**AirSpace Transcript Season 10, Episode 1: The Science Never Stops**

**Emily:** *(excited)* Are you ready Matt? Are you ready?

**Matt:** *(resigned)* Yeah, I think I'm ready

**Emily:** Are you sure?

**Matt:** mmhmmm

*AirSpace theme in then under*

**Matt:** Welcome to season 10 of AirSpace from the Smithsonian's National Air and Space Museum. I'm Matt,

**Emily:** And I'm Emily. The museum has tons of artifacts, thousands of objects that tell the history of air and space. And every once in a while, a scientist comes along and asks if they can use something in our collection to do even more science.

**Matt:** And if it's a credible ask, and it won't damage the artifact, and it will advance research in some way, we say 'yes, scientist. Come visit us, and we'll help you do science on our stuff.'

**Emily:** We're talking about how that whole process works and taking you behind the scenes while real science happens on our Viking lander today on AirSpace sponsored by Lockheed Martin.

*AirSpace theme up and out*

**Emily:** So Matt, I don't do anything with collections at our museum because I'm not a curator. You're the curator. It's not really an uncommon thing for museums' collections to be working collections.

**Matt:** Yeah. You know, a lot of museums have collections that are based on the idea that you're saving stuff so that people can do research with it. We think about that a lot with natural history museums[1], for example, right? Where they have collections of all different types of life or shells or rocks. And, you know, those are either research or teaching collections a lot of the time.

[1] https://naturalhistory.si.edu/research/collections-national-museum-natural-history

And the same is true of technology museums or history of science and technology museums like ours, where our collection becomes kind of the physical record especially on the space side of what's been used to, you know, explore space and learn things about the planets, the solar system, et cetera.

And you know, one of the cool things about our collection is because we collect all of these spacecraft and in many cases, they're the test models, development models, or flight spares that didn't go, but that are just like the flown thing. And because so many of those things themselves were kind of like one of a kind spacecraft that were used to, you know, carry a specific set of instruments to a specific planet, you know, what we have can be the only representation of that thing that flew.

And on the air side, our artifacts tend to be aircraft that have a very specific history. So studying them up close can be important to researchers of history, but also to engineers who are looking for inspiration for the next big technological leap forward.

**Emily:** What's it like when you get a request from somebody to use an object that's in your collection?

**Matt:** So my collection is, you know, related to planetary exploration, planetary science, Earth science[2]. And there are about a dozen of us who curate different parts of the space history collection, whether that's, you know, human spaceflight, the Apollo missions, rockets, all of those things.

So my part of the collection is specifically the stuff that's been used to do planetary science. And so, you know, as new missions are being developed, occasionally I do get somebody reaching out to me asking if they can come look at a thing.

And if they just want to look at a thing, that's usually easy. An engineer wants to come out and see for example, how one of the rovers is actually put together because they can look at the schematics and they can look at pictures, but when they can actually look at the thing and see it in three dimensions and get up close to it, sometimes they see what's not on the paper, which is that kind of tacit knowledge about how the thing was actually built.

But if you want to touch the artifact, that's a whole other thing, right? ‘Cause I don't even touch the artifacts most of the time we have professional conservators[3] and object handlers who do most of the touching of the objects when they need it.

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[2] https://airandspace.si.edu/people/staff/matthew-shindell
[3] https://airandspace.si.edu/about/organization/departments-staff/conservation

And we try not to touch them when they don't need any kind of work or to be cleaned or anything like that. So it's a little bit more of an ask, right? When somebody wants to do something to an artifact and, and so that's when you have to start weighing the balance between the preservation of the object and its long term care versus its actual value as a piece of space exploration and the sort of ongoing activities of NASA.

Because, you know, most of the time it is coming from NASA and most of these things came from NASA in the first place. And part of the agreement that we have between the museum and NASA is that, you know, we are helping them preserve their history.

And we are also, you know, preserving these things so that they can continue to have a record of them. We aren't NASA's museum, but we do have that relationship with them where, you know, we want our collections to remain valuable and useful to the folks who built it. Whether that's NASA or someone else.

**Emily:** Well, and I think this is really interesting, Matt, because I feel like for a lot of folks, collecting, curation, and conservation feel like all something that are one job, one job of a single human. I think for a lot of folks, they don't understand the difference between conservation and the work that you're doing as a curator.

Because while they're totally related, you're not the one who's completely worried about how do you preserve this paint from chipping off of this item that wasn't designed to last for 50 years.

**Matt:** Yeah. And, you know, that'll be different from museum to museum. We are very fortunate at the Smithsonian that we have different departments that specialize in doing every part of the museum's job, you know, helping the museum fulfill its mission.

At smaller museums, you might have one person doing a lot of that stuff themselves, or they'd have to bring someone in who's an expert on it. We have all the experts in house, which is always fantastic. So like, whenever there is a question about an artifact, what we should or shouldn't subject it to, how much light it can handle, how, how fragile it might be to having a sensor put on it or whatever the ask is then we can sort of convene a conversation and decide what we can and can't allow to happen to the artifact.

So I feel very privileged to be able to work in a space that, you know, I have all of that expertise to draw on so that I'm never the one who's making the decision alone. Although ultimately as the curator, it is kind of my decision at the end of the day whether to say yes or no, I have to take a lot of other people's informed opinions on board and think about that before making a decision. So I never feel like I'm out on a limb when I say yes or no.

**Emily:** And for this episode we reached out to one of the people who you consult with when you get this ask, the Museum's Chief Conservator

**Malcolm:** Yeah, my name is Malcolm Collum[4], and I'm the chief conservator at the National Air and Space Museum. In that role, I'm responsible for the care and preservation and protection of the National Collection.

**Emily:** The big conservation question is whether or not the science can be done without actually hurting the object or erasing any signs of its original use and purpose.

**Malcolm:** And of course, you know, in my position once something becomes an artifact in the National Collection our objective is to try to keep the artifacts as original and representing their original mission or scientific objective as much as possible. So as long as the nature of that research doesn't harm or alter the artifact we usually permit it.

**Emily:** So, in the case of the story that we're telling today, you, Matt Shindell, has gotten a request from somebody in the scientific community to look at and touch one of the artifacts that's under your curatorial umbrella. What happens next?

**Matt:** Right, so the first thing I did was I reached out to our conservators, uh, the folks who have handled the artifact recently. So for example, in this case, it was the Viking Lander[5]. The Viking Lander had just recently gone through conservation because we took it off display in Milestones of Flight[6] in order to renovate that space.

And we were going to put it back on display in Milestones of Flight. So it's already been through conservation, which means that somebody has been up close and personal with that artifact; has cleaned it, has noted any kind of problems that the artifact is having, has stabilized any materials that need stabilizing.

In the case of most spacecraft, it's usually flaking paint. Cause that space paint was never meant to sit in Earth conditions for years on end. Um, and you know, they have the best kind of closeup knowledge of whether something's going to be good or bad for the artifact. So the first thing I did was I wrote to our head conservator, Malcolm Collum, as well as some other conservation folks, uh, to get their opinion on whether or not we could do this.

**Malcolm:** They wanted to put a seismic device on the actual Viking Lander that we have on display downtown at the National Mall. And it's our job to make sure that, yeah, that

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[4] https://airandspace.si.edu/people/staff/malcolm-collum
[5] https://airandspace.si.edu/collection-objects/lander-mars-viking-proof-test-article/nasm_A19790215000
[6] https://airandspace.si.edu/air-and-space-quarterly/spring-2023/milestones-flight

can be done safely. There are flat surfaces on the Lander and it, it is originally designed as a test model of the original landers that landed on Mars. And so it is about as accurate an example of one of the actual landers that are still on the surface of Mars.

So their research can best be revealed by interacting with the original test model. There's no harm to the artifact being done, but we're advancing this particular line of research, which is great.

**Matt:** And one thing I haven't mentioned, but probably should is that we do try to preserve everything about the artifact as we get it when we first take it in, right? We're trying to preserve not just the object itself, but the history of its use. And one of the cool things about doing this type of project where scientists or engineers come in to make use of the artifact again, is that that becomes part of that history of use as well.

So we're not trying to, you know, add new marks to the thing or, or dents or anything like that. But still this becomes part of that artifact's story.

*Music Button*

**Emily:** I didn't get to go into the Milestones Gallery to see all this happen, but Matt, you were able to join the researchers from the Johns Hopkins Applied Physics Labs to come to the museum and actually do their seismological research using the Viking Lander, which was the first mission to land a spacecraft and send images back from the surface of Mars in 1976[7]. Interesting year.

**Matt:** Yes, also the year that the museum opened and that I, Matt was born. I, I landed the same year. *Emily laughs*

This was obviously a really interesting project from the standpoint of the science that they wanted to do, but also bringing people into the museum, into a gallery that's still under construction.

So the Milestones of Flight Hall is one of our big signature galleries. It's the one that you walk into when you first walk in the doors of the museum, and it's got all of the sort of, you know, record breaking or, or the firsts from aviation and spaceflight. And the Viking Lander is there, of course, because it was that first successful Mars landing mission that really sets the tone for most of what we've done on the surface of Mars since then.

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[7] https://science.nasa.gov/mission/viking/

And so, yeah, this was a construction site. This was a hard hat area. And we had to uncover the lander from underneath its protective tarp in order to place these, uh, seismometers onto Viking. And so it was kind of a cool and interesting thing. We all had to go put on our, our PPE, our hard hats and our safety goggles and vests and, and go down on the floor.

**Matt (in museum):** Here are gloves, and you also need vests, and where are the hard hats? Oh, hard hats are in here

**Matt:** And then of course we have the extra, uh, dimension of having Jen with her microphone and everything there as well, which we don't usually have, right? When we go into the construction site or when we do this type of artifact research.

So we had a group of researchers from Johns Hopkins University,

**Ben:** So, my name is Ben Fernando[8]. I'm a seismologist working at Johns Hopkins University, on some of the NASA missions to the Moon and Mars

**Kevin:** My name is Kevin Lewis[9]. I'm a professor at Johns Hopkins University in the Department of Earth and Planetary Sciences. I'm Ben's advisor. I'm here to support him, this is his experiment today.

**Emily:** And I thought when you first was such an interesting experiment that they wanted to run. I feel like, as a person who is near and dear to Voyager data[10], that a lot of folks think we can't get anything else out of Voyager data and I'm like, no, wait, but there's more.

I love the fact that we're going back and trying to dig through data from the 70s and trying to learn more about Mars.

**Matt:** Yeah, and the fact that this is a construction site where people are banging things around and lifts are rolling back and forth meant that they could collect some really meaningful data. So the fact that it was a construction site meant it was kind of like the ideal situation for this type of research.

**Ben:** So, InSight[11], which was a NASA mission that I worked on, had collected a great deal of seismic data from the surface of Mars between 2018 and 2022.

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[8] https://eps.jhu.edu/directory/benjamin/
[9] https://eps.jhu.edu/directory/kevin-lewis/
[10] https://science.nasa.gov/mission/voyager/science-data-access/
[11] https://science.nasa.gov/mission/insight/

And that was really useful for understanding more about how Mars' interior worked, how often it's struck by meteoroids today, and how some of those surface processes, like the atmospheric weathering, couple into the interior. Viking, which is this mission that we're working on here, collected similar data back in the 1970s[12], but a lot of it was affected by wind noise, and that was mostly from wind shaking the antenna dish, which is on top of the lander.

What we're trying to do here is to basically figure out what sort of signals that wind might have produced on the antenna, because the tests were not successfully conducted before Viking launched. And by doing it on this instrument here, we're able to basically try and clean up some of the Viking data back in the 70s and see if we can make it more useful.

**Emily:** What I love so much about this idea that they had was that they really can go in and they can ask the question, we know InSight detected Marsquakes. Some people think Viking detected Marsquakes, but they didn't have enough information about all this noise that might be coming from the lander itself.

So, can we take that information that you're getting from the Air and Space Museum with these seismometers attached to Viking and use that to subtract out all of this noise from the Viking data and see whether or not Viking actually detected Marsquakes.

**Ben:** This is the only way that we could conceivably do these measurements today. So the actual instrument is obviously on the surface of Mars. It never came back. And as I mentioned, the tests that we, that Andy and others tried to do on this before it launched in the mid-1970s, they weren't recorded successfully. So that data was never stored and able for us to use today.

The advantage of doing a test like this today is that we can go back and try and clean up that Viking data without this artifact here at the museum there's been no way for us to do that.

**Matt:** The Andy that Ben references was a member of that original Viking team and worked with the seismometer on Viking back in the seventies.

**Andy:** I'm Andy Lazarewicz retired right now. Worked on Viking when I was a graduate student at the University of Hawaii. And I also worked for long stretches at Caltech, MIT, and JPL. I was at JPL during the flight.

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12 https://data.nasa.gov/Earth-Science/VIKING-LANDER-2-MARS-SEISMOLOGY-RESTORED-DATA-V1-0/nmdt-k5k6/about_data

**Matt:** So there was this continuity of new researchers coming to this data, but also, you know, folks who've been working with the data for years coming to perform this experiment.

**Andy:** So I was a graduate student during that time and then we ended up with uncertain results. We had two events that we believed were Marsquakes, but could not prove them. And so they became possible Marsquakes[13]. And that's the way they were published in 1977. And I kept the data and promised myself that when the second lander lands on Mars, I will use their data to figure out the Viking data.

So I kept the data for about 10 or 20 years. And then at Boston College, when I was there, somebody decided to clean out the tape closet and threw my data out. So in 2018 when I retired, InSight landed. I retired in August, InSight landed in November and I became in partnership with them to try to recover the Viking data.

And so it's, I started the data by taking my old codes that are photocopies of line printer outputs that are 50 years old. And from that, I ended up building, after about four years, a set of analysis techniques using InSight data to resolve this. And published where I proved, or believed I proved, that the two events we had were real.

After that, these folks here, Ben Fernando and company, decided they were going to use the data I have and check it, whether it would be Marsquakes, or impacts.

**Matt:** So there are, there are multiple Viking articles out there at various museums and science centers. Ours happens to be the most complete version. It's made from the real hardware that was used on the flown Viking landers and was used to test the Lander when they were preparing for its mission.

That’s why Ben knew there was only one place to go when he decided he wanted to do these tests.

**Ben:** So our plan was basically, um, turn the nodes on once we get there, deploy them so we'll put them out, just take lots of pictures for the orientations, and then we've got a hammer, um, and a strike plate to tap on the floor. We've got a plate to protect the floor.

We've got a fan so we can blow on the lander if that's okay. Like literally a desk fan, which should change the resonance. Um, and Andy's got a couple things he wanted to try as well

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[13] https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2022JE007660

**Emily:** Ben, Kevin, and Andy came to visit us in September with their sensors, sometimes called nodes, which are encased in plastic, they're about the size of a Nalgene water bottle, and they weigh about two pounds. They'll record any and all vibrations that happen in the gallery and on the lander.

**Ben:** So, I'm just turning on the nodes now. What that basically means is they're going to start recording, uh, the seismic data, and we're just connecting them up before we put them out onto the lander.

In order to sync all of the different measurements between them, they all need to be operating on the same clock system. So otherwise, if we didn't do that, we wouldn't know what signal lined up with what signal between the different sensors. The way that they do that is that they, um, acquire a GPS signal from satellites, and then that basically means that they're all measuring the same time to a much greater accuracy than if we just used a clock to do it

**Matt:** Once the nodes were turned on and recording, there was a back and forth between me, the curator, and the researchers, and the folks from the Collections Preservation Unit[14], Lisa Young and Becca Hiatt, about where and how to place the sensors.

**Ben:** Yeah, so question. The seismometer box is the one at the back, right?

**Andy:** Yes.

**Ben:** But you suggested not actually on the box?

**Andy:** On the box I think would be a problem because the box is just a box. It doesn't vibrate. So the sensors themselves are attached to this, that's why I would put it either here if you can.

**Ben:** There's probably space behind the box over here.

**Lisa:** That is very tights, I don’t went it to scrape, this paint flakes off very easily. So I don't want it to scrape onthe way down to that surface. Yeah. Just in case yeah, but if you can reach your arm in there,

**Ben:** I can yeah,

**Andy:** I think that's probably the best place because it's the closest

[14] https://airandspace.si.edu/about/organization/departments-staff/collections-processing-unit

**Emily:** They ended up putting a small layer of mylar between the sensors and the lander for protection. They placed two sensors on the lander, and then additional sensors on the display and the floor around it. Then they did a few calibration tests.

**Ben:** Um, I think we'll do some knock tests if that's okay as well. So we've got a metal plate, we'll just drop a hammer on it from like this high.

**Kevin:** Down here, not up there

**Ben:** Yeah, I'm not on the Lander

**Matt:** Yeah, I think

**Lisa:** Sure, just don't ruin our floor.

**Matt:** Yeah, we just did this floor, didn't we?

**Lisa:** Yeah, we're gonna get in big trouble if there's any harm to the floor.Yeah, please. That'd be good….

**Matt:** They set the metal plate They brought on a piece of floor protecting cardboard

**Kevin:** so we'll probably just kind of like, let the hammer fall, not like wailing on it

**Ben:** Why don't we do that… No, no. Why don't we do that before you get on the, I'm just going …*(fades out)*

**Matt:** and then lined up the hammer they also brought for the drop.

**Ben:** Um, actually, do you mind, um, measuring so we, at least we can control how much energy is going into it then?

**Kevin:** What do you want, this foot pad?

**Ben:** No, no, no, like just how high we're going to drop it from, does that make sense?

**Kevin:** Oh yeah, sure

**Ben:** So maybe like 10 centimeters? I don't think we need a sort of nuclear explosion or anything.

**Kevin:** 10 centimeters seems low. Maybe 20?

**Ben:** 20? Okay. I just don't want to fall. Is that 20?

**Kevin:** A little higher. Uh, yep. My thumb down here. Okay. A little lower.

**Ben:** A little lower. Okay. Everyone ready?

**clank**

**Emily:** They also had a small desk fan that they used to blow some air around by the Lander, and then Matt had to use a thread to very carefully and gently pull on the antenna arm, which hopefully created just enough vibration to register on their seismometers.

**Andy:** So, it's along those two foot pads.

**Matt:** The ones on that side?

**Andy:** Right, and the ones on that side. Roughly in that direction. And then crosswise. This way, too. Raise it as high as you can. Cause you want to get that thing to oscillate just a little bit.

**Matt:** Is this a good direction?

**Andy:** Yes.

**Matt:** How many times do you want me to pull it?

**Andy:** Pull it like three times with three different pulls.

**Matt:** Okay. And then what direction?

**Andy:** this way, 90 degrees to where you are.

**Matt:** Like over here?

**Andy:** Yeah, you want to pull hard enough that you think the thing will move, will just respond a little bit

**Matt:** You just need those two directions? Yes. Okay, well I did three pulls each way.

**Andy:** Okay, we'll give it a try. Is

**Matt:** Is that good?

**Andy:** We'll see. We don't know. The answer's a positive, definitive maybe

**Matt:** *laughs* Science.

**Emily:** But I just, I had this picture of like Matt on this like really tall rickety wooden ladder leaning over with like

**Matt:** It wasn't like that

**Emily:** somebody holding him by the belt and like wrapping a string around a thing and just like pulling it up a little bit and I don't know why it felt like a Norman Rockwell painting but that's, that's, that's my wish for you Matt is to have somebody do a Norman Rockwell painting of that.

**Matt:** I like it. I like that. *Emily laughs*

So after everything was set up, this is when the kind of time lapse begins, right? The sensors sat for a few weeks picking up the vibrations that happened on the Lander and in the gallery so that Ben and his team could use that data to figure out what the Viking from, figure out what the Viking data from the 1970s was telling us.

**Emily:** And we're just going to have to update you when we get more information, because we don't know the results, because science is hard.

**Matt:** Yeah, I just gave those sensors back to Ben last week, so we're still waiting to hear what they recorded.

**Emily:** Matt, this is not the first time somebody has made a request of you. This certainly isn't the first time there's been a request to get in up close and personal with one of our artifacts for scientific reasons, not just because it would be cool. What are some of the things that either you've been involved in or you know had happened before you started at the museum?

**Matt:** Well, one of the more recent examples is from our Stardust return capsule[15]. So, you know, the Stardust mission flew out to the Comet Wild 2 and collected material from the Comet's coma and brought those back to earth in that return capsule.

If you witnessed the OSIRIS REx[16] landing with the asteroid samples from the asteroid Bennu, the Stardust capsule entered and landed in much the same way.

And what happened with that one was that scientists, once they got the samples that Stardust had brought back with it, they wanted to know if there was a possibility that they had also collected bits of the spacecraft in addition to bits of the comet, because when you're out there flying in space there are things that sort of blow the paint or other things off of the surface of your spacecraft. And possibly that ends up in the, the sort of collecting medium, which in this case was aerogel.

So one of the things that they wanted to do was to kind of eliminate that possibility by coming and taking a look at what materials the, the spacecraft had on it that were possibly ablated.

So they came to us and our head conservator, Malcolm, with a request to take samples off of the return capsule

**Malcolm:** So they needed to basically take a sample so they could have this baseline reference. So if they see something that matches the elemental composition of the sample they took from the spacecraft, they'll know that this is not interstellar dust.

So we allowed that because it was a critical aspect of their analysis of these particles. They needed to eliminate the possibility that some of these impacts could be sources of contamination. I think that's probably the only example where we allowed scientists to come and physically take a material sample off of one of the artifacts.

**Emily:** That's so cool. Aerogel[17] is weird.

**Matt:** *laughs* Right. Exactly. And then one of my favorite stories, really, is something that happened long before I came to the museum. Back in, in 1977, NASA, the Jet Propulsion Laboratory, gave us a beautiful full scale model of the Voyager probe, right? Voyagers 1 and 2 that explored the outer solar system.

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[15] https://airandspace.si.edu/collection-objects/capsule-stardust/nasm_A20080417000
[16] https://science.nasa.gov/mission/osiris-rex/
[17] https://www.aerogel.org/

Before that mission even launched, NASA started offering us this beautiful full scale model that was built from spare parts and also some test models and other things. A fully complete representation of Voyager.

And then almost exactly 10 years later in, in 1987, NASA came back to us and said, look, we're trying to, to create a Venus mission. And we're going to have to build this thing out of spare parts from other missions. And we want to use parts of Voyager. And so we really need your Voyager bus, the main body of the spacecraft, uh, because we're planning to use a Voyager bus for this spacecraft and we need yours to help us develop that.

And we said, yes. And NASA gave us a facsimile bus that we replaced the original with. And I'm not entirely sure what they then did with the bus that they took from us. If that's the one that went to Venus on the Magellan[18] mission, which is the Venus mission that they developed from all these spare parts, or if they used it only in developing the spacecraft and then used another bus. I'm still trying to get to the bottom of that one.

So if anybody's out there and knows whether our Voyager bus went to Venus in the 1980s. I'd love to know it, because I'd love to write a story about the bus that showed up at the museum and ended up at Venus.

But, um, I think that's a great story of like, you know, you think that these things are old hardware, old missions, you know, obsolete, but in fact, sometimes they become incredibly useful again, when NASA decides it wants to use the same technology, uh, for a second go around.

**Emily:** So we're not just preserving history for ourselves and for humanity, We're we're, preserving history for all kinds of reasons.

**Matt:** Yeah, we're preserving the future.

*AirSpace theme in then under*

**Emily:** AirSpace is from the National Air and Space Museum.

AirSpace is produced by Jennifer Weingart and mixed by Tarek Fouda. Hosted by Dr. Matt Shindell and me, Dr. Emily Martin. Our managing producer is Erika Novak. Our production coordinator is Sofia Soto Sugar. And our social media manager is Amy Stamm.

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[18] https://science.nasa.gov/mission/magellan/

A big thank you to our guests in this episode; Malcolm Collum, head conservator at the National Air and Space Museum. Dr. Ben Fernando, and Dr. Kevin Lewis from Johns Hopkins University, and Dr. Andy Lazarewicz. And thank you to the NASM Collections Preservation Unit for facilitating our foray into the construction zone, with special thanks to Lisa Young and Becca Hiett.

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*AirSpace theme up and out*