercial sector as a whole has grown rapidly in recent years, and that the construction industry accounts for a substantial share of this market.

Estimates of the number of registrations of commercial drones and the issuance of certifications for drone pilots provide some indication of the size and projected growth of the U.S. market for commercial drone services. The Federal Aviation Administration indicates that the number of registered non-model UAVs—the type of drones that are typically used in commercial applications—totaled 110,604 by year-end 2017,<sup>13</sup> and it expects this number to reach 451,800 in 2022.<sup>14</sup> The Federal Aviation Administration (FAA) also expects the number of remote pilot certification (RPC) issuances to increase during 2017-2022 from 73,673 to more than 300,000.<sup>15</sup> RPCs—issued by the FAA—are required for pilots that fly drones weighing 55 pounds or less for commercial purposes.<sup>16</sup>

A number of market observers have produced estimates that provide some insight into the size and growth (or growth potential) of the construction-related drone services market. While these estimates focus on different indicators, they all suggest that this market is large and likely to experience rapid expansion. For example, a recent report published by Skylogic Research predicts that the U.S. market for drone services directed at the architecture, engineering, and construction firms will reach \$1.4 billion in

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<sup>11</sup> The use of each of these four technologies expected to grow by between 7-8 percent by 2020. Budiac, “Construction Technology Trends,” January 2, 2018.

<sup>12</sup> Other technologies assessed in this survey included building information modeling, robotics/automated technology, and radio-frequency identification, which were used by 61 percent, 30 percent, and 30 percent of respondents, respectively. KPMG, “Building a Technology Advantage” 2016, 16.

<sup>13</sup> The largest share of these drones is employed in aerial data collection and photography (48 percent) followed by utility and industry inspection (28 percent) and agriculture (17 percent).

<sup>14</sup> This is the FAA’s “base” estimate for 2022. It indicates that the number of registered non-model UAVs could reach as high as 717,895 in that year. FAA, “FAA Aerospace Forecast: Fiscal Years 2018–2038”, 41–43.

<sup>15</sup> FAA, “FAA Aerospace Forecast: Fiscal Years 2018–2038,” 44–45.

<sup>16</sup> FAA, “Certificated Remote Pilots,” accessed April 9, 2019; FAA, “Become a Drone Pilot,” accessed April 9, 2019.

2018. It also estimates that over a five-year period, the value of this market will exceed \$9.4 billion, having increased by 15 percent annually.<sup>17</sup> Goldman Sachs estimates that overall commercial drone sales during the five-year period from 2016-2020 have the potential to reach \$3.9 billion in the United States and \$20.6 billion globally. Their report speculates that drone use in the construction industry will account for the second-highest share of U.S. drone sales during the period (with \$1.3 billion or 37 percent), and the largest share of global sales (with \$11.2 billion or 54 percent).<sup>18</sup> Further, a customer survey conducted by drone solutions firm DroneDeploy indicates that in 2017 the use of aerial data experienced the greatest increase in the construction industry (239 percent), followed by the mining and agricultural industries (which posted increases of 198 percent and 172 percent, respectively).<sup>19</sup>

The use of drones is also increasing in overseas construction markets. For example, in 2019, UK-firm ProDroneWorx reported that 52 percent of the British and Irish construction industry representatives polled in a recent survey reported that they were using drones, up from 33 percent in 2017. Drone use among this group was very nascent, with 45 percent indicating that they had only started using drones within the past year and just 14 percent identifying as “early adopters” by reporting that they had used drones for between 3 and 5 years. Drone use will likely increase in this market, as 74 percent of responding firms that had not yet used drones reported that they intend to use this technology in the future.<sup>20</sup>

## The Role of Drones in the Construction Industry

Drones are a valuable data collection tool, enabling construction firms to capture a large amount of current data, high-resolution images, and other information at job sites in a relatively short amount of time. This information can be used to track and monitor progress or change on a project, develop site maps, and calculate the volume of soil or other material in a stockpile, among other tasks.<sup>21</sup> Sources in the construction industry indicate that drones are a particularly valuable tracking tool because they are able to make identical flights repeatedly.<sup>22</sup>

Commercial UAVs are also used for a variety of other functions throughout the construction project lifecycle.<sup>23</sup> For example, drones are used to conduct inspections in areas that are difficult to access or in cases where a traditional approach might require the diversion of traffic or a machinery or site shutdown.<sup>24</sup> Drones can be a useful tool in firms’ marketing efforts, as the ability to take a large number

<sup>17</sup> Snow, Colin, “The Quick Start Guide,” 2018.

<sup>18</sup> By comparison, drone use in the agriculture industry was expected to account for the largest share of U.S. drone sales during the period (with \$1.4 billion or 39 percent), and the second-largest share of global sales (with \$5.9 billion or 29 percent). Goldman Sachs, “Profiles in Innovation,” March 13, 2016, 11.

<sup>19</sup> DroneDeploy, “2018 Commercial Drone Industry Trends,” May 2018.

<sup>20</sup> ProDroneWorx, “More than Half of Construction Firms,” January 17, 2019.

<sup>21</sup> PwC, “Clarity from Above,” May 2016, 5; Dillow, “The Construction Industry is in Love with Drones,” September 13, 2016; Heiskanen, “How Drones Are Speeding Up Construction,” July 20, 2017, (accessed June 13, 2018): industry representatives, phone interviews by USITC staff, January 21 and 27, 2020.

<sup>22</sup> Industry representative, phone interview by USITC staff, June 13, 2019; Snow, “The Quick Start Guide,” 2018.

<sup>23</sup> Industry representative, phone interview by USITC staff, June 13, 2019.

<sup>24</sup> Accenture, “A Business Approach for the Use of Drones” 2016, 5; Aarni Heiskanen, “How Drones Are Speeding Up Construction,” July 20, 2017; industry representative, phone interview by USITC staff, January 23, 2020.

of photos from specific and unique positions aid in the visualization of a potential project (for example, by allowing clients to see the view from a yet-to-be-built office).<sup>25</sup> Drones can be used to move equipment to and around a construction site.<sup>26</sup> Drones equipped with thermal cameras can be used to assess the condition of machinery on a construction site.<sup>27</sup> Drones have also been used on a very limited basis to accomplish construction tasks. For example, two firms—Sharper Shape and SkySkopes—have pioneered a method to use drones in the pulling of power lines between transmission towers, a task otherwise accomplished by individuals or helicopters.<sup>28</sup> As technology develops, companies might also be able to use drones for a number of other building tasks, such as painting, constructing ventilation systems, and—when combined with 3D printing technology—repairing structures with parts created on the job site.<sup>29</sup>

The results of two separate surveys published in 2015 and 2018 suggest that the construction industry most commonly uses drones to track progress at construction sites. Specifically, 76 percent of respondents to the 2015 survey (conducted by Navigant) and over 50 percent of respondents to the 2018 survey (conducted by DroneDeploy) reported using drones for progress tracking. A relatively large number of respondents to both surveys reported using drones for planning purposes (45 percent in 2015 and over 20 percent in 2018). Over half of respondents to the 2015 survey also reported using drones in marketing and inspection.<sup>30</sup>

## In-house Programs and Third-party Services Suppliers

In the construction industry, UAV services are provided by both dedicated services providers and in-house teams. Firms that are new to the use of drones or that are unwilling to devote resources towards building their own drone capabilities may see an advantage in working with a third-party supplier of drone services.<sup>31</sup> However, firms that rely heavily on the data captured by drones have an incentive to develop in-house drone capabilities.<sup>32</sup> Several large construction firms—such as Skanska USA, PCL Construction Enterprises Inc., Turner Corp., Gilbane Building Co., and Hensel Phelps, among others—have developed in-house drone capabilities.<sup>33</sup>

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<sup>25</sup> sUAS News, “How Drones Are Helping Construction Companies” January 18, 2017; Danielak, “The Benefits of Employing Drones in Construction,” February 14, 2018; Lawson, “7 Ways Drones Are Improving the Construction Industry,” March 28, 2017.

<sup>26</sup> Burger, “6 Ways Drones Are Affecting the Construction Industry,” March 17, 2018.

<sup>27</sup> Industry representative, phone interview by USITC staff, January 23, 2020.

<sup>28</sup> Power, “Sharper Shape, SkySkopes,” September 12, 2017; CNBC, “Check out these drones,” June 18, 2018.

<sup>29</sup> PwC, “Clarity from Above” May 2016, 6.

<sup>30</sup> Navigant, “Drones in Construction – 2015 Survey Report,” 2016, 4; DroneDeploy, “2018 Commercial Drone Industry Trends,” May 2018.

<sup>31</sup> Karpowicz, “What Impact Will Changing Regulation Have” January 22, 2018; March, “Top Trends Shaping Drone Use,” March 27, 2017.

<sup>32</sup> March, “Top Trends Shaping Drone Use,” March 27, 2017.

<sup>33</sup> ENR, “Building a Drone Program,” ENR webinar, November 28, 2018; Turner, “Atlanta,” accessed June 17, 2019; Grothman, “Drone Pilots Add Safety to Projects,” May 21, 2019; Gagne, “Predicting the Future in the Construction Industry,” January 2, 2020.



Industry representatives note that in recent years, commercial drone users have increasingly favored in-house solutions. Several factors, including the decreasing complexity of drone use, hardware and software improvements, and recent U.S. regulatory changes that have facilitated commercial drone applications have made the development in-house drone capabilities more likely.<sup>34</sup> In the construction industry, risk management concerns have reportedly had an important impact on firms' decisions to outsource or develop drone capabilities. One industry representative indicates that in the recent past, the lack of FAA regulations raised liability concerns that led construction firms to outsource drone operations.<sup>35</sup> However, the development of regulations and a desire to manage risks by assuming greater control of drone operations have prompted the increasing development of in-house drone programs.<sup>36</sup> It is argued that moving drone programs in-house may increase safety as construction firms have a better understanding of job site hazards and protocols than third-party drone firms.<sup>37</sup>

While one source estimates that drone operations in the construction industry are evenly split between internal and third-party operations,<sup>38</sup> precise data on the shares of construction firms that develop in-house drone programs (rather than hiring outside providers) are unavailable. However, a recent CompTia survey indicates that, across all industries, almost 40 percent of business customers use both in-house and third-party drone capabilities, while slightly smaller shares rely exclusively on in-house programs (34 percent) or external providers (27 percent).<sup>39</sup> DroneDeploy expects in-house drone programs to grow more quickly than the outsourcing of drone services in the near term, and estimates that drone services providers will continue to play a key role as contributors to firms' efforts to launch and scale their drone programs.<sup>40</sup> Similarly, another source predicts that while in-house drone operations will likely become more prevalent, there will always be some demand for outsourced drone services.<sup>41</sup>

## Factors Influencing Construction Firms' Use of Drones

UAVs reportedly offer several advantages to firms in the construction industry. Drones may reduce a firms' labor and equipment costs as they can complete tasks—such as design work, mapping, and surveying—that may otherwise involve manned aircraft, cranes, and a professional staff.<sup>42</sup> For example, a recent study by the Minnesota Department of Transportation estimated that using UAVs to inspect one particular bridge in that state would cost approximately \$20,000, as compared to about \$59,000

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<sup>34</sup> March, "Top Trends Shaping Drone Use," March 27, 2017; industry representative, interview by USITC staff, June 13, 2019; DroneDeploy, "2019 Commercial Drone Industry Predictions," May 2019.

<sup>35</sup> Industry representative, interview by USITC staff, January 23, 2020.

<sup>36</sup> Industry representatives, interviews by USITC staff, January 23 and 27, 2020.

<sup>37</sup> Industry representatives, interviews by USITC staff, January 23 and 27, 2020.

<sup>38</sup> Industry representative, interview by USITC staff, January 23, 2020.

<sup>39</sup> CompTia, "The Drone Market," May 2019.

<sup>40</sup> DroneDeploy, "2019 Commercial Drone Industry Predictions," May 2019.

<sup>41</sup> Industry representative, phone interview by USITC staff, June 13, 2019.

<sup>42</sup> Danielak "The Benefits of Employing Drones in Construction," February 14, 2018; Accenture, "A Business Approach for the Use of Drones" 2016, 5; Dillow, "The Construction Industry is in Love with Drones," September 13, 2016; industry representative, phone interview by USITC staff, January 23, 2020.

using traditional means.<sup>43</sup> One industry representative indicates that these lower costs enable more frequent inspections and the faster identification of potential problems.<sup>44</sup>

Drones can increase the speed, accuracy, and efficiency with which construction tasks can be accomplished, as they are capable of collecting precise data and high-quality images in a fraction of the time required by manned teams.<sup>45</sup> Drones reportedly can map a construction site in minutes, while it may take workers over a month to complete the same task.<sup>46</sup> Industry observers report that drone use can improve communication, enabling increased collaboration between on- and off-site personnel and fewer data collection delays.<sup>47</sup> Drones can capture data and images from different perspectives than are possible using traditional methods.<sup>48</sup> Drones also improve workplace safety, as they can eliminate or reduce the need for people to work at high, contaminated, or otherwise dangerous locations and can monitor worksites for potential safety issues.<sup>49</sup>

While drone use offers several advantages to construction firms, some factors may discourage the use of this technology. The adoption of drones requires training, investment, and consideration of the best and most effective use cases for the technology.<sup>50</sup> Several industry observers note that there are concerns regarding the safety and privacy of bystanders and nearby property owners, and the potential liability issues associated with these risks.<sup>51</sup> There is also a concern that drones will replace workers and lead to job loss.<sup>52</sup> Drone technology has some disadvantages, such as short battery life.<sup>53</sup> Further, regulatory stringency and uncertainty may discourage drone use among construction firms.<sup>54</sup>

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<sup>43</sup> Heiskanen, "How Drones Are Speeding Up Construction," July 20, 2017.

<sup>44</sup> Industry representative, phone interview by USITC staff, June 13, 2019.

<sup>45</sup> Mitchell, "This Startup Uses Self-Flying Drones," September 27, 2016; PwC, "Clarity from Above," May 2016, 5; Heiskanen, "How Drones Are Speeding Up Construction," July 20, 2017; industry representatives, phone interviews by USITC staff, June 13 and 18, 2019 and January 23, 2020.

<sup>46</sup> Mitchell, "This Startup Uses Self-Flying Drones," September 27, 2016.

<sup>47</sup> Mansour, "How Drones Will Revolutionise the Construction Industry," April 29, 2018; Burger, "6 Ways Drones Are Affecting the Construction Industry," March 17, 2018.

<sup>48</sup> Industry representatives, phone interviews by USITC staff, June 13, 2019 and January 21, 2020.

<sup>49</sup> PwC, "Clarity from Above," May 2016, 5; Accenture, "A Business Approach for the Use of Drones" 2016, 5; sUAS News, "How Drones Are Helping Construction Companies," January 18, 2017; industry representatives, phone interviews by USITC staff, June 13, 2019, January 23 and 27, 2020.

<sup>50</sup> Industry representatives, phone interviews by USITC staff, June 13 and 18, 2019.

<sup>51</sup> Murison, "Drones in Construction," June 8, 2016; full drone, "The pros and cons of drones," June 2, 2016; Pinnacle Finance, "Drones in the Remodeling and Construction Industry," April 21, 2016. UAV-related liabilities are not typically covered under standard insurance policies and drone coverage is not mandatory; however, insurance firms offer additional coverage to mitigate against such risks. Hickman, "Up, Up, and Away," September/October 2016; Famakinwa, "Drones on Construction Sites," November 10, 2016.

<sup>52</sup> Industry representatives, phone interviews by USITC staff, January 21 and 23, 2020.

<sup>53</sup> Industry representative, phone interview by USITC staff, January 27, 2020.

<sup>54</sup> Murison, "Drones in Construction," June 8, 2016; Pinnacle Finance, "Drones in the Remodeling and Construction Industry," April 21, 2016; Arizona Contractor License Center, "Drones in the Construction Industry," February 9, 2016.

## Regulation and Other Factors Affecting the Use of Drones

Overall, regulations have a substantial impact on drone use in the commercial sector as a whole and the construction industry in particular. National and sub-national regulations have evolved rapidly in recent years. Although these regulations can differ substantially from location to location, many address similar issues. These include when, where, and under what conditions commercial drone flights are allowed, the licensing and registration of drones and drone operators, and insurance requirements, among others.

Industry representatives indicate that prohibitions on flying over people, have the most substantial impact on drone operations in the construction and engineering sectors.<sup>55</sup> For example, one firm reported that it is difficult to comply with the restriction on flying over people as a pilot can violate this rule by flying over a single person and that following this rule affects the quality of the data gathered by a drone.<sup>56</sup> In the United States, drone operators can obtain waivers allowing flights over people and one industry representative reports that obtaining these waivers is easier than it was in the past.<sup>57</sup> However, in the absence of this waiver, drone flights could not occur while a construction site was open, or would require spotters.<sup>58</sup>

Prohibitions on flying drones beyond visual line of sight (BVLOS) and over moving vehicles were also identified as issues by some industry experts. However, not all industry experts agree on the importance of BVLOS measures. Several experts indicated that BVLOS restrictions have little or no impact on drone operations at construction sites, and one expert indicated that BVLOS may only impact drone use at large sites.<sup>59</sup>

Based on information maintained by UAV Coach—a firm that provides training, information, and other resources to drone users—prohibitions on flying over people are common. UAV Coach reports information on drone regulations in 200 countries, among which about 56 percent allow and regulate the use of drones, about 8 percent ban drone use, and 36 percent have no drone regulations.<sup>60</sup> Among the countries that allow and regulate the use of drones, 25 countries maintain bans on flights over people and another 59 countries place some restriction on flights near or above people or crowds (for example, forbidding drones to fly within a certain distance of large gatherings, or requiring approval for flights over people). A larger number of countries limit BVLOS flights, with 72 countries maintaining bans on BVLOS flights and another 10 countries allowing such flights only under certain conditions. By

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<sup>55</sup> Industry representatives, phone interviews by USITC staff, June 13 and 18, 2019 and January 21, 23, and 27, 2020.

<sup>56</sup> Industry representatives, phone interview by USITC staff, June 18, 2019.

<sup>57</sup> Industry representatives, phone interviews by USITC staff, January 21, 23, and 27, 2020.

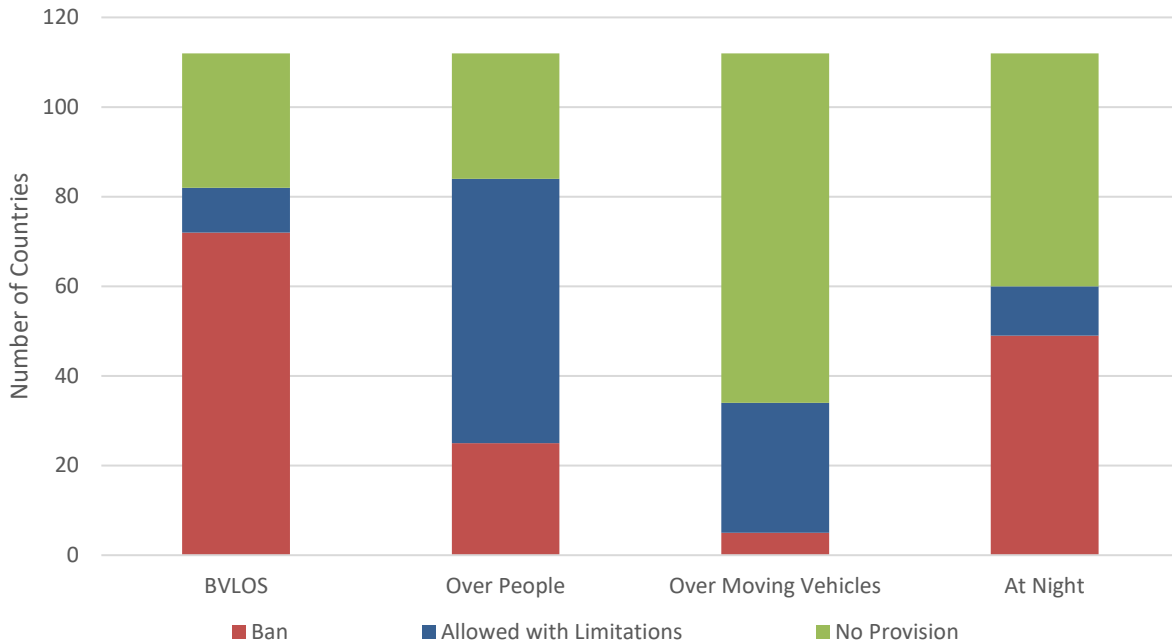
<sup>58</sup> Industry representative, phone interview by USITC staff, January 27, 2020.

<sup>59</sup> Industry representatives, phone interviews by USITC staff, June 13 and 18, 2019 and January 21, 23, and 27, 2020.

<sup>60</sup> Countries that have banned drones include Algeria, Barbados, Bhutan, Brunei, Cote d'Ivoire, Cuba, Iran, Iraq, Kuwait, Kyrgyzstan, Madagascar, Morocco, Nicaragua, Saudi Arabia, Senegal, and Syria. USITC staff analysis based on information compiled from UAV Coach, "Master List of Drone Laws," (accessed May 31, 2019 – July 2, 2019).

comparison, UAV Coach reports that only 34 countries ban or limit flights over or near vehicles.<sup>61</sup> While drone firms report that these measures affect their operations, they recognize the importance of addressing safety concerns and do not necessarily favor their immediate removal.<sup>62</sup>

**Figure 1** Key provisions of National Drone Regulations



Source: USITC staff analysis based on information compiled from UAV Coach, “Master List of Drone Laws,” accessed May 31, 2019–July 2, 2019.

Notes: Based on an analysis of the conditions under which drones may fly beyond visual line of sight (BVLOS), over people or moving vehicles, or at night in 112 countries which allow and regulate the use of drones.

Industry representatives also indicate that airspace restrictions impact their ability to provide drone services at construction sites.<sup>63</sup> UAV coach reports that several countries prohibit drone use within a certain radius of airports and/or other sensitive locations.<sup>64</sup> As with flying over people, drone operators can also obtain waivers to fly in restricted airspace in the United States. One representative indicates that the development of the Low Altitude Authorization and Notification Capability (LAANC) system<sup>65</sup> has facilitated the process of obtaining these waivers, and that the future institution of remote ID regulations may further ease waiver approvals.<sup>66</sup>

<sup>61</sup> UAV Coach did not find any countries that allow operators to fly drones over people, BVLOS, or over or near vehicles without restriction. USITC staff analysis based on information compiled from UAV Coach, “Master List of Drone Laws,” accessed May 31, 2019 – July 2, 2019.

<sup>62</sup> Industry representatives, phone interviews by USITC staff, June 13, 2019 and June 18, 2019.

<sup>63</sup> Industry representatives, phone interviews by USITC staff, January 23, 2020.

<sup>64</sup> USITC staff analysis based on information compiled from UAV Coach, “Master List of Drone Laws,” accessed May 31, 2019 – July 2, 2019.

<sup>65</sup> LAANC is a joint FAA-industry effort which automates the process through which drone pilots can apply for and receive approval to fly in controlled airspace at heights up to 400 feet above ground. FAA, “UAS Data Exchange (LAANC),” webpage, [https://www.faa.gov/uas/programs\\_partnerships/data\\_exchange/](https://www.faa.gov/uas/programs_partnerships/data_exchange/) (accessed July 27, 2020).

<sup>66</sup> Industry representative, phone interview by USITC staff, January 23, 2020.

A large number of countries regulate the height, speed, and timing of drone flights. For example, UAV Coach reports that 49 countries ban the use of drones at night, and another 11 countries allow nighttime flights with permission or under certain circumstances (for example, in cases where the drone is equipped with lights so that it is visible in the sky). Insurance requirements are common, as 38 countries require drone operators to carry liability insurance and 5 countries recommend such insurance or specify that operators are liable for damages caused by a drone. Several countries also require commercial drone operators to obtain licenses or certifications, register or label their drones, and/or obtain permits for drone flights.<sup>67</sup>

While most drone regulations apply to all drone operators, certain provisions are directed toward, or have a particularly large effect on, foreign drone operators. For example, certain countries—including India, Israel, Mexico, Qatar, and Rwanda—restrict the operation or registration of drones to citizens or companies based in the country. One industry representative indicated that it can be difficult to bring drone equipment into a foreign country,<sup>68</sup> and some countries maintain customs regulations that apply to drones.<sup>69</sup> Industry representatives also report that a lack of sufficient resources to maintain overseas operations, the risk of not getting paid, and the large amount of work in the U.S. market discourage participation in foreign markets.<sup>70</sup>

In the United States, commercial drone flights are subject to several limitations under FAA small aircraft rules (or Part 107 rules). Among other things, these provisions prohibit BVLOS flights, flying at night, flying over people, the simultaneous operation of multiple drones, and the operation of drones from moving vehicles and aircraft.<sup>71</sup> However, as indicated above, the FAA allows individuals to apply for waivers, allowing them to circumvent some of these rules. As of December 9, 2019, the FAA had issued more than 3,400 Part 107 waivers.<sup>72</sup> Industry association AUVSI analyzed the waivers granted in the two years following the establishment of the Part 107 rules and found that 92 percent of these waivers allow nighttime flights. Only one percent of these waivers allow BVLOS flights, and less than one percent allow drones to fly over people.<sup>73</sup>

Like many other countries, the United States also requires pilot certification and drone registration for commercial drone operations. In order to be certified, individuals must pass a test and apply for a certificate from the FAA.<sup>74</sup> One industry representative indicated that it is easy to obtain certification, and believes that licensing requirements will be tightened in the near future.<sup>75</sup> The FAA's drone registration fee is \$5 and registration numbers must be displayed on drones. Pilot certifications and drone registrations are valid for 2 and 3 years, respectively.<sup>76</sup> Industry representatives interviewed for

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<sup>67</sup> USITC staff analysis based on information compiled from UAV Coach, "Master List of Drone Laws," accessed May 31, 2019 – July 2, 2019.

<sup>68</sup> Industry representative, phone interview by USITC staff, June 13, 2019.

<sup>69</sup> USITC staff analysis based on information compiled from UAV Coach, "Master List of Drone Laws," accessed May 31, 2019 – July 2, 2019.

<sup>70</sup> Industry representatives, phone interviews by USITC staff, June 13, 2019 and June 18, 2019.

<sup>71</sup> U.S. regulations allow pilots to operate drones from moving vehicles in areas that are sparsely populated. FAA, "Fact Sheet – Small Unmanned Aircraft Regulations," June 21, 2016.

<sup>72</sup> FAA, "Part 107 Waivers Issued," December 9, 2019.

<sup>73</sup> AUVSI, "Waivers Under Part 107: Interactive Report," October 24, 2019.

<sup>74</sup> FAA, "Certificated Remote Pilots," accessed June 28, 2019.

<sup>75</sup> Industry representative, phone interview by USITC staff, June 18, 2019.

<sup>76</sup> FAA, "Certificated Remote Pilots," accessed June 28, 2019; FAA, "Become a Drone Pilot," accessed June 28, 2019.

this study provide different opinions on the impact of FAA regulation on the drone industry. For example, one expert argues that the FAA's lengthy rule-making process has discouraged investment in U.S. drone firms, while another contends that the development of Part 107 rules has enabled industry growth by eliminating certain requirements and increasing accountability.<sup>77</sup>

Certain individual U.S. states also maintain regulations on the operation of drones. These include, for example, provisions that prohibit drone legislation at the local level, ban the operation of drones in state parks, and prohibit privacy violations, among various others.<sup>78</sup>

In addition to regulations, industry representatives identified several other factors that impact their ability to provide services in the United States. Software-related issues were identified by a couple of industry representatives: one individual indicated that streamlining data programs and improvements to the computer storage and processing capabilities would facilitate the provision of drone services, while another indicated that the dominance of Chinese firm DJI in the drone hardware market and that firm's measured and selective approach towards developing compatible software for use in certain industries is restraining industry growth.<sup>79</sup> Further, one industry representative indicated that, in the future, uncertainties regarding the use and installation of remote ID technology could affect the use of drones at construction sites.

Privacy and data security concerns were also identified as issues that may impact drone use.<sup>80</sup> Industry representatives also identify limitations on the use of Chinese-manufactured drones<sup>81</sup> as a possible barrier. One industry representative stated that these rules have impacted construction work on military bases as it has been difficult to find a competitively priced UAV that satisfies military standards, while another indicated that they have impacted drone use in the energy sector but have not yet affected construction.<sup>82</sup>

Industry experts identified several factors that may discourage U.S. firms from providing drone services in overseas markets. These include customs measures and other provisions impacting the cross-border transfer of equipment, the risk of not receiving payment, the challenge finding enough work in a foreign country to support an overseas presence, and ample opportunity in the U.S. market.<sup>83</sup>

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<sup>77</sup> Industry representatives, phone interviews by USITC staff, June 18, 2019 and January 27, 2020.

<sup>78</sup> For more information, see UAV Coach, "Master List of Drone Laws," <https://uavcoach.com/drone-laws/>.

<sup>79</sup> Industry representatives, phone interviews by USITC staff, January 21 and 23, 2020.

<sup>80</sup> Industry representative, phone interview by USITC staff, January 27, 2020.

<sup>81</sup> The U.S. Department of the Army banned the use of DJI drones in August 2017 and ceased the operation of all of its drones in January 2020 as most drones in its fleet included Chinese parts. Pending legislation would reportedly prohibit all U.S. Executive Branch agencies from purchasing drones and drone components that are manufactured in China and would ban the operation of Chinese-made drones by U.S. Government agencies six months following the law's enactment. McNabb, "The Ban on Chinese Drones, Part 2," *dronelife*, August 14, 2020.

<sup>82</sup> Industry representatives, phone interviews by USITC staff, January 27 and February 27, 2020.

<sup>83</sup> Industry representatives, phone interviews by USITC staff, June 13 and 18, 2019 and January 27, 2020.

## Competitive Position of U.S. and Foreign Drone Services Providers

Due to data unavailability, it is not clear which countries host the largest and most competitive markets for drone services, but industry sources suggest that the United States is well positioned in this market.<sup>84</sup> According to an assessment of the drone services market by Drone Industry Insights, many of the world's top drone services firms are based in the United States, and all but three of the top 20 drone services firms in 2019 were based in OECD countries. At the same time, no one country dominated the market. Among the leading 20 drone services firms in 2019, 13 firms specialized in inspection and/or mapping and surveying services—activities that may be particularly useful to construction firms. These included two U.S.-based firms (Measure and Avitas Systems), three UK-based firms (Cyberhawk, Sky-Futures, and Team UAV), and two Australia-based firms (Australian UAV and National Drones). Other leading firms in this segment of the drone services market are based in Japan (which is home Terra Drone—the world's leading drone services provider specializing in inspection, mapping, and surveying services), Malaysia, Spain, India, the UAE, and Finland.<sup>85</sup>

UAV Coach identifies a number of key providers of drone-based data processing and mapping services to the construction industry. Most of these firms—which include 3DR, DroneDeploy, Skycatch, esri, Maps Made Easy, Skydio, Geocue Group, Bentley, and Trimble Stratus—are based in the United States. Other countries with firms in this market segment include Switzerland (Pix4D), the UK (Pixpro), and Israel (Datumate).<sup>86</sup>

One industry representative indicated that the global drone services market is like other emerging markets as there are firms throughout the world providing valuable services. Currently, few firms provide overlapping services. The services offered by individual providers tend to be unique, and firms that supply similar services pursue acquisitions and partnerships.<sup>87</sup>

Industry representatives interviewed for this article indicate that the United States is the world's largest market for drone services due to the extent of opportunity in the market, integrated FAA systems, and clear regulations. While some consider U.S. drone rules to be relatively onerous, they provide a clear framework for drone operations which has encouraged market participation.<sup>88</sup> One industry representative suggested that other countries may be leaders in certain segments of the drone services market—for example, Rwanda in the drone delivery segment and Australia, China, and Israel in the provision of completely automated drone flights—but agreed that the United States is the world's largest market for drone services.<sup>89</sup>

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<sup>84</sup> In the absence of discrete data on output, trade, and foreign direct investment in the drone services industry—particularly in the segment that provides services to construction firms—it is not clear which countries host the largest and most competitive markets for such services.

<sup>85</sup> Schroth, "Report – Drone Service Provider Ranking 2019," August 19, 2019.

<sup>86</sup> UAV Coach, "The Top 100 Drone Companies to Watch in 2019," accessed December 10, 2019.

<sup>87</sup> Industry representative, phone interview by USITC staff, January 21, 2020.

<sup>88</sup> Industry representatives, phone interviews by USITC staff, January 21, January 23, and February 27, 2020.

<sup>89</sup> Industry representative, phone interview by USITC staff, February 27, 2020.

U.S. drone services providers are reportedly active in overseas markets including Canada, Australia, and Europe, among others.<sup>90</sup> Industry experts suggest that drone rules in certain markets (such as Australia and New Zealand) facilitate drone operations, and that Canadian regulations have improved.<sup>91</sup> Rules in other locations (such as Europe) are reportedly less welcoming.<sup>92</sup> One industry representative contends that lax drone regulations (such as those in Latin America) may facilitate operations, but also expose firms to liability.<sup>93</sup>

## Prospects for Growth and Increased U.S. Competitiveness in the Global Drone Services Industry

Industry observers contend that UAV use in the construction industry will grow as the benefits of this technology become increasingly apparent and as governments update regulations to address this emerging industry.<sup>94</sup> The development of technologies and regulations that would enable and require the remote identification drones may reportedly increase the pace of growth in the drone market.<sup>95</sup> Industry sources also indicate that new lower-cost and easy-to-use drones as well as improvements to sensors and battery life may have a positive impact on the industry.<sup>96</sup> In a 2019 survey, drone providers anticipated that regulatory improvements, enhanced hardware capabilities, and an increase in service offerings would be the top drivers of business growth during the coming year.<sup>97</sup>

At the same time, one industry representative argues that growth in commercial drone use may occur more slowly than expected due to firms' reluctance to change business practices and acknowledges that there are concerns among workers regarding the impact of drone use on jobs. This representative contends that construction firms will continue to be among the earliest adopters of drone technology, but that other industries will lead in terms of the depth of the data and information collected by drones.<sup>98</sup>

Several representatives identified developments that may impact the nature of future drone use. These include continued growth in the development of in-house drone capacity (as opposed to reliance on third-party drone firms) and increasing use of automated drones. Some experts anticipate that the use of artificial intelligence may enhance the collection of data via drone as well as the subsequent analysis

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<sup>90</sup> Industry representatives, phone interviews by USITC staff, June 13, 2019 and January 23, 2020.

<sup>91</sup> One industry representative contends that revisions to Canadian drone rules have made them more similar to those in the United States, while another suggests that Canadian regulations could be further improved and that some firms choose not to fly UAVs in Canada due to digital integration issues. Industry representative, phone interview by USITC staff, January 21 and 23, 2020.

<sup>92</sup> Industry representative, phone interview by USITC staff, January 21 and 23, 2020.

<sup>93</sup> Industry representative, phone interview by USITC staff, January 21, 2020.

<sup>94</sup> CompTia, "The Drone Market," May 2019; DeCamera and McMillan, "Use of Drones on Construction Projects," December 9, 2019.

<sup>95</sup> Industry representatives, phone interviews with USITC staff, January 23 and 26, 2020.

<sup>96</sup> DroneDeploy, "2019 Commercial Drone Industry Predictions," May 2019; industry representative, phone interview with USITC staff, January 27, 2020.

<sup>97</sup> CompTia, "The Drone Market," May 2019.

<sup>98</sup> Industry representative, phone interview by USITC staff, January 21, 2020.



of such data.<sup>99</sup> Further, one industry representative identified mapmaking and surveying as the activities that may be most impacted by drone use among construction firms.<sup>100</sup>

The research for this paper was conducted prior to the onset of the COVID-19 crisis. As such, industry projections and estimates regarding the future of drone use in the construction industry do not account for the recent changes in supply and demand stemming from measures intended to contain the virus. Some industry sources indicate that the crisis has prompted increased drone use in the construction industry, particularly for remote site inspection and monitoring.<sup>101</sup> This is an evolving situation and a potential topic for future analysis.

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<sup>99</sup> Industry representatives, phone interviews by USITC staff, January 27 and February 27, 2020.

<sup>100</sup> Industry representative, phone interview by USITC staff, January 23, 2020.

<sup>101</sup> Walsh, Bryan, "Coronavirus Brings the Age of Drones Closer," *Axios*, May 30, 2020, <https://www.axios.com/coronavirus-drones-pandemic-surveillance-cbd80f98-4b86-49bd-806f-8e86ec42e3aa.html> (accessed July 21, 2020); Meisels, Michelle, "Deloitte: Contractors Can Combat COVID-19 Crisis with Resilience," *ENR*, July 1, 2020, <https://www.enr.com/articles/49665-deloitte-contractors-can-combat-covid-19-crisis-with-resilience> (accessed July 21, 2020).

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