



Position Paper:

## The NASA Commercial Crew Program

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### Summary

The National Space Society (NSS) strongly endorses the \$848 million 2015 NASA budget for Commercial Crew, along with the \$250 million supplemental Commercial Crew request. At a time when the availability of the Russian supplied Soyuz, our current sole method of getting American astronauts to the ISS (at \$70 million per seat), is being increasingly questioned and political relations with Russia are deteriorating, we need to move Commercial Crew to the top of NASA's priority list. NSS strongly recommends that the following considerations guide the Commercial Crew program:

- A minimum of two complete, technologically independent commercial crew systems should be brought to operational status. Commercial Crew can only be fully successful with real competition between multiple USA-based service providers.
- The value of Commercial Crew lies not just in providing the US the means of transporting astronauts to the ISS without relying on Russian spacecraft, but also in significantly strengthening the US commercial orbital access industry.

Consistent with these considerations, NSS urges the following:

- The full 2015 NASA administration request of \$848 million for Commercial Crew be appropriated by Congress.
- The additional special appropriation requested in the 2015 NASA budget in the amount of \$250 million for Commercial Crew be approved by Congress to compensate for the shortfall in the Commercial Crew line in previous budgets. If this full amount NASA has stated is required to reach operational status by 2017 is not provided, additional schedule slips are possible, leading to more money being transferred to the Russians.<sup>1</sup>
- The "hold" placed on \$171 million in the 2014 budget, making it dependent on a cost-benefit analysis of the Commercial Crew program, should be removed to avoid further delays in this vital program. Although the "hold"

language is part of the approved 2014 NASA budget, it requires no additional funds for Congress to remove this impediment to the successful completion of Commercial Crew.

- Sufficient funding for Commercial Crew should be provided in 2016 to bring at least two independent commercial suppliers to operational status in 2017 as currently planned by NASA.

## **Impetus for Commercial Crew**

Commercial Crew is a program administered by NASA targeted toward the development and operation of privately operated crew vehicles capable of reaching the International Space Station (ISS). This program is essential to restore the US's ability to transport crews to and from the ISS without depending on Russian vehicles. With the retirement of the Space Shuttle, the only means currently available for crew transport to the ISS are Russian Soyuz craft. In the most recent contract with the Russians which runs through 2017, they receive \$70.7 million per passenger.<sup>2</sup> This addition to prior contracts totals \$424 million to fly six astronauts to the ISS between mid-2016 and 2017, when NASA hopes that this task might be taken on by the Commercial Crew vehicles currently under development. The price per seat to the ISS charged by the Russians has been steadily rising from an initial \$51 million, to \$55.8 million, and then to \$62.75 million before reaching the current high of \$70.7 million.

The Commercial Crew program is also providing significant support for improvement of the US orbital access industry. This industry has the potential to significantly strengthen many aspects of global society and the US economy. If properly structured, the Commercial Crew program will substantially improve US competitiveness in this global industry.

## **Background/History**

The Commercial Crew program has been implemented in a number of phases. Commercial Crew Phase 1 ran from 2010-2011 and was funded at \$50 million spread over five different companies. Commercial Crew Phase 2 ran from 2011-2012 and was funded at \$270 million to four companies. The third phase was called "Commercial Crew Integrated Capability" and ran from 2012-2014. This phase is on-going at the current time, and includes three companies: Sierra Nevada Corporation (\$212.5 million), Space Exploration Technologies (\$440 million), and The Boeing Company (\$460 million). This phase overlaps with another program, "Certification Products Contract Phase 1" running from 2013-2014, also awarded to three companies: Sierra Nevada Corporation (\$10 million), SpaceX (\$9.6 million), and Boeing (\$9.9 million).

The Commercial Crew program has been proceeding well, considering the limited funding made available, and each surviving competitor has made significant progress toward a viable solution. It should be noted that the Commercial Crew program has made major use of Space Act Agreements which enabled the now operational COTS (Commercial Orbital Transportation Services) program to develop two all-new uncrewed vehicles to supply the ISS with cargo for far less money than traditional NASA contract procedures.

The current system solutions in the competition are:

- Sierra Nevada: Dream Chaser/Atlas V
- SpaceX: DragonRider/Falcon 9
- Boeing: CST-100/Atlas V

All of these solutions, and especially the two vendors receiving “full” awards (SpaceX and Boeing),<sup>3</sup> show every indication of being capable of bringing the program to a successful conclusion. The Atlas V is a highly reliable vehicle with a long record of successful launches.<sup>4</sup> The Falcon 9.1 has been successfully launched three times so far, and by the time of the first crewed flight can be expected to have much more launch experience. Boeing has a long history of producing reliable space vehicles, and the SpaceX DragonRider is based on the cargo Dragon currently operational in the Commercial Resupply Program (CRS) that followed COTS. Development of the Dream Chaser is proceeding successfully as well.

## Issues

### *Strengthening the US Orbital Access Industry*

The Commercial Crew program offers the potential to strengthen the US orbital access industry and build the foundation for a true private crewed orbital access industry. In the past, the US government has supported the development of new industries in various ways, ranging from Federal airmail contracts supporting early aviation to current nanotechnology research centers. Another example, and perhaps the most successful, would be the creation by the US military/DARPA of the data switching network that has become the current global Internet.

An opportunity exists today for Congress to enable the creation of a commercial crewed orbital access industry. This industry involves not just space tourism, but also satellite repair and refueling, industrial research, and private commercial space stations. Commercial Crew is a key enabler of this new industry, and can significantly contribute to strengthening the larger US space access industry, which has vast potential for the creation of large numbers of well paying American jobs.

Strong industries must have competition. A major advantage of the nature of the Commercial Crew program is that the competitive environment keeps costs low, and forces each competitor to seek other markets for their solution. For example, Sierra Nevada is marketing the Dream Chaser to European governments and achieving some success.<sup>5</sup>

But the development of alternative markets is also related to the timely success of the Commercial Crew program. Companies such as Bigelow Aerospace have flown multiple orbital test vehicles to demonstrate some of the technologies that they are planning to deploy to create inflatable private space stations. At one point delays in the readiness of Commercial Crew vehicles led Bigelow to lay off a substantial portion of its workforce to conserve capital.<sup>6</sup> Although Bigelow has since won a contract to attach an inflatable module to the ISS, its Commercial Space Station plans<sup>7</sup> remain in a holding pattern until the Commercial Crew program moves to operational status so that private persons can purchase tickets to orbit.<sup>8</sup>

*Funding Shortfalls*

There has been a long history of Congress substantially underfunding Commercial Crew, which has the effect not only of delaying the point where the US once again can launch astronauts to the ISS independently of the Russians, but also of greatly increasing the payments made to the Russians over time. Originally the first flight of Commercial Crew was planned for 2015. Consider the following facts:

Fiscal Year	Administration Request (millions)	Appropriation (millions)	% of request appropriated
2009 <sup>9</sup>	150	50	33.5%
2010 <sup>10</sup>	0	0	Nap
2011 <sup>11</sup>	500	321	64.2%
2012 <sup>12</sup>	850	397	46.7%
2013 <sup>13</sup>	830	525	63.3%
2014 <sup>14</sup>	821	696	84.7%

Note that in 2014 Congress appropriated \$696 million, but with \$171 million “held” pending the outcome for congressionally mandated studies on the value of the Commercial Crew program.

Some might note that many NASA programs don’t receive all of the requested funding. This is, of course, true, but there exists, as demonstrated above, a clear pattern of failure on the part of Congress to fully fund a relatively modest Commercial Crew effort in the context of maintaining or increasing funding for other NASA programs. Further, these funding shortfalls are significant, and are consistent with Congress’s expressed support for an early down-select to a single provider.<sup>15</sup>

The primary impact of the historically weak Congressional support for Commercial Crew has been to funnel American money to the Russian space program rather than to jobs in the USA. More recently, funding and support for Commercial Crew in Congress has been growing,<sup>16</sup> with increasing recognition of the merits of competitive programs such as COTS which reached full operational status in January 2014 under the CRS rubric with two private companies (SpaceX and Orbital Sciences) ferrying cargo to the ISS. The time is long overdue for Commercial Crew to be fully funded to enable it to proceed as rapidly as possible to full operational status.

### *“The Hold”*

In the approved 2014 budget, language exists holding back \$171 million of the allocated Commercial Crew funding until the NASA administrator certifies an independent cost-benefit analysis of the Commercial Crew program.<sup>17</sup> This action, while apparently reasonable, is just another obstacle being placed in the path of the Commercial Crew program by those in Congress whom for a variety of reasons are opposed to the program.

It should be noted that this level of scrutiny – an independent cost-benefit analysis – is not being applied to other NASA programs such as SLS and Orion. This is another piece of evidence of the political nature of the “hold.”

It is possible to alter the outcome of a cost-benefit analysis via careful selection of underlying assumptions. In the case of a cost-benefit analysis of Commercial Crew, key areas to consider are the operational lifetime of the ISS, the probability that the ISS will be followed by a similar LEO base, and the crew size of the ISS.

Commercial Crew should not be viewed as terminating with a theoretical end-of-life date for the ISS. It should be noted that the Administration is currently proposing an ISS extension for an additional four years, meaning that the anticipated Commercial Crew operations will be extended for four years to 2024. It is very likely, and indeed highly desirable that the life of the ISS will be extended well beyond this date. NASA has certified that an extension to 2028, an additional four years beyond that just proposed by the Administration, is possible without major efforts.<sup>18</sup>

China has announced that their large space station (CSS) will become operational in the 2020-2024 timeframe, and they are currently seeking international partners. It is difficult to imagine that the USA will at just that moment de-orbit the ISS, and abandon LEO space research to the Chinese.<sup>19</sup> Thus, all analysis of Commercial Crew value should be based on the realistic assumption that either: (a) the ISS lifetime is significantly extended beyond 2020; (b) the ISS is replaced with a follow-on USA/International/commercial station; and/or (c) Commercial Crew vehicles will continue to be used to transport crew to LEO in support of other future NASA

projects, e.g. assembly of a Mars ship from multiple launches. In all of these scenarios, low-cost, specialized, and reliable transport of crew to Low Earth Orbit (LEO) will be of continuing value to NASA.

The current size of the ISS crew is limited to six, since only two Soyuz “lifeboats” can dock to the ISS at the same time, and each Soyuz can carry only three astronauts. The introduction of Commercial Crew vehicles that can carry up to seven astronauts allows for expansion of the ISS capabilities to support a crew of up to 14. Even the use of a single Commercial Crew vehicle would allow for an expansion from six to seven, something that would significantly increase the scientific return from the ISS. The ISS can accommodate one additional long term crew member with minimal effort. The ISS can also, as was demonstrated during the Shuttle program, accommodate multi-week “surges” of additional crew members. Thus, Commercial Crew vehicles could expand the output of the ISS by periodically allowing teams of, for example, 5 scientists accompanied by 2 crew members, to live on the ISS for weeks at a time. It is expected that expansion to a permanent crew of 14 might require additional facilities to be added to the ISS.

Any cost benefit-analysis of Commercial Crew must give full weight to the advantages of allowing for a larger ISS crew, something which the current Soyuz will not support. Further, it should be noted that the number of astronauts on the Commercial Crew vehicles significantly affects the cost per seat. Arbitrary limits of, for example, four astronauts per vehicle artificially increase the cost per seat by a large factor.

#### *“The Down-select”*

There has long been a strain of criticism in Congress that calls for an immediate down-select in Commercial Crew to a single contractor, in the name of saving money and moving forward more rapidly.<sup>20 21</sup> Traditionally, NASA has run “competitive” procurement processes in which a number of proposals are considered, and then one is chosen to be developed into a flight article. This approach, although a reasonable one for experimental or some operational vehicles, is not the best approach for building a new industry. The traditional NASA approach has the effect of the system or service ultimately being supplied by a single “monopoly” vehicle from a single vendor, and provides no competition that would work to lower costs over time. Commercial Crew, like CRS, is intended to create a situation in which NASA has multiple, independent methods of moving crew to and from the ISS. Two fully independent USA-based providers combined with occasional use of the Russian Soyuz is the minimum system that will put real competitive pressures on all vendors.

A highly desirable characteristic of a fully successful Commercial Crew program is the operational availability of two technologically and financially independent solutions. For example, selecting the Dream Chaser/Atlas V and the CST-100/Atlas V introduces a single point of failure, the Atlas V. It would be equally risky to select

as the two solutions the Dream Chaser/Falcon 9 and the Dragon/Falcon 9 for the same reason. Similarly, choosing the Dream Chaser/Atlas V and the Dream Chaser/Falcon 9 as the two solutions makes the Dream Chaser a potential single point of failure.

Some critics of Commercial Crew envision a down-select to a single provider,<sup>22</sup> which is then alternated with Orion launches to the ISS. If done, this approach is not optimal for developing a commercial crew launch industry in the near term. In this scenario, the relatively high costs of Orion and its booster will mean that the single remaining “Commercial Crew” provider will have minimal on-going incentive to reduce costs or improve service.

### *Commercial Crew Safety*

Some critics fear that Commercial Crew will not provide sufficient crew safety.<sup>23 24</sup> NSS believes these concerns should be considered in a broader context.

**CONCERN:** The next phase of Commercial Crew will deemphasize safety since in the Commercial Crew solicitation NASA listed cost as the first metric for judging competitors, with safety listed second.

**RESPONSE:** This vein of criticism seems to be based not on actual data, but on a suspicious reading of Commercial Crew contract solicitations. Since NASA has switched from Space Act Agreements to FAR contracts for the next and final phase of Commercial Crew in part to allow for greater control to ensure crew safety, it is ironic that these concerns are just now surfacing. Even if safety were listed as the first priority in the contract solicitation, this would not mean that any amount of money could then be spent on crew safety without regard for cost. Listing crew safety as a second priority does not mean that suddenly rockets will be launched with rusty bolts and leaking fuel tanks. Safety is being demonstrated in Commercial Crew by actual tests, such as the two abort tests planned by SpaceX for 2014, as well as detailed reviews by NASA of the Commercial Crew vehicles. This abort capability should significantly increase safety compared to the Space Shuttle. The Commercial Crew providers must also meet FAA safety requirements in order to obtain launch and reentry licenses from the FAA.

**CONCERN:** NASA will lack the accounting tools to verify cost or pricing data. Critics speculate that such ground rules will lead to underbidding by contractors, resulting in either cost overruns or a disaster in space.

**RESPONSE:** In non-governmental commercial contracts, buyers typically do not receive any financial data about the costs incurred by a provider. Whether a provider makes money on a contract, and how much if they do, is the business of the provider. The concern of the customer is to ensure that the contract contains milestones demonstrating all critical requirements, including safety. The critics have not put forward any evidence to suggest that NASA will not do as well in this

respect with Commercial Crew as it did with the hugely successful – and safe – COTS program.

CONCERN: “... modifications to existing systems are inevitable, necessary, and expensive.”<sup>25</sup> It is implied that the funds needed to deal with these modifications will result in less safe operations.

RESPONSE: There is good reason to suppose that Commercial Crew, like COTS/CRS, will not see the requirements changes and escalating costs that are so common in traditional spacecraft development. The key methods of ensuring this is a simple set of requirements, established up front and then not changed materially, which thus far seems to be the case with Commercial Crew, combined with regular milestones demonstrating concrete progress.

NSS recognizes that the Commercial Crew program is based on a heritage of reliability. Re-use of well-known or existing technology is also very helpful in ensuring reliable operations. Boeing is making use of the highly reliable Atlas V. SpaceX is building its solution on a Dragon capsule that has already visited the ISS and returned to Earth multiple times, and which was designed from the start with human crews in mind. These architecture decisions presage reliable operations for Commercial Crew.

It should be noted that various defenders of Commercial Crew have responded with vigorous rebuttals to those raising safety concerns, although emphasizing different points than are discussed in this paper.<sup>26 27</sup>

### *Using Orion for Transport to the ISS*

One justification for Orion is possible use to ferry crews to the ISS. Launching an Orion to the ISS should be viewed as an extreme emergency measure to be put on the table only when both Commercial Crew solutions have failed and a Soyuz is not available. Sending an Orion/SLS to the ISS solely for crew transport would be too expensive to merit serious consideration. The Orion could be launched to the ISS on some other vehicle, such as a Delta IV Heavy or the Atlas V, but would most likely be a higher cost solution relative to the Commercial Crew alternatives, especially those using the Falcon 9 booster. It should be noted that the Delta IV Heavy would need to be human-rated to implement this scenario, which would require an additional allocation of funds not currently covered in any planned NASA program.

The crew capacity of Orion is also an issue, as it is limited to four astronauts in the standard configuration.<sup>28</sup> All of the Commercial Crew vehicles have a potential capacity to carry seven astronauts. With two “lifeboats” docked at the ISS, the Commercial Crew vehicles would support an ISS crew of up to 14, while Orion would potentially limit this number to eight. Even the use of a single Commercial Crew vehicle as a “lifeboat” on the ISS would allow the crew to immediately expand by one member (from 6 to 7), who could then do science full time.



Finally, all of the Commercial Crew Earth return vehicles are designed for ground as opposed to sea landings. This holds out the promise of significant operational cost savings over Orion, which is designed for water recovery only.<sup>29</sup>

Considering the above points, as the Commercial Crew program demonstrates success, there will be no need for the Orion program to be moved forward in strict parallel with Commercial Crew with the idea that it will provide another level of redundant access to the ISS. Two Commercial Crew solutions plus the Soyuz will provide extremely robust access to the ISS. The value added by a fourth higher cost method of reaching the ISS is marginal. This matter can be reconsidered in the advent of long-term Soyuz unavailability.

## Recommendations

- *Commercial Crew should be funded to provide an absolute minimum of two technologically and financially independent solutions.*
- *Commercial Crew should be fully funded in 2015 at \$848 million, with no “held” amount. It is imperative to move forward as quickly as possible to operational capability, and to stop sending money to Russia.*
- *The \$250 million supplemental Commercial Crew request should be approved to compensate for past shortfalls as requested by the administration. Funding in 2016 should be sufficient to support a minimum of two technologically different suppliers to operational readiness in 2017.*
- *Commercial Crew should be managed with the understanding that the goal is to create a true commercial crewed launch industry, similar to the fashion in which Federal airmail contracts encouraged the early growth of commercial aviation. This requires that Commercial Crew be operated in as competitive a fashion as possible. In particular, the purchase of large blocks of launches from one vendor is to be avoided. Ideally, each launch, or possibly small blocks of launches, would be sent out for competitive bids.*

## Footnotes/References

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<sup>1</sup> NASA Administrator Blog: [Launching American Astronauts from U.S. Soil](#), April 30, 2013.

<sup>2</sup> Aviation Week: [NASA To Pay Russia \\$424 Million For Six Soyuz Seats](#), May 1, 2013.

<sup>3</sup> Note that SpaceX and Boeing are currently being funded at about twice the level provided to Sierra Nevada. SpaceX and Boeing are described as having “full” awards in the current contract, while Sierra Nevada has a “half” award.

<sup>4</sup> United Launch Alliance website: [Launch Vehicles - Atlas V](#).

<sup>5</sup> Space News: [European Space Agency Could Contribute Hardware to SNC's Dream Chaser Spaceplane](#), January 8, 2014

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- <sup>6</sup> Space.com: [Private Space Station Builder Downsizes Dramatically](#), October 6, 2011.
- <sup>7</sup> Wikipedia: [Bigelow Commercial Space Station](#).
- <sup>8</sup> [Bigelow Aerospace website](#).
- <sup>9</sup> Space Politics: [Shelby wins battle on stimulus funding](#), July 3, 2009.
- <sup>10</sup> Space Policy Online: [NASA IG Warns on Commercial Crew as NASA Celebrates End of COTS](#), November 14, 2013.
- <sup>11</sup> Ibid.
- <sup>12</sup> Ibid.
- <sup>13</sup> Ibid.
- <sup>14</sup> Space Policy Online: [Appropriators Release FY2014 Omnibus Bill, NASA Does Well](#), January 13, 2014.
- <sup>15</sup> Parabolic Arc: [House to NASA: Down Select to Single Commercial Crew Competitor Immediately](#), April 25, 2012. Note that the desire of the House to down-select to a single provider is not speculative, and in fact appears in a [House Committee on Appropriations report](#).
- <sup>16</sup> Parabolic Arc: [Congressional Cuts Force NASA to Send More Money to Russia](#), January 29, 2014. Although this article takes a downbeat tone, it should be noted that the bar chart shows that the Commercial Crew budget has been increasing over the years, although still falling short of the requested amount.
- <sup>17</sup> Innerspace: [Commercial Crew Still Under Fire](#), January 17, 2014.
- <sup>18</sup> The Washington Post: [International space station operation extended by Obama until at least 2024](#), January 8, 2014.
- <sup>19</sup> Space News: [China Unveils Space Station Research Plans](#), November 12, 2013.
- <sup>20</sup> Spaceflight Now: [Competition at core of commercial crew program](#), May 2, 2012.
- <sup>21</sup> Previously cited [House Committee on Appropriations report](#).
- <sup>22</sup> Parabolic Arc: [House to NASA: Down Select to Single Commercial Crew Competitor Immediately](#), April 25, 2012.
- <sup>23</sup> Space News: [Opinion: NASA Forgets Key Lesson from Columbia Accident](#), January 20, 2014.
- <sup>24</sup> Aviation Week: [Opinion: NASA Crew Plan Fails To Put Safety First](#), February 3, 2014.
- <sup>25</sup> Space News: [Opinion: NASA Forgets Key Lesson from Columbia Accident](#), January 20, 2014.
- <sup>26</sup> Space News: [Opinion: A NASA for the Future](#), February 3, 2014.
- <sup>27</sup> Space News: [Opinion: Avoiding Risk – and Success](#), February 24, 2014.
- <sup>28</sup> NASA Spaceflight.com: [NASA ESD set key Orion requirement based on Lunar missions](#). As discussed in this reference, Orion will support up to four astronauts, with an “evolution path” to six. This suggests that Orion capsules generally available would support only four crew members, while a special version would need to be purchased to support six astronauts. This would still be one fewer than for the Commercial Crew vehicles.
- <sup>29</sup> NASA Spaceflight.com: [Orion landings to be splashdowns](#), August 5, 2007.

**About the National Space Society (NSS):** NSS is an independent non-profit educational membership organization dedicated to the creation of a spacefaring civilization. NSS is widely acknowledged as the preeminent citizen's voice on space, with over 50 chapters in the United States and around the world. The Society publishes *Ad Astra* magazine, an award-winning periodical chronicling the most important developments in space. To learn more, visit [www.nss.org](http://www.nss.org).