



January 2020

NASA COMMERCIAL CREW PROGRAM

Significant Work
Remains to Begin
Operational Missions
to the Space Station

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Highlights of GAO-20-121, a report to congressional committees

Why This Matters

Since retiring the Space Shuttle in 2011, NASA has depended on Russia to transport astronauts to the International Space Station (ISS). NASA's Commercial Crew Program is a multibillion dollar effort to re-establish a U.S. capability to get a crew to space, but it is years behind schedule. NASA may have to continue to rely on the Russian transport option or risk losing access to the ISS in 2020.

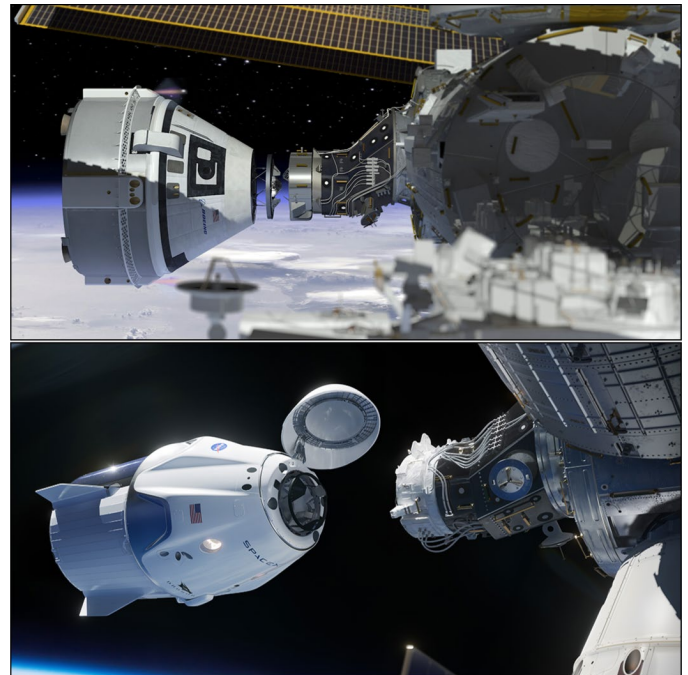
Key Takeaways

NASA will have fewer astronauts on the ISS in 2020 unless the Boeing and SpaceX spacecraft are ready to fly missions, but significant work remains for both. NASA has few back-up options if delays continue and will have only one astronaut on the U.S. side by April 2020. Most of this astronaut's time will be spent on maintenance activities rather than on research and development.

To fly as soon as possible, NASA has been planning to complete its reviews of the contractors' systems under aggressive time frames. This approach is risky because it assumes the contractors will complete multiple activities on time. Boeing and SpaceX must conduct additional test flights, train astronauts, and get a license from the Federal Aviation Administration (FAA).

FAA licenses cover the contractors' launch and reentry activities. FAA may grant waivers for changes to the license that do not jeopardize public safety. For example, FAA may grant waivers for changes in launch trajectory. NASA needs to know when such changes have been made in case they affect the crew. While NASA and FAA have coordinated on launch licensing for years, they have not yet decided how they will communicate about waivers. As a result, NASA may not have all the information it needs for launch decisions.

Artists' Depictions of Boeing (top) and SpaceX (bottom) Spacecraft Docking with the International Space Station



Source: Boeing (top) and SpaceX (bottom). | GAO-20-121

What GAO Recommends

We recommended in 2018 that NASA develop a plan to maintain access to the ISS; this recommendation has yet to be implemented. In this report, we add two recommendations to improve communications on waivers between NASA and FAA. Both agencies agreed.

How GAO Did This Study

We reviewed NASA and FAA's memorandum of understanding and joint program management plan, and program and contract documents. We interviewed NASA, FAA, Boeing, and SpaceX officials to understand progress toward the mission and the extent to which NASA and FAA have coordinated.

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Abbreviations

DOT	Department of Transportation
FAA	Federal Aviation Administration
INKSNA	Iran, North Korea, and Syria Nonproliferation Act
ISS	International Space Station
NASA	National Aeronautics and Space Administration
Roscosmos	Russian Federal Space Agency

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January 29, 2020

The Honorable Jerry Moran
Chairman
The Honorable Jeanne Shaheen
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
United States Senate

The Honorable José Serrano
Chairman
The Honorable Robert B. Aderholt
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
House of Representatives

Following the retirement of the Space Shuttle in 2011, the United States was left with no domestic ability to provide crew access to the International Space Station (ISS). Since then, the National Aeronautics and Space Administration (NASA) has relied on obtaining seats on the Russian Soyuz spacecraft to maintain a U.S. presence on the station. NASA's Commercial Crew Program is facilitating the multibillion dollar commercial development of a crew transportation system that can provide safe, reliable, and cost-effective transportation to and from the ISS and that would end this dependency.

NASA's acquisition strategy for the Commercial Crew Program is similar to the one it used on the Commercial Cargo Program, but different from its strategies for other spacecraft it has built for humans, from Mercury to Gemini and Apollo to the Space Shuttle. Under the Commercial Crew Program, two contractors—Boeing and SpaceX—design, develop, build, own, and will eventually operate their spaceflight systems and infrastructures. The contractors have access to NASA's expertise and resources throughout the development process, but NASA engineers are not the ones making design decisions, and NASA personnel are less involved in processing, testing, launching, and operating the crew transportation system. In addition, NASA must certify the contractors' spacecraft, launch vehicle, and ground support systems before the contractors can begin operational missions to the ISS. In the end, NASA will buy a crew transportation service—a ride for its astronauts to and

from the ISS. For each operational mission, the contractors are required to obtain and maintain a Federal Aviation Administration (FAA) license for launches and reentries.

The House Committee on Appropriations included a provision in its 2017 report for GAO to continue to review NASA's human space exploration programs, including the Commercial Crew Program.¹ This report is the latest in a series of reports addressing the mandate. This report assesses (1) the extent to which NASA and the contractors are preparing to transition from certification to operations and (2) the extent to which NASA, FAA, and the contractors have made progress towards licensing the first operational missions.

To assess NASA and the contractors' transition to operations, we reviewed program and contract documents, including quarterly progress updates and monthly risk charts. We reviewed the October 2019 ISS flight plan to gain insight into the ISS astronaut rotations through the end of 2020. We reviewed the Commercial Crew Program's flight readiness process, which outlines how the agency will approve an operational mission, and identified the milestone that begins that process. We compared time frames outlined in the flight readiness plan against the program's proposed schedule to support a March 2020 operational mission. We reviewed NASA's contracts with Boeing and SpaceX to determine to what extent NASA has flexibility about when it begins the flight readiness process. We also interviewed program and contractor officials to understand NASA's process to prepare for each operational mission, as well as progress made by each contractor to complete tasks, such as manufacturing hardware, prior to their first operational missions. For each contractor, we reviewed Commercial Crew Program and contractor documents to identify the current status of the hardware as well as updates to technical risks that we identified in our June 2019 report.² We also reviewed the contractors' training plans and spoke with program and contractor officials to determine the status of astronaut training as well as roles and responsibilities for NASA and the contractor.

¹H.R. Rep. No. 115-231, at 62 (2017).

²NASA Commercial Crew Program: Schedule Uncertainty Persists for Start of Operational Missions to the International Space Station, [GAO-19-504](#) (Washington, D.C.: June 20, 2019)

To assess the extent to which NASA, FAA, and the contractors have made progress toward licensing the first operational mission for each contractor, we reviewed NASA and FAA's June 2012 Memorandum of Understanding and April 2016 Joint Program Management Plan as well as contract documents. Through our review of these documents, we identified steps NASA and FAA have taken to document the roles and responsibilities of FAA, NASA, and each contractor. We also interviewed NASA, FAA, and contractor officials to understand to what extent the parties have collaborated and coordinated to date and to obtain a status update on the license applications.

We conducted this performance audit from May 2019 to January 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

In 2014, NASA awarded firm-fixed-price contracts to Boeing and SpaceX for the development of crew transportation systems that meet NASA requirements and for the initial service missions to the ISS.³

Boeing's spacecraft—CST-100 Starliner—is composed of a crew module and a service module.

- The crew module will carry the crew and cargo. It also includes communication systems, docking mechanisms, and return systems for Earth landing.
- The service module provides propulsion on-orbit and in abort scenarios as well as radiators for thermal control.

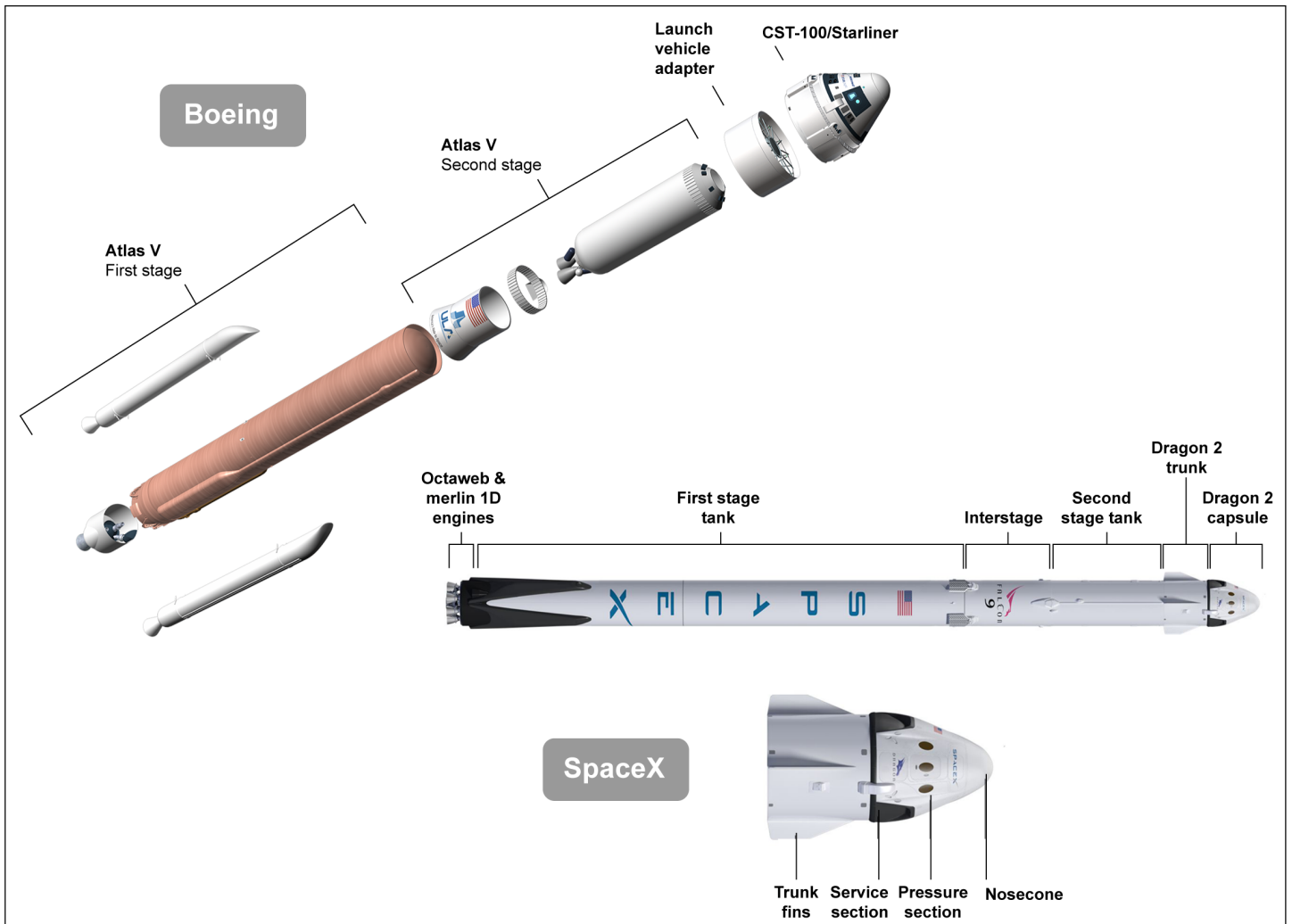
SpaceX's spacecraft—Dragon 2 or Crew Dragon—is composed of a capsule, which we refer to as the crew module, and a trunk, which we refer to as the support module.

³A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administration burden upon the contracting parties. FAR 16.202-1.

- The crew module is composed of a pressure section and a service section. This module will carry the crew and cargo. It also includes avionics, docking mechanisms, and return systems for a water landing.
- The support module includes solar arrays for on-orbit power and guidance fins for escape abort scenarios.

Figure 1 shows the spacecraft and launch vehicles for Boeing and SpaceX's crew transportation systems.

Figure 1: Boeing and SpaceX Crew Transportation Systems

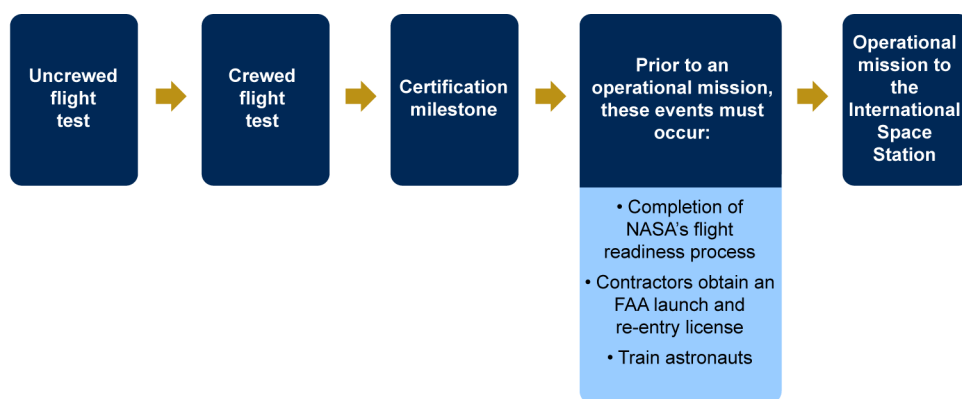


Source: Copyright © 2016 United Launch Alliance, LLC. (top image); © 2016 SpaceX (bottom image). | GAO-20-121

After the contractor has successfully completed all of its test flights and various other activities, NASA determines at the certification milestone whether the crew transportation system and astronaut training plan meet the Commercial Crew Program's requirements. Following this contract milestone is an agency certification review, which authorizes the use of a contractor's system to transport NASA crew to and from the ISS.

After certification, the Commercial Crew Program, the FAA, and the contractors must complete additional activities prior to an operational mission to the ISS, as shown in figure 2.

Figure 2: Notional Commercial Crew Program Path to Operational Missions



Source: GAO analysis of National Aeronautics and Space Administration and Federal Aviation Administration documents. | GAO-20-121

- The Commercial Crew Program must verify readiness through its flight readiness process. This process begins with a milestone where NASA reviews any new or open requirements, among other things. The program's flight readiness process ends with the program manager's approval to proceed with the operational mission.
- The contractors are required to obtain and maintain FAA commercial space transportation licenses to authorize launch and reentry operations. The contractors submit an application for a license to the FAA, which has 180 days to review the application and decide if it will grant a license.
 - The FAA, within the Department of Transportation (DOT), is responsible for ensuring the protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch and reentry activities. The FAA executes its public safety responsibility by issuing licenses or

experimental permits that authorize those operations in accordance with applicable regulations and statutory authority. During FAA-licensed operational missions for Commercial Crew, NASA retains responsibility for astronaut safety and mission assurance.

- NASA's Flight Operations Directorate and the contractors must train astronauts for the operational missions. The Flight Operations Directorate provides ISS training, including the use of ISS systems or spacewalks, while the contractors provide training on their spacecraft related to launch and ISS docking.

Since NASA retired the Space Shuttle in 2011, it has relied on purchasing seats from the Russian Federal Space Agency, Roscosmos, on the Russian Soyuz spacecraft to transport astronauts to and from the ISS. In order to purchase those seats and conduct onboard required activities to safely operate the ISS, NASA has requested and obtained an exemption to Section 6 of the Iran, North Korea, and Syria Nonproliferation Act (INKSNA), which generally prohibits NASA from making any payments to Roscosmos in connection to the ISS.⁴

NASA Is Aggressively Pursuing Transition to First Operational Missions; Contingency Options All Have Limitations

At the time of our review, the Commercial Crew Program was on a path to compress the remaining schedule activities in order to try to launch the first operational mission to the ISS by March 2020. Underpinning the Commercial Crew Program's proposed schedule to launch an operational mission by this date was the assumption that a crewed test flight would occur in December 2019, which did not happen. The number of U.S. astronauts on the ISS is scheduled to begin decreasing at the end of March 2020. Decreasing the number of U.S. astronauts on the ISS will affect NASA's ability to continue to maintain the station and conduct research. NASA officials stated they will not fly operational missions until it is safe to do so. Before they can fly an operational mission, the contractors will also have to complete testing, finish building hardware, and train the astronauts. As of November 2019, NASA officials had identified three options, each with limitations, to ensure a U.S. presence on the ISS: operate the ISS with one U.S. astronaut, use Boeing's crewed test flight as a way to transport astronauts to and from the station for an

⁴Iran, North Korea, and Syria Nonproliferation Act, Pub. L. No. 106-178 (2000), as amended by Pub. L. No. 107-228, § 1306 (2002); Pub. L. No. 109-112, §§ 3-4(e)(1) (2005); Pub. L. No. 109-353, § 3 (2006); Pub. L. No. 110-329, § 125 (2008); Pub. L. No. 112-273, § 4 (2013); Pub. L. No. 116-94, Division I, Title VII, § 701 (2019).

extended stay, or pursue a statutory exemption to INKSNA to allow the purchase of additional Soyuz seats. In December 2019, while our report was with NASA and DOT for review and comment, Congress approved an extension of 5 years to NASA's exemption from the INKSNA prohibition. This extends NASA's ability to purchase seats from Roscosmos to December 31, 2025.

NASA Must Complete a Significant Number of Activities before Conducting First Operational Missions

Through the course of our review, NASA's Commercial Crew Program did not have a publicly available schedule for completing certification and conducting the first operational mission. In July 2019—following the reassignment of key leadership that oversees the program—the NASA Administrator stated that one of the first tasks once new leadership is in place would be to reexamine the cost and schedule for the Commercial Crew Program, among other key programs. In October 2019, the NASA Administrator had identified new leadership, but a schedule for when either contractor would be ready to fly an operational mission was still pending.

We have previously found that the contractors' schedules regularly change, and this pattern continues.⁵ It is important to have a schedule so that NASA can gauge the program's progress and demonstrate accountability to decision-makers. While the program has an internal schedule it is working toward, neither contractor has had a publicly available schedule that reflects that internal schedule.

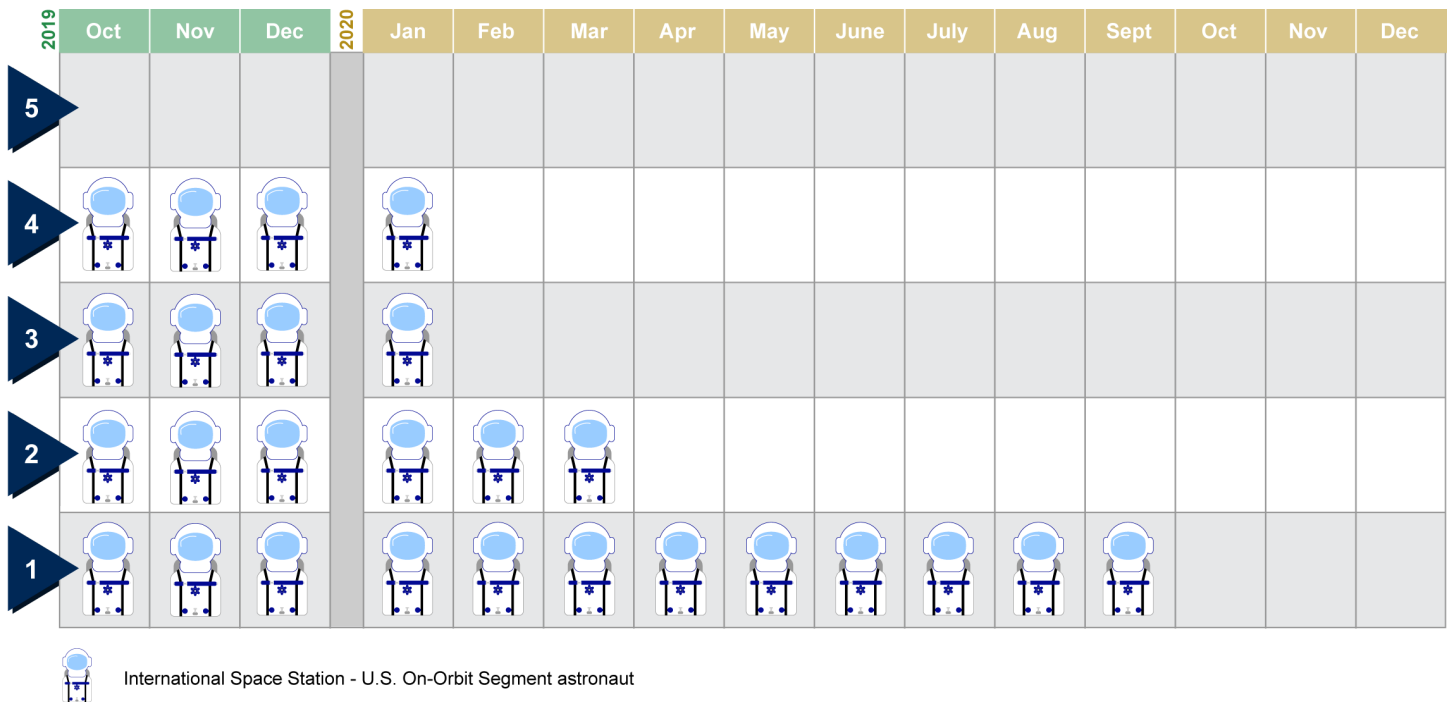
- As of February 2019, SpaceX planned to conduct an uncrewed test flight in March 2019—which it successfully completed—and a crewed test flight in July 2019. As of December 2019, it had not conducted its crewed test flight and NASA has not announced a new schedule. SpaceX officials stated that they plan to conduct this crewed test flight in early 2020.
- As of March 2019, Boeing planned to conduct an uncrewed test flight in August 2019 and a crewed test flight by late 2019. Boeing conducted its uncrewed test flight in December 2019. During this test flight, Boeing successfully launched and landed its spacecraft, but the spacecraft did not reach the planned orbit and did not dock with the

⁵GAO, *NASA Commercial Crew Program: Schedule Pressure Increases as Contractors Delay Key Events*, [GAO-17-137](#) (Washington, D.C.: Feb. 16, 2017); *NASA Commercial Crew Program: Plan Needed to Ensure Uninterrupted Access to the International Space Station*, [GAO-18-476](#) (Washington, D.C.: July 11, 2018); and [GAO-19-504](#).

ISS. NASA officials told us that the spacecraft did not reach the planned orbit after an anomaly with the mission elapsed timer, and that the investigation into this anomaly is ongoing. NASA has not provided an update on a planned date for a crewed test flight.

Even as the program is revisiting its schedule, external schedule pressure to conduct an operational mission soon is increasing. ISS program officials told us that they need a Commercial Crew Program contractor to begin flying operational missions by March 2020. As shown in figure 3, the NASA presence on the ISS is set to drop to one astronaut in April 2020 and none by October 2020 if a Commercial Crew Program contractor is not able to begin flying operational missions, unless NASA purchases a seat on the Russian Soyuz spacecraft.⁶

Figure 3: Planned Number of Astronauts on the U.S. On-Orbit Segment of the International Space Station Transported on a Russian Soyuz Spacecraft, as of October 2019



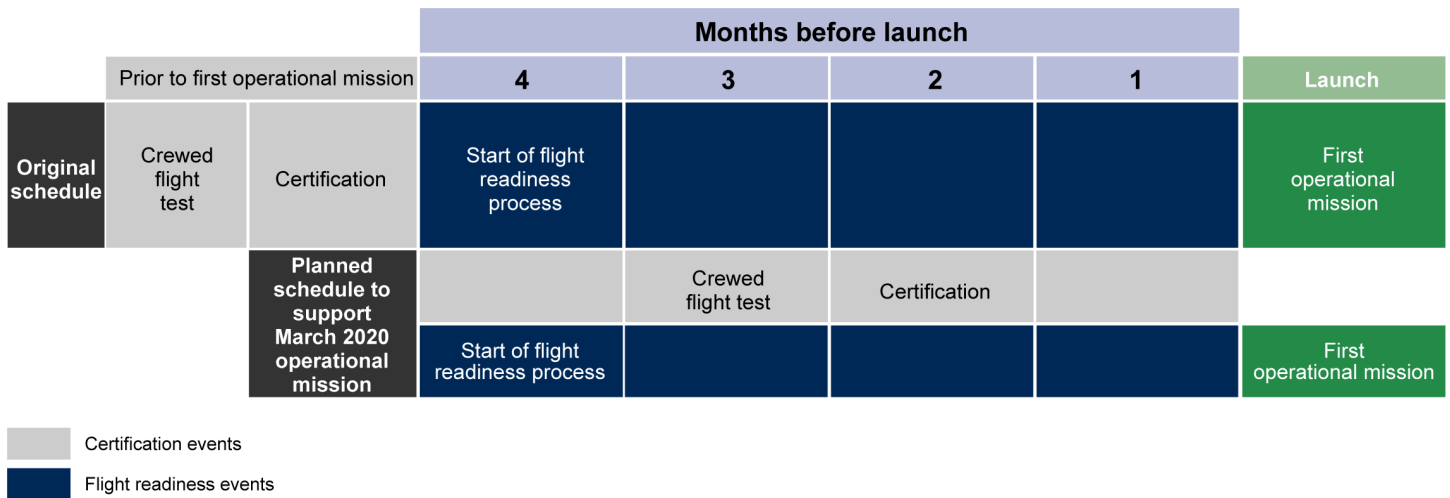
Source: GAO analysis of National Aeronautics and Space Administration documents. | GAO-20-121

⁶NASA's presence could be maintained by an astronaut from any of the countries that support the U.S. on-orbit Segment of the ISS, which includes the United States, Canada, Japan, and participating countries of the European Space Agency.

ISS program officials told us that having an operational mission in March 2020 would allow the ISS to continue normal operations, which includes both regular maintenance activities and research and development. If NASA has just one astronaut on the ISS, that astronaut will have to spend more time on required ISS maintenance activities rather than research and development. Further, NASA will have a limited ability to maintain and repair the ISS. For example, spacewalks are often used for preventive and corrective maintenance, and NASA officials told us these require two U.S. astronauts. If there is only one U.S. astronaut on the ISS, NASA officials said they would not plan to conduct any spacewalks. However, in the event of an emergency, officials told us that NASA is training Russian cosmonauts to perform critical contingency spacewalk activities.

In light of the need to continue normal operations on the ISS, through the course of our review NASA was planning to support an operational mission by March 2020. To do so, it was planning to conduct several activities concurrently, including the contractors' test flights. NASA planned to concurrently complete each contractor's certification—the process NASA uses to ensure the contractors' systems meet its requirements for spaceflight—with NASA's flight readiness process—the process NASA uses to approve an operational mission for flight. According to program documents, completion of the contractor's certification is required prior to starting the flight readiness process. Further, the flight readiness process is required to begin about 4 months before the scheduled launch date for each operational mission. However, in order to support an operational mission in March 2020, the Commercial Crew Program planned to begin the flight readiness process before completing certification (see fig. 4). Underpinning the Commercial Crew Program's proposed schedule to launch an operational mission by March 2020 was the assumption that a crewed test flight would occur in December 2019, which did not happen.

Figure 4: Original Schedule of Reviews Compared to Schedule Needed to Support March 2020 Operational Flight



Source: GAO analysis of National Aeronautics and Space Administration program documents. | GAO-20-121

If NASA continues to pursue this path, the overlap of NASA’s two processes introduces schedule risk because of the compression of several activities in a 4-month window and the completion of key events—including the crewed test flight and certification—closer to the first operational mission than originally planned. Program officials told us that they believed this concurrent approach was doable because they will have completed the majority of work to support certification prior to each contractor’s crewed test flight.

We have previously raised concerns, however, about workload for the program office.⁷ Previously, NASA was able to manage its workload because the two contractors’ test flights did not overlap. For example, recently, the program was able to complete work to support SpaceX’s uncrewed test flight in March 2019, and then it was able to switch focus to complete work to support Boeing’s uncrewed test flight. Commercial Crew Program officials stated that their workforce is already working at full capacity to complete development activities and support certification, and they are trying to utilize resources, such as additional staff, from across the agency to complete the higher workload.

⁷GAO-17-137, GAO-18-476, and GAO-19-504.

Contingency Options Have Limited Usefulness to Avoid a Reduced Presence on the ISS If Contractors Do Not Fly by March 2020

NASA officials have stressed that they will not fly an operational mission until NASA and the contractors are ready and it is safe to do so. As a result, NASA is considering alternatives to ensure a U.S. presence on the ISS in the event one or both of the Commercial Crew Program contractors are not ready to fly an operational mission by March 2020, but these options have limitations. These options include:

- Operate the ISS with one U.S. crew member. As previously stated, NASA would not plan to conduct spacewalks in this scenario, and the astronaut would spend more time on ISS maintenance activities than on research and development.
- Use Boeing’s crewed test flight as a way to transport U.S. astronauts to and from the ISS. In July 2018, we found that NASA modified Boeing’s contract to allow NASA to add a third crew member and extend the length of the flight test, if NASA chooses to do so.⁸ This would have limited usefulness, however, if Boeing continues to experience delays completing its hardware, training the crew, and conducting test flights.
- Obtain an exemption to INKSNA in order to purchase additional Soyuz seats from Roscosmos. In December 2019, while our report was with NASA and DOT for review and comment, Congress approved an extension of 5 years to NASA’s exemption from the INKSNA prohibition. This extends NASA’s ability to purchase seats from Roscosmos to December 31, 2025. There is a Soyuz launch planned for October 2020 that would return in spring 2021, which could potentially extend U.S. access to the ISS; however, NASA will need to negotiate the purchase of that seat with Roscosmos and NASA would still have to operate the ISS with one astronaut from April to October 2020.

In July 2018, we recommended that NASA develop and maintain a contingency plan for ensuring a presence on the ISS until one of the contractors was certified.⁹ NASA agreed with this recommendation. To fully address this recommendation, NASA would need to provide documentation regarding planning efforts—for example, those associated with the options outlined above—to ensure uninterrupted access to the ISS. A comprehensive plan that captures these planning efforts, including time frames for taking action, would provide decision makers within NASA

⁸[GAO-18-476](#).

⁹[GAO-18-476](#).

and Congress insight into what options exist, even if they are limited, and when they may need to be executed.

Contractors Must Complete Testing, Hardware Builds, and Astronaut Training to Support the First Operational Missions

Significant work remains for the contractors to support first operational missions. We have previously reported that the contractors have been delayed 2 years beyond the original dates in their contract, and that over time, both program and contractor officials have told us they struggle to establish stable schedules.¹⁰ Before they can conduct an operational mission, Boeing and SpaceX each must complete their remaining test flights.

Both contractors must also finish preparing the spacecraft for their first operational missions while addressing ongoing technical issues. More information follows.

SpaceX. SpaceX has several spacecraft in production and shifted spacecraft assignments as a result of an April 2019 anomaly, which destroyed one of its spacecraft during a test event. As seen in table 1, flight spacecraft 3 was originally assigned to SpaceX’s first operational mission, but will now be used for its crewed test flight.

Table 1: Mission Assignment and Current Status of SpaceX’s Spacecraft as of November 2019

Spacecraft	Mission assignment		Current status
	Before April 2019 anomaly	After April 2019 anomaly	
Flight Spacecraft 1	Uncrewed Test Flight In-Flight Abort Test ^a	Uncrewed Test Flight	Flown in March 2019. Destroyed in an April 2019 testing event when an anomaly occurred.
Flight Spacecraft 2	Crewed Test Flight	In-Flight Abort Test ^a	In construction
Flight Spacecraft 3	First Operational Mission	Crewed Test Flight	In construction
Flight Spacecraft 4	Second Operational Mission	First Operational Mission	In construction

Source: GAO analysis of Commercial Crew Program and contractor documents. | GAO-20-121

^aThe in-flight abort test is used to demonstrate a spacecraft’s ability to safely carry crew away from a launch vehicle emergency, if necessary.

¹⁰GAO-17-137, GAO-18-476, and GAO-19-504.

To support an operational mission in March 2020, program officials told us that SpaceX plans to complete construction of flight spacecraft 4—now the first operational mission spacecraft—3 months earlier than originally planned. SpaceX and program officials identified two reasons why this acceleration may be possible. First, they told us there will likely be manufacturing efficiencies that could allow SpaceX to meet the accelerated schedule for its first operational mission. Program officials said the spacecraft design for the first operational mission is the same as the other spacecraft, and that this would be SpaceX’s fourth time building the spacecraft. Second, SpaceX officials said they modified their facilities and brought in additional resources.

However, SpaceX’s ability to accelerate the hardware builds may be constrained due to additional late rework resulting from the ongoing anomaly investigation and from SpaceX’s remaining test flights. As of September 2019, the SpaceX investigation team, which includes NASA participation, had identified several contributors to the anomaly. For example, a stuck-open valve allowed propellant to migrate within the system. SpaceX has redesigned the system and is implementing the hardware changes on its remaining spacecraft. However, the investigation is still ongoing, so additional hardware changes may be identified. Furthermore, following the in-flight abort test and the crewed test flight, SpaceX may identify new hardware changes, which could require additional late rework.

In addition to incorporating hardware changes instituted after the anomaly and accelerating its hardware builds, SpaceX continues to address technical risks identified by program officials. These include (1) SpaceX’s plan to conduct launch vehicle propellant loading procedures after the astronauts are on board and (2) the design of its launch vehicle engine. The propellant loading procedure risk remains open because, as of November 2019, SpaceX still needed to demonstrate the loading process at several upcoming events, including the in-flight abort test. The launch vehicle engine risk remains open because SpaceX needed to complete the required follow-on test campaign of its engines as of November 2019.

Boeing. Boeing has 2 spacecraft in production. For its first operational mission, Boeing plans to refurbish the spacecraft it is using for its uncrewed test flight. As shown in table 2, work cannot start on the refurbishment process until the uncrewed test flight is complete.

Table 2: Mission Assignment and Current Status of Boeing's Spacecraft as of November 2019

Spacecraft	Mission assignment	Current status
Flight Spacecraft 1	Crewed Test Flight	In construction
Flight Spacecraft 2	Uncrewed Test Flight First Operational Mission	Constructed Will need to be refurbished after the uncrewed test flight is complete

Source: GAO analysis of Commercial Crew Program and contractor documents. | GAO-20-121

There is a risk that the refurbishment process for the first operational mission may take longer than planned, depending on the spacecraft's condition after it is used for Boeing's uncrewed test flight. As of January 2020, NASA officials told us that an assessment of the spacecraft's condition was ongoing. Boeing has not completed this refurbishment process previously. However, officials stated that they expect to gain experience with the process because some refurbishment work is required on flight spacecraft 1 between its use for a test event and then its use for the crewed test flight. Boeing officials estimate that the crew module refurbishment process will take 4 months. Boeing conducted its uncrewed test flight in December 2019. Allotting 4 months for the refurbishment process means that Boeing will not be able to support an operational mission before April 2020, assuming the crewed test flight is completed by then as well.

In addition to refurbishing a flown spacecraft for the first time, Boeing continues to address technical risks identified by program officials. This includes a risk that the initiators that trigger separation events, such as the separation of the crew and service module prior to reentry, may generate debris and damage the spacecraft. In June 2019, we found that Boeing had identified a solution to contain the debris that was sufficient for its test flights.¹¹ Since our last report, program officials said that a number of problems were found in recent testing and that the independent engineering technical authority noted that the current initiator containment design is not acceptable for the crewed flight test. Program officials told us that they accepted this risk for the uncrewed flight test, but that additional testing will need to occur before the crewed flight test.

¹¹[GAO-19-504](#).

Astronaut Training. While completing hardware builds, both contractors must also finalize and execute their astronaut training plans to support their first operational missions. Though NASA has not yet certified the plans, program officials said they understood the contractors' training plans well enough to give the contractors approval to begin training.

Before they can fly an operational mission, the contractors may need additional time following their crewed test flights to update and complete the astronauts' training. NASA officials said that it is not possible to know how much time will be needed to incorporate lessons learned from the crewed test flights into the training plans. However, NASA officials estimated that the program and the contractors could need 3 to 6 months after their crewed test flights to update and finalize training before the first operational missions. NASA officials said they and the contractors would need this time to incorporate lessons learned from the crewed test flight into the training program, complete astronaut training, and prepare for the first operational mission flight readiness review.

Collaboration on FAA Licensing Process Has Been Underway for Years, but NASA and FAA Have Yet to Finalize Mechanism to Communicate about Waivers

Boeing and SpaceX each have developed a working relationship with FAA to facilitate the licensing process. Since 2017, FAA officials have unofficially observed the contractors' development activities, including the test flights, leading up to the first operational missions, to gain awareness and familiarity with both contractors' systems. Contractor officials told us that this has overall been a positive experience since it allows FAA and the contractors to work on the license application before it is submitted, including working through areas that might delay or prevent the license from being awarded. For example, Boeing officials stated that they worked with FAA to determine how to provide FAA access to communication channels as the launch progresses in the event FAA loses access to real-time data. Both contractors told us that they do not foresee an issue in obtaining a license and believe that, if any issues do arise, they have existing mechanisms that would allow them to resolve the issues.

Since 2012, NASA and FAA have also worked together to understand the other agency's requirements or standards in order to ensure the contractors will be able to obtain a license. NASA and FAA have collaborated in a number of ways, including the following:

- NASA and FAA signed a Memorandum of Understanding in 2012 that outlines the areas of work on which the two agencies agree to

collaborate, including the advancement of public and crew safety and avoiding conflicting requirements and multiple sets of standards.¹²

- In 2012, FAA and NASA officials reviewed the other agency's requirements to identify potential barriers to FAA licenses for Commercial Crew Program missions and to avoid duplicating agency efforts. This exercise resulted in identifying issues needing additional attention. For example, FAA and NASA identified the need to define a "government astronaut" to ensure NASA's astronauts could perform their expected duties on an FAA licensed mission. Simple clarification allowed the number of issues to be reduced.
- The agencies expanded on the Memorandum of Understanding through the Joint Program Management Plan (joint plan) in 2014. The joint plan defines how NASA and the FAA will collaborate to share information, analysis, and resources, thereby reducing the burden on the contractors. The joint plan also documents resolution of many of the outstanding issues identified in 2012.
- Several working groups were also created to help facilitate communication between the two agencies. NASA officials told us that while the working groups are less active now, FAA and NASA officials continue to collaborate through biweekly meetings. Officials from both agencies stated that they have strong working relationships with their counterparts.

One of the remaining open issues is how NASA and FAA will communicate regarding waivers that FAA could grant during the licensing process. FAA may grant waivers for changes to the license that do not jeopardize public safety. NASA officials explained that they want to be aware of FAA waivers before making a flight readiness decision to ensure that the waiver does not have an implication for crew safety. For example, NASA officials told us that FAA could grant a waiver to the contractor's launch trajectory lines. NASA officials explained that such a waiver could affect the crew in the event of an abort.

Both FAA and NASA officials have stated that they have not yet developed formal channels or mechanisms to share information related to license waivers for Commercial Crew missions because this has not been a priority for either organization. As of October 2019, however, NASA and

¹²The original Memorandum of Understanding expired in 2018. NASA officials told us they have reviewed and approved it, and that as of July 2019, it was being reviewed and approved by FAA officials.

FAA officials stated that they have begun to draft an update to the joint plan that would document how FAA and NASA will communicate about waivers. FAA officials said that they plan to have a draft completed by the end of 2019, but it would still need to be reviewed and approved by both agencies before taking effect. As of October 2019, there was no time frame for the review and approval process. Two of the primary goals of the agencies' joint plan were to outline the roles and responsibilities of both agencies and to ensure that each agency has the appropriate level of information and insight to execute its responsibilities under their respective authorities. Until FAA and NASA finalize the mechanism for communication about license waivers, NASA is at risk of relying on informal communication mechanisms when making a flight readiness decision.

Conclusions

While NASA and the contractors continue to make progress developing crew transportation systems to help the United States re-establish its domestic ability to provide crew access to the ISS, uncertainty remains about when operational missions can begin. NASA's plans to compress the transition from completing certification to the start of operational mission may not leave enough time to complete key reviews. It also remains to be seen whether either contractor can finish manufacturing the hardware and training the astronauts in order to support NASA's planned time frames. In light of this uncertainty regarding when operational missions can begin, it is even more important that NASA complete action on our open recommendation to develop a contingency plan, with time frames, to ensure a presence on the ISS.

NASA and FAA have collaborated since the early phases of the Commercial Crew Program and addressed a number of issues. However, time is running out for NASA and FAA to finalize a mechanism to communicate about waivers; in the meantime, the agencies are relying on informal lines of communication. Establishing a mechanism for how FAA will communicate with NASA about license waivers would ensure NASA is aware of any waivers that might affect its flight readiness decision.

Recommendations for Executive Action

We are making a total of two recommendations, including one to NASA and one to FAA.

The NASA Administrator should ensure that NASA documents how NASA and FAA will communicate about any waivers granted during the licensing

process for a Commercial Crew Program mission before an operational mission is conducted. (Recommendation 1)

The FAA Administrator should ensure that FAA documents how NASA and FAA will communicate about any waivers granted during the licensing process for a Commercial Crew Program mission before an operational mission is conducted. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a copy of this report to NASA and DOT for comment. In written comments, NASA agreed with our recommendation and estimated it would address the recommendation in the first quarter of calendar year 2020. NASA's comments are reprinted in appendix I. In written comments, DOT agreed with our recommendation, and its comments are reprinted in appendix II.

We are sending copies of this report to the appropriate congressional committees, the NASA Administrator, and the Secretary of the Department of Transportation. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix III.



Cristina T. Chaplain
Director, Contracting and National Security Acquisitions

Appendix I: Comments from National Aeronautics and Space Administration

National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001



DEC 24 2019

Reply to Attn of:

Human Exploration and Operations Mission Directorate

Ms. Cristina T. Chaplain
Director
Contracting and National Security Acquisitions
United States Government Accountability Office
Washington, DC 20548

Dear Ms. Chaplain:

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, "NASA Commercial Crew Program: Significant Work Remains to Begin Operational Missions to the Space Station" (GAO-20-121) dated November 20, 2019.

In the draft report, GAO makes one recommendation intended to improve communications on waivers between NASA and the Federal Aviation Administration (FAA). Specifically, GAO recommends the following:


Recommendation 1: The NASA Administrator should ensure that the NASA documents how NASA and FAA will communicate about any waivers granted during the licensing process for a Commercial Crew Program mission before an operations mission is conducted.

Management's Response: NASA concurs. The Commercial Crew Program (CCP) and FAA are in the process of writing an Addendum to the 2014 Joint Program Management Plan. The Addendum is expected to be completed by the end of the first quarter of 2020 and will document how FAA communicates waivers to CCP. Additionally, the joint FAA/USAF/NASA Launch Entry Steering Group (LESG) was formed and is used by the agencies to communicate on a variety of subjects for CCP missions. These communications would include FAA licensing waivers and emergent issues.

Estimated Completion Date: March 31, 2020

Once again, thank you for the opportunity to comment on the subject draft report. If you have any questions or require additional information, please contact Michelle Bascoe on (202) 358-1574.

Sincerely,



Douglas L. Ferro
Associate Administrator
for Human Exploration and Operations

Appendix II: Comments from the Department of Transportation



**U.S. Department of
Transportation**
Office of the Secretary
of Transportation

Assistant Secretary
for Administration

1200 New Jersey Avenue, SE
Washington, DC 20590

DEC 20 2019

Cristina T. Chaplain
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office (GAO)
441 G Street NW
Washington, DC 20548

Dear Ms. Chaplain:

The Federal Aviation Administration (FAA) has a strong relationship with the National Aeronautics and Space Administration (NASA). We will continue to work together to improve our coordination processes.

Upon review of the GAO draft report, we concur with the recommendation to ensure that FAA documents how it and NASA will communicate about any waivers granted during the licensing process for a Commercial Crew Program mission before an operational mission is conducted. We will provide a detailed response within 180 days of the final report's issuance.

We appreciate the opportunity to respond to the GAO draft report. Please contact Madeline M. Chulumovich, Director, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if you would like to obtain additional details.

Sincerely,

A handwritten signature in black ink, appearing to read "Keith Washington".

Keith Washington
Deputy Assistant Secretary for Administration

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Cristina T. Chaplain, (202) 512-4841 or chaplainc@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Molly Traci, Assistant Director; Kristin Van Wychen, Analyst-in-Charge; Laura Greifner; Kurt Gurka; Joy Kim; Roxanna T. Sun; and Alyssa Weir made significant contributions to this report.

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