NASA AMA: We are expanding the first human-rated expandable structure in space. . . .AUA!

JSCNASA [1] and r/Science AMAs[1]

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April 17, 2023

Abstract

We're signing off for now. Thanks for all your great questions! Tune into the LIVE expansion at 5:30am ET on Thursday on NASA TV (www.nasa.gov/ntv) and follow updates on the @Space_Station Twitter. We're a group from NASA and Bigelow Aerospace that are getting ready to make history on Thursday! The first human-rated expandable structure, the Bigelow Expandable Activity Module (BEAM) will be expanded on the International Space Station on May 26. It will be expanded to nearly five times its compressed size of 8 feet in diameter by 7 feet in length to roughly 10 feet in diameter and 13 feet in length. Astronaut Jeff Williams is going to be doing the expanding for us while we support him and watch from Mission Control in Houston. We're really excited about this new technology that may help inform the design of deep space habitats for future missions, even those to deep space. Expandable habitats are designed to take up less room on a rocket, but provide greater volume for living and working in space once expanded. Looking forward to your questions! *Rajib Dasgupta, NASA BEAM Project Manager *Steve Munday, NASA BEAM Deputy Manager *Brandon Bechtol, Bigelow Aerospace Engineer *Lisa Kauke, Bigelow Aerospace Engineer *Earl Han, Bigelow Aerospace Engineer Proof: http://www.nasa.gov/press-release/nasa-televises-hosts-events-for-deployment-of-first-expandable-habitat-on-0 We will be back at 6 pm ET to answer your questions, ask us anything!

the WINNOWER

REDDIT

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JSCNASA R/SCIENCE

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How do you handle radiation? I imagine that an expandable structure must be initially compact, making it difficult to have good radiation shielding and be safe for human usage. Really interesting work!

PM_ME_POTATO_PICS

Radiation protection is indeed critical for astronauts on the Space Station and eventually traveling to Mars. As a technology demonstrator, BEAM will be fully instrumented with a variety of sensors by the Space Station crew after deployment and ingress, including thermal, debris impact, and radiation sensors. In addition, there are already sensors on the aft bulkhead that will measure dynamics loads during deployment this Thursday. Data from the sensors inside BEAM will be downloads by engineers on the ground throughout the 2-year mission on the Space Station. This data will be invaluable for the viability and design of future expandable habitats. Radiation can behave differently when passing through multiple fabric layers vs. metallic shells. It remains to be seen how BEAM's radiation protection will compare to standard metallic modules, but that is a big part of the reason for doing this tech demo, paving the way for the use of expandable structures in future exploration missions. - sm

For deep space missions, how do you envision your inflatable habitats protecting astronauts from radiation and how, if at all, will the gas(es) used to inflate the structure vary based on application? Are

there any plans on eventually incorporating self-healing polymers in your future designs so as to make your structures more robust in the unlikely event of a minor puncture?

Lawls91

Great question. Infatables have protection in terms of MMOD and thermal protection ad has a robust MMOD and thermal protection design. BEAM demonstration will provide us data on radiation protection. The gas used to inflate the structure if it is used for habitats has to be 21% Oxygen breathing air. Self healing polymers are very advanced materials with low TRL but will be used for future designs of inflatables. If successful, they can provide a huge benefit. RDG.

What have been the most difficult hurdles you have run into that were not initially anticipated?

whatntheactualfuckme

Perhaps the biggest challenge was ensuring that BEAM does not impart large loads into the Space Station when it deploys. BEAM's forward bulkhead is currently attached to the Space Station's Node 3. When BEAM is deployed early this Thursday morning (NASA TV coverage begins at 4:30 AM CDT), the aft bulkhead will move away from Node 3 and stop moving when BEAM is fully deployed. Simplistically, lets say that 1500 lbs, half of BEAM's 3K lbs, moves away from the Space Station. Engineers needed to make absolutely sure that when this 1500 lbs suddenly stopped moving, it didn't jerk the BEAM/Space Station interface too hard. So, they limited this maximum impulse load by adding energy absorbers to BEAM's internal design that limit how fast the aft bulkhead can move away from the Space Station. Plus, initial inflation will occur manually with the Space Station crew introducing air very slowly from Node 3 into BEAM through a small manual valve. It takes very little air pressure (only ~0.4 psi) to fully expand BEAM with this manual inflation method. After BEAM is fully extended and can no longer impart a "jerk" load to the Space Station, the crew will activate BEAM's automatic pressurization system that will open valves on the internal air tanks to fully pressurize BEAM to close to normal Space Station pressure (14.7 psi). - sm

What have been the most difficult hurdles you have run into that were not initially anticipated?

whatntheactualfuckme

One of the larger hurdles that we ran into was on the subject of handling the dynamic effects during expansion. When air is first introduced into the module, the structures want to expand away from each other very quickly. Since BEAM is attached to ISS during this process, much analysis and testing was performed to ensure that the forces involved could be managed so as not to harm anything currently on ISS. -BB

Has any thought gone into how to safely decommission the BEAM module once it has reached its end-of-life?

Are there any special considerations to take as compared to the standard modules?

HyenaCheeseHeads

Good question. The end of mission plan is to jettison BEAM from below the Space Station using the robotic arm. BEAM will naturally drift away from the Space Station and re-enter the earth's atmosphere about a year later. NASA engineers have analyzed this reentry and determined it will pose an extremely low risk to people on the ground. Remember that most of BEAM is made of fabric materials that will burn up quickly during reentry. The metallic parts of BEAM (for example, the two bulkheads on

either end) are made of aluminum which should also burn up during entry. Even in a worst case scenario in which most or all of these bulkheads make it all the way to the ground, there is an extremely low risk of falling near anyone according to conservative computer model analysis.

The rest of the Space Station also will reenter the earth's atmosphere after the end of its usable lifetime, but it will be a controlled, guided entry, meaning it will be targeted to enter above an ocean, far from populated areas. BEAM has no propulsion or guidance capability, but still poses an extremely low risk to us on the ground. - sm

What kinds of usage could this have for travel beyond LEO? Should we expect structures on off world colonies to be made with these kinds of expandable materials?

This feels like a huge milestone, at least by old science fiction standards

mustardman24

Expandables can be used for deep space habitats like on the surface of Mars. It can also be used as transit habitats attached to ORION on our way to deep space. Expandables can be used on the Earth for several useful protective structures application

Hey guys, what kind of effective serviceable lifespan do you expect for the inflatable modules? How does this compare to the 'standard' metal modules in use today?

WhollyUninterested

BEAM is scheduled for a 2-year mission on the Space Station. However, it could easily last for 5 or more years. Existing Space Station metallic modules are designed for the full lifetime of the Space Station through 2024. - sm

Probably a dumb question, but where does all the air used for the expansion come from? How much is required?

mwholt

There are 8 air tanks inside of BEAM. However, the Space Station crew will initially expand BEAM this Thursday morning by introducing a little bit of air from Space Station into BEAM through a small manual valve on the BEAM bulkhead. It takes very little air, only ~0.4 psi worth, to expand BEAM to its full shape. Once that manual inflation process is done, then the Space Station crew will activate BEAM's internal tank system to automatically pressurize BEAM to full pressure at or near Space Station's pressure of 14.7 psi. Altogether, it takes about 42 lbs of air to fully pressurize BEAM's internal volume of 565 cubic feet (16 cubic meters). - sm

Will the module be expanded in vacuum and then pressurized, or will it be inflated by air pressure like a balloon?

KubrickIsMyCopilot

The introduction of air into the module will provide the force required to expand the module. However, it's different than a balloon in that a balloons membrane stretches significantly when pressurized, while the shell of BEAM is a much more "stiff" membrane that stretches very little. In reality, BEAM's shell

can be better described as unfolding during expansion, rather than inflating. -BB

Two questions:

What specific applications do you envision for BEAM?

How strong is the expansive material (i.e. what sort of issues with space debris can it deal with)?

MadGeekling

For deep space terrestrial habitat applications Like Martian habitats. Strength is approximately 12,500 lbs/in.

RDG

How difficult would it be to adapt a BEAM-style system to a surface colony on Mars or the Moon?

mrstickball

BEAM is a technology demonstrator providing the data and experience essential to build expandable habitats for future exploration missions, including lunar and Martian missions. As a tech demo, BEAM is much stronger and more dense than an operational habitat would be for a Mars or moon mission. Expandable habitats offer the advantage of launching small, taking up less room on launch vehicles, and then getting big in space or on the surface of Mars or the moon, and may eventually offer lower mass than metallic models at larger volumes (though the mass advantage hasn't been demonstrated yet in space flight). - sm

I've always wondered how the internal parts of the module can fit. With the rest of the ISS, the walls are covered in all sorts of cabinets and the like, so how do those fit inside the module before it's expanded?

The_King_of_Ways

Great question. BEAM's internal metallic components (e.g., air tanks) are attached to the aft bulkhead, which is also metallic. Internal sensors will be mounted to the interior of the soft goods by the Space Station crew after they deploy and ingress BEAM. These sensors were not pre-attached to the soft goods interior due to concerns about damage during deployment. This is an advantage of metallic modules: the can be internally outfitted before launch and more easily since there are more mounting areas around the shell interior. As a tech demo, BEAM will not have items like cabinets, but future operational habitats may require a central metallic structure between the bulkheads for attaching cabinets and other metallic outfitting. - sm

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The_King_of_Ways

The core of expandable spacecraft offer the space and attachment points for crew support systems, research racks, etc. Once on orbit, the astronauts can move the equipment to the expanded walls. The BEAM is a bit different because there is only a small core structure that wasn't designed to support

crew systems. BEAM expands axially and radially, but future spacecraft will probably have a fixed core (and only expand radially). Check out the cutaway image of the B330 on the Bigelow website! ~LK

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The_King_of_Ways

BEAM is unique because it is primarily a testing and demonstration module, and therefore does't require a great deal of equipment on the interior. Future modules will have all of the equipment, subsystems, supplies, etc. stored within the internal core structure, while the soft materials are packaged around it. Once expanded, the module can be outfitted and reorganized with the stored hardware. -BB

Hi guys! what were the difficulties in creating these expandable structures? what makes them work?

Doctorwhogityboogity

The magic is really in the strength of the materials (what we refer to as the "softgoods"). The expansion process, itself, is passive. Once restraint straps and a few other mechanisms are released, the addition of air to the system pushes the walls of the softgoods out. The structure becomes rigid as the air pressure increases. ~LK

Is this structure scalable? What sorts of limits?

penrosetile

Most definitely scalable. BEAM is 16m3 of internal volume. The latest Bigelow module BA 330 is 330 m3.

RDG

Hey guys! Structural Engineer here.

What are the concerns of design engineers related to impact loads from space debris? How hard is it to puncture these inflated structures?

BillSixty9

The layered MMOD shield is designed to decimate debris particles before they reach any of the structural layers, so it also absorbs the energy. The shield compresses and, therefore, does not transfer load to the structure. The MMOD shielding capability of the BEAM is equal to (if not better than) the rest of the Station modules. If you're interested in learning more about shielding against space debris, I'd recommend searching "Whipple shields". Thanks for the question! ~LK

Have there been any cases that you know of, in your department or otherwise, where Kerbal Space Program has been used to test or share ideas, or even inspire ideas?

monkeydave

We recently sat down with Das Valdez of Kerbal Space Academy to talk about BEAM. Check it out here: https://www.twitch.tv/dasvaldez/v/66066218

-EH

I'm really excited by this technology.

Will anyone be going inside this particular BEAM, and will they be inside a suit or not?

Also, how did it feel to watch your project go up on a reusable rocket?

dodgyville

Crew will ingress/egress the BEAM intermittently over the two year nominal mission duration. The BEAM is a shirt sleeve environment so no suit or anything like that.

It was pretty amazing and we were also ecstatic for SpaceX.

-EH

How do you test the fabric against the impact of micrometeoroids here on earth?

SaltyMN

We have the ability to simulate impacts from micrometeoroids by conducting Hypervelocity Impact Testing, whereby representative samples of our entire soft material shell are impacted by projectiles traveling on the order of 7 kilometers per second! We can then verify that no damage is done to the innermost protective layers. -BB

Bigelow Folks: Will the B-330 have a window installed in order to allow the astronauts working to open it and enjoy the cool breeze of space?

upandawayJ

Yes! In fact, the B330 will have four windows integrated into the soft goods exterior. However, astronauts will not have the ability to open the windows from the inside.

If you inflate one of these modules can you deflate it and reinflate it again or is it one time use?

aspiringsomebody

Technically, the module could be depressurized and repressurized, however repackaging the module is not feasible. To date, we have not come across a scenario where depressurizing and repressurizing would be required, so the current designs are for a single deployment. -BB

What's the procedure for expanding this thing? What safety precautions do you put in place on the ISS during the expansion of it, or while it's expanded? What differences are there between how the Bigelow Module is connected to the station vs. other modules? Super excited for this by the way!

ferlessleedr

There are several steps involved with the expansion process including: closure of an ascent vent valve that allows the module to vent air during ascent, release of retention straps that hold the soft goods tightly packed during launch, separation of the forward and aft structures, and eventually a controlled expansion. The controlled expansion is accomplished by the crew manually opening and closing a valve that allows small amounts of air to flow into the module. Once the module takes shape, internal pressurized air tanks will open allowing the module to pressurize and eventually match the internal pressure of ISS. -BB

Hello, thanks for the AMA!

Just wondering, what is a realistic maximum size for such a structure?

Also what is a possibility of this structure that interests you the most?(This question is for each team member :D)

Thanks!

lolredditor

We haven't really researched a realistic maximum size for the structures because the launch vehicle fairings are the limiting factor. I can tell you that we could build a structure to fit the largest available fairing. In my opinion, the potential for expandables in cislunar space is really exciting. I'll let the rest of the team weigh in. ~LK

I have two questions.

How long does the inflation process take?

Also does the BEAM depend on the atmosphere inside the the ISS to inflate and if so is there anything that would allow for the BEAM to inflate itself (possibly through chemical reaction or stored atmosphere)?

rubiks14

The duration of the BEAM deployment process will depend on daylight passes and access to TDRS. Nominally, the process will take a few hours.

The BEAM was delivered to station with air in pressurized tanks so most of BEAM's full pressurized volume will not be dependent upon ISS resources.

-EH

What is being tested during this two-year test period? Why was two years chosen as the testing period?

atomfullerene

The following things will be tested. Dynamic Loads, radiation, Orbital debris impact and thermal

RDG

Hey guys! Thanks for talking to us. This *is* a serious question, (though some of you might wonder how I wandered in here). As a more literary than science-minded person, **why should I care about the ISS and these recent advancements**? How do these advancements impact all of our lives here on the ground? Thanks!

Mondayslasagna

The materials and medical research that is currently happening on the ISS has direct benefits and applications on Earth. This is a great question and I wish I had more time to expand on my answer. Please visit the ISS research page to learn more: http://www.nasa.gov/mission_pages/station/research/benefits/index.html ~LK

How much more room for activities would you say there will be?

snowman_M

So much! -BB

What were your favorite classes in college guys?

141_1337

Mechanics of Materials, Control Theory and Heat Transfer. ASU School of Engineering! ~LK

I want to join Nasa/space industry in the future.

What can I do at high school to make myself more attractive to employers or anything that would help in general?

Thanks :)

Dubata

I would recommend getting involved in activities that interest you and applying your learning to real world projects as much as you can. For example, a lot of the people on our team were involved with rocket clubs or other science-related clubs in high school. Showing that you're passionate about the industry and having a science or engineering degree to back it up is the way to start. Best of luck to you and welcome to the space industry family! ~LK

What is this particular module going to be used for?

How do you hope to see the ISS (or other manned space missions) further use these expandable structures?

An inflatable living space doesn't seem as sturdy as good old-fashioned metal modules. The first impression of expandable space modules I think people could have is that all it will take is one rip it's all over. So tell me why it's perfectly safe.

Epistemify

BEAM serves as a technology demonstration along with having the ability to provide useful data about radiation, thermal, and micrometeoroid impacts. We are hoping to continue our great relationship with

NASA and provide expandable habitats for an array of uses ranging from scientific experimentation for long-term life support systems, deep space transportation habitats, or even surface modules for Lunar or Martian applications. A common misconception is that the hull of an expandable module is carrying a large amount of elastic energy as a greatly stretched membrane, something like a balloon. The membranes of our habitat, however, are incredibly stiff in comparison (and several times stronger per weight than metals commonly used in space applications). This means that tears or punctures, although unlikely, would not propagate and can be handled in a very controlled manner just as they would on current metallic modules. -BB

Do expandable habitats seem like they could be used as surface habitats ? Say on the surface of Mars ?

daltonhrrll

Yes, definitely! Just as in the movie, The Martian...only without the catastrophic explosion that nearly killed Matt Damon. :) Expandable habitats have the advantage of being launched small, taking up less volume on launch vehicles and in transit, and then become big later, expanding to full volume in space or even after being pre-deployed to the surface of Mars. - sm

What are the most common degrees in your team? Are there people with computer science degrees? What are their responsibilities?

dreadington

Lisa and Brandon have Mechanical Engineering backgrounds. I have an Aerospace background. Computer Science is definitely a valuable degree to have and there are plenty of ways to utilize your degree in the space industry.

-EH

This pic from Tim Peake shows the damage to a window from a paint fleck.

How do expandables react to the problems of orbital debris?

DasGanon

Expandables mitigate MMOD similar to many of the other modules that are currently on station, via MMOD shielding. The difference is what's underneath the shielding!

-EH

I suppose this is probably more a question for the ISS itself, but given this is also adding extra volume to the ISS, how is the air created to fill this volume?

RedSquirrelFtw

The BEAM was launched with air stored in pressurized tanks. This air will be utilized during deployment to fill the volume of BEAM.

-EH

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RedSquirrelFtw

The BEAM includes air tanks that will be used to pressurize it. Only a small amount of Station air will be used to get the BEAM to take its shape, initially, before the tank valves are open. Once the tanks are empty, the BEAM will essentially have "given back" the air. Thanks for your question! ~LK

Thanks for taking the time to answer our questions. How long has the BEAM module been in development? As a corollary, can you describe, briefly, the design and testing process?

bruhaha6745

The BEAM was contracted by NASA in late 2012. The design of BEAM followed a traditional design process utilized by many engineering organizations (i.e. PDR, CDR, FDR, etc.). Testing adhered to standard NASA qualification and acceptance testing requirements and some additional unique tests that were required for the unique BEAM module!

-EH

How are the seams joined together? What alternatives were considered and how was the final approach decided on?

ZizeksHobobeard

Can't tell you! -BB

When someone goes inside, will they be tethered and in a space suit in case if catastrophic failure?

OCogS

BEAM has undergone rigorous testing to ensure it meets the current NASA safety standards. Crew will be able to enter the module as a standard "shirt-sleeve" environment without the need for a space suit or tether. -BB

What gas(es) will you be using to expand the BEAM?

bakaken

Standard breathing air. ~LK