hi I'm Beth Wilson and today I am with our chair of the Aeronautics Department Bob van der Linden Bob how are you today I'm fine thank you how are you good Bob can you tell me where we're sitting this morning we are sitting in the cockpit of a Boeing 747 and why do we have a Boeing 747 in our collection well we have a 747 here so our visitors can get some idea of the scale and scope of what a modern airliner looks like and now we only have the nose cone is that correct that's correct why just the nose cone well primarily because the rest of
the airplane would not fit in this building and where do we get this airplane we got this airplane from Northwest Airlines and do you want to show me exactly how big the whole airplane is i hope you glad to thanks Bob so this is just 35 feet then yes and so what is the plane double that size it's a bit bigger than that well how do I start walking why don't you tell me where oh well okay here Bob keep going how about now Bob almost there how about no Bob there you go that's it
okay so how do you get a plane this big off the ground that's the four forces of flight this is stem in 30

hi I'm Beth Wilson and I'm coming to you live from the America by air gallery at the National Air and Space Museum in Washington DC and in this gallery we take a look at the history of commercial aviation beginning with early male planes going all the way to our Boeing 747 nose cone now Bob and I talked a little bit about how we get a plane this big off the ground and to help me to cover the four forces flight I've got
Marty here Marty do you want to explain how we get something this big off the ground sure so we're gonna talk about the four forces of flight those are weight drag lift and thrust so let's start with what keeps us on the ground and that's weight so weight is simply gravity pulling us back down towards the ground now everybody look around is anybody floating around up there in the ceiling no gravity is doing its job it's pulling us back here to earth so in order to fly we've got to counteract that weight the next ones drag and drag is the opposite motion
that we want to go so if we want to go

forward drag pulls us back and that's

caid by friction and differences in

air pressure now that's kind of hard to

understand so I've got a little

demonstration here I've got two pieces

of paper they're exactly the same

but if I take this one and i wad it up

and then drop them Newton's laws tell us

that they should hit the ground at the

exact same time but watch what happens

the wadded-up paper hit way faster than

the one that stayed flat and that's

because of drag the friction of the air
coming down with the flat one caused it to go slower so those are the two forces that keep us on the ground well that's very nice but that doesn't tell me how we get up into the air and stay there exactly so it takes two other forces to get us up into the air and to keep us there the first is lift lift is the force that pushes us up into the air it's mm and it's caused by differences in air pressure so let's take a look at this airfoil this is an airplane wing that's basically been chopped up like a loaf of bread the bottom of this wing is
nice and flat the top is curved now

pressure pushes down on all sides of this wing all the

but as it flies through the air the air going over the top gets squeezed down

and goes faster and that creates a low-pressure area over the top of the wing the high pressure underneath pushes

that wing up into the air that's kind of confusing you guys get that let's try an example you guys all have a strip of paper in your hands hold those up we're gonna put them up above our top lip and we're gonna blow okay what do you think
is gonna happen is it gonna go up or

00:04:59,300 --> 00:05:06,079
down it's gonna go okay let's see the

00:05:04,759 --> 00:05:07,939
paper went up and that's simply because

00:05:06,079 --> 00:05:10,159
we blew air underneath it and push that

00:05:07,939 --> 00:05:12,290
paper up now we're gonna hold that same

00:05:10,160 --> 00:05:13,640
piece of paper under our bottom lip and

00:05:12,290 --> 00:05:15,290
we're gonna blow over the top of it

00:05:13,639 --> 00:05:15,519
what's gonna happen is it gonna go up or

00:05:15,290 --> 00:05:19,730
down

00:05:15,519 --> 00:05:21,769
everybody says down let's try the paper

00:05:19,730 --> 00:05:24,140
came up that's because we cause that air

00:05:21,769 --> 00:05:26,209
to go faster over the top and then and

00:05:24,139 --> 00:05:28,099
create a low-pressure area underneath we

00:05:26,209 --> 00:05:31,099
had higher pressure that push that paper

00:05:28,100 --> 00:05:32,510
up into the air so that's lift but
that's not the only force that we need
we also need thrust if you take a look
at this propeller
it's shaped like an airfoil when we turn
that on its side it gives us forward
motion which is thrust so lift gets us
into the air thrust keeps us in the air
okay and you said that propellers create
thrust yes there's no propeller on this
airplane there are not but a lot of the
same concepts are used in jet engines if
you look at this cutaway of an airplane
jet engine you'll see that on the inside
is a series of air foils just like this
propeller and it pulls that air into the engine creating thrust so we create that thrust to get us up into the air

now this plane is significantly different than the Wright brothers plane or any plane with a propeller the designs have changed dramatically in the last hundred years and the materials that we've used have changed a lot but those four forces of flight have stayed the same okay so every single airplane in this gallery relies on the four forces of flight to get us off the ground and to stay in the air it's
exactly right okay and I think we have

an online question can we get an online

question how do you do helicopters work

the same way as airplanes they do if we

look at the propeller again you'll see

that it looks very similar to what's on

the top of hill

copter it's got these air foils and when

it spins it creates that low pressure on

the top higher pressure underneath

because the air going over the top is

faster low pressure there

high pressure underneath and it gives us

lift that takes the helicopter up into
the air so a helicopter is works the

same way it's just a little different

look exactly okay now today's show we're

going to talk about composites but

before we get started on the composite

part of it I've got a 30 second

challenge for you all so let's get

started with that

okay so does anyone have a guess of what

this might be just a guess

give me a guess good what do you think

it is it's part of an airplane

okay

this is actually part of a composite

airplane and you can see it's like
really light but it needs to be very

strong in order to build an airplane out

of it so we're gonna test this strength

and to do that I need a volunteer out of

the audience you want to come up come

right here we have hold on a second we

have this but we have to be safe because

you know you're gonna hit this all right

we don't want pieces to go flying into

your eyes so on the count of three all

right hit it as hard as you can one two

three but that little hammer didn't do

much but keep them on what do you think

about this one do you guys think this is
00:09:15.049 --> 00:09:29.419
going to do it one two three what do you

00:09:23.779 --> 00:09:32.120
think no there's there's there's it

00:09:29.419 --> 00:09:37.009
didn't break did it so not only is it

00:09:32.120 --> 00:09:40.580
light but it's also strong right now we

00:09:37.009 --> 00:09:43.069
don't have a composite plane in our

00:09:40.580 --> 00:09:45.200
museum here but our friends at the

00:09:43.070 --> 00:09:48.740
Museum of Flight in Seattle do have a

00:09:45.200 --> 00:09:51.440
Boeing Dreamliner and they're chief

00:09:48.740 --> 00:09:53.480
curator Dan Hagedorn is going to show us

00:09:51.440 --> 00:09:55.880
some of that plane right now

00:09:53.480 --> 00:09:57.680
I'm an excellent curator here at the

00:09:55.879 --> 00:09:58.480
Museum of flying at historic Boeing

00:09:57.679 --> 00:10:00.519
Field

00:09:58.480 --> 00:10:02.320
the beautiful blowing 787 dreamliner
that you see behind me represents the state-of-the-art in composite technology. I'd like you to come on board with me and take a look at some of the wonderful things that composite technology is going to do for you as a member of the traveling public. One of the first things to recognize is how extremely clean and smooth traditional wrinkles, vivid lines, panel lines, and so forth if you find on traditional metal build aircraft, you will find about every six times on the year.
enjoy seed however where the different

barrels as they call them or joined

together to form the fuselage

these were extremely smooth

and extremely strong may contribute

significantly

one of the most interesting engineering
developments in the boeing 787

dreamliner

are its ranks which of course are also

made of composite materials one thing

that's noted by passengers and those on

the ground like is the incredible degree

of flex in the wing structure while the

aircraft is in flight this often
referred to when you look at the aircraft goes on as the Boeing smile when Boeing was testing the engineering on those wings they flexed as much as 25 feet at the wingtips displaying not only the rigidity of the wings and their ability to flex but also the fact that they gave them much more comfortable ride to the passengers onboard the aircraft without any risk to the aircraft whatsoever okay okay so that is a quick view of a Boeing Dreamliner and we are going to talk more about composites now and I’m so lucky to have
material engineer here Arlene Brown from the Boeing Company now we've been talking about airplane composites but obviously these aren't pieces of airplanes do you want to tell me why we have this out here yeah if you make something that big you really want to be able to recycle it right so it turns out plastics the type that are in water bottles for instance those will melt and they're easy to recycle but this is basically an epoxy composite in our airplane and so we needed to develop a method and so for instance the raw
materials can turn into something like this if we have some excess or we can even take the actual finish composite parts like when we cut our circle out for the window and another company can go chop them up and turn them into parts and this is actually chopped fiber that originally came from an airplane base okay so what you're telling me is that I'm not going to find a Dreamliner in one of those airplane graveyards you can recycle it exactly okay so I think what we'd like to do now is take a look at actually how we make the parts of the
airplane using composites goo like epoxy

00:12:58,159 --> 00:13:02,439
resin is already on this slick carbon

00:13:00,679 --> 00:13:05,479
tape that is being put onto spools

00:13:02,440 --> 00:13:08,000
spools feed the custom carbon tape into

00:13:05,480 --> 00:13:09,950
a robot head this automated fiber

00:13:08,000 --> 00:13:12,528
placement process allows us to place a

00:13:09,950 --> 00:13:14,480
composite material where it’s needed and

00:13:12,528 --> 00:13:17,838
in the direction we want for efficient

00:13:14,480 --> 00:13:19,909
design using heat and pressure the robot

00:13:17,839 --> 00:13:22,160
head lays the tape onto a rotating

00:13:19,909 --> 00:13:24,649
barrel the barrel is sealed under

00:13:22,159 --> 00:13:26,328
bagging materials and the air removed it

00:13:24,649 --> 00:13:27,860
is then baked in one of the world's

00:13:26,328 --> 00:13:30,409
largest autoclaves

00:13:27,860 --> 00:13:33,050
an autoclave is a giant oven that
applies pressure once the part is done. 

baking we remove it and take off the bagging the part is then inspected and joined to the other airplane sections. 

this process allows us to make large integrated structure and minimizes waste while optimizing strength and stiffness.

okay Arlene so I have a piece of composite here but what you have are the raw material so do you want to tell us a little bit about what these are as compared to this oh I'd love to so this is epoxy resin otherwise known as glue and it actually is basically kind of a
liquid form though when we we marry it

up with the carbon fiber you just saw

the carbon fiber on those spools going

out and those spools actually have a

little bit of this in that fiber and

then what we make is something that we

said we sometimes call prepreg and we

take this material and this is what the

form is when it goes into the basically

the autoclave which is a giant oven when

it comes out it looks like this okay so

d this baked is this but this is really

smooth here but my piece it looks like

it has fabric in it this this doesn't
look the same what's the difference

between this and my actual airplane part

we call reinforcement instead of just being one

piece of tow is actually woven into a fabric in kind of the same way that you close them for actually woven okay now

the students that we here are from Jefferson Academy and they actually built some composite materials and ran some experiments would you like to take a look oh that would be terrific okay

alright guys today we are gonna test our
composites and I can't wait to see how

00:15:39,620 --> 00:15:43,250
you guys did in building them yesterday

00:15:41,029 --> 00:15:45,799
so let's review a little bit of

00:15:43,250 --> 00:15:48,019
composite is any material that's made of

00:15:45,799 --> 00:15:49,519
two or more materials put together and

00:15:48,019 --> 00:15:51,740
it gives it a different characteristic

00:15:49,519 --> 00:15:53,360
for example today we're going to be

00:15:51,740 --> 00:15:54,200
testing some composite materials that

00:15:53,360 --> 00:15:55,879
you guys made

00:15:54,200 --> 00:16:00,009
now the first test we're going to do is

00:15:55,879 --> 00:16:00,009
what we're we're going to test first

00:16:01,750 --> 00:16:04,970
we're gonna take two pieces of cardstock

00:16:03,889 --> 00:16:06,769
and we're going to test them we're gonna

00:16:04,970 --> 00:16:08,660
lay them on top of each other and test

00:16:06,769 --> 00:16:12,559
how much strength they have is that a
composite no it's just the same material

it just happens to be two pieces of it

what's the next thing that we're gonna test what are we gonna test next yeah we're gonna take two card stocks and you guys blew them together yesterday is that a composite material yeah because it's got two different materials combined and we're hoping that it increases the strength so what was the third thing that we're going to test that's exactly right a layer cardstock glue a layer fiberglass cloth more glue and layer
cardstock so let me show you guys how

we're gonna set this up today and I'll

use this as our example

you guys all built your testing

apparatus yesterday and the way that

you're gonna do this is you're gonna

come over here you're gonna reach in and

pull your string up and then you're

gonna slide this through it everybody

see that then after you do that you're

gonna come over here and you're very

slowly remember very very slowly you're

gonna pour that water into the funnel

we're gonna weigh this before we start
to get a baseline on it and then we're gonna weigh it after it it fails to see how much water it held see how much weight your composite was able to hold you guys ready to start look at this guy's the paper cut before the composite gave away so the string on there actually cut into the paper before it had a chance for that composite to give away that's awesome your composite held up great how much a hundred and six that's amazing good job guys and this was the one you built okay so
it looked like they were very successful.

with their composites the kids did a great job building the composites.

actually we've got one of them that's gonna share their results alia you want to share your results with us hang your experiments a composite increase I could father increase the amount of water of how much water it was hole into the jet so there was more it held more weight which one worked the best the two composite with the fabric between them okay so the big composite deposit worked yeah because posits really increased the amount of strength that they were able
to hold okay and do you want to start us

off with a question yes since I'm an

Avery how can composite help me in my

everyday life so how can composites help

somebody that's in eighth grade oh well

Sporting Goods in general there's a lot

of stuff that's coming out it's not just

to be shown here it's tennis racquets

golf clubs hockey sticks all sorts of

things bikes now that are all lighter

you'll find that they actually might be

in some of the electronics that you have

for instance and if you've got somebody

that's driving you to and from hopefully
that you know as we get more composites

in the cars it's helping to reduce the
gas bill the fuel bill and now we have

an online question

why're composite composites an

improvement over metal for for building

airplanes well what we saw earlier today

was a demonstration of really how
durable they are because you have pale

bottles and things like that but you

especially have people that drop tools

and stuff like that sometimes so that's

just one thing they also they don't

corrode they're more fatigue resistant
which is has to do with when the pressure goes out and in for instance on the airplane and there's lower maintenance costs this is like the for the Dreamliner and we talkin thirty percent lower maintenance costs because all of these different things that add up and the other thing is part count we have almost two thirds the part count because we've got these huge integrated structure barrels instead of you know one barrel might be replacing over you know fifteen hundred pieces of aluminum that would go in a normal fuselage how
many parts are in a Dreamliner around

2.3 million got it three million and we

have another online question we're here

why Arkham the same question we have

yeah well I have them web where have

composites made the most difference on

an airplane that's a tough one

so I'm gonna go with the the combination

of the exterior we've had composites on

the interiors for a very long time and

so with the the Dreamliner we went on

the outside and it wasn't just that it

was lighter it was because you can shape

it from an aerodynamic point of view as

well and you can put some sections thin
and some sections thick instead of having to use the same thickness everywhere because you have different requirements and different needs in different places.

Okay, so the composites are great for the outside, but our friend Dan out at Seattle is going to tell us how it's making a difference for the passengers on the inside of the Dreamliner. Welcome aboard Boeing 787 Dreamliners GA zero zero three here at the museum of flight at historic Boeing Field in Seattle Washington now we're going to be
taking a look around the interior of the aircraft to show you some of the passenger accommodations that have been made possible by the composite structure of this aircraft as you make your way to your seat on the Dreamliner there's several things that will become apparent to you very quickly the first thing you're going to notice is how quiet it is aboard this aircraft both on the ground while you're waiting to take off as well as in flight the second thing you're going to notice is the incredible feeling of spaciousness that the
aircraft provides to you as you make your way through your flight this is facilitated by the fact of the overhead lighting you here you see and behind me the blue lighting effect that is prevalent on the aircraft as we have are sitting here but there's also a wonderful rainbow effect that has a very calming influence something that's far more subtle however that you're not going to notice right away is the incredible degree of atmospheric control to the aircraft has a direct result of the composite structure of the aircraft
you're going to feel as though you're flying at a lower level and the humidity controls aboard the aircraft are directly controlled by the crew itself it's going to feel much more comfortable but last but not least as the overhead bin something that we're all familiar with they deploy very very nicely aboard this aircraft and more importantly they're quite large these are all a direct result of the composite structure of this aircraft one of the wonderful passenger amenities provided by the composite structure of the Dreamliner is not only the relative location but the
size of the passenger windows that

you'll find at every one of the

passenger seats am I left here and I'm sitting on a seat at the relative elevation of most of the standard coach seats and first and business class seats on the Dreamliner you'll notice that I don't have to do this or this or this in order to look out the window and have a panoramic view remember those pesky pull up pull down shades that you found on conventional airliners not going to find those on the 787 dreamliner instead every single passenger
with the aircraft using this very simple control right below the portal right here controls a relative clarity or opaqueness of their individual window you can darken it you can lighten it and the relative degree of darkening is completely at the control of the individual passenger they can also be controlled from a central location by the flight attendants and the crew if necessary but in the final analysis every passenger has complete control over the relative clarity of the portal that they're sitting next to so Arlene
one of the things that really intrigued me when we saw the inside is the larger windows because you know we're used to the small ones how come we can make the larger windows on the composite airplane that really goes back to that whole video we've got this huge composite barrel it's all in one material but we're able to lay in extra material around the window frames oh okay we don't have to penalize the whole thing for just those holes okay that's interesting and we have some audience questions so let's start with our
audience how long does it take to big a

557
00:26:19,279 --> 00:26:25,639
composite how long does it take to make

558
00:26:22,400 --> 00:26:29,540
a composite well a lot depends on what

559
00:26:25,640 --> 00:26:31,190
the size is and so there were some parts

560
00:26:29,539 --> 00:26:32,899
you could make in a half an hour and

561
00:26:31,190 --> 00:26:35,509
then you you know bake it for a few

562
00:26:32,900 --> 00:26:37,610
hours and some could could take days

563
00:26:35,509 --> 00:26:39,470
depends on what your size is and how

564
00:26:37,609 --> 00:26:43,879
complex it is and we have an online

565
00:26:39,470 --> 00:26:46,490
question what type of composite products

566
00:26:43,880 --> 00:26:48,350
can we expect in the future has the

567
00:26:46,490 --> 00:26:52,429
Space Agency helped in the development

568
00:26:48,349 --> 00:26:55,779
of composite materials so I'll take the

569
00:26:52,429 --> 00:26:58,610
second one first because the Space Age

570
00:26:55,779 --> 00:27:00,920
really was instrumental it was super
important especially early on for developing the materials and you'd be surprised at the number of things that you're working on in the space arena that ultimately end up in the everyday world okay so very important and we do make things that we're metal rockets now we'll have for instance composite parts too so we're making those lighter and easier to live okay so we have one quick question can anything damage like a pause it can anything damage a composite yes so although we hammered it we were
designing for people to drop tools and that sort of thing right but if you had something like a forklift and you run it in it will still go go through the side so they're not indestructible they're not indestructible and that reminds me there are a lot of different types of composites and plastics and I want to warn you we we custom-designed to the material that you saw us hammering on it doesn't mean necessarily that every composite you see you can treat that way okay well thank you so much Arlene this has been really very educational and
that is all the time we have for this

system and I'd like to thank our friends

at the Museum of Flight in Seattle for the wonderful tour of their Dreamliner

and my new co-host Marty and I'd also like to thank the Boeing Company and I hope to see you all again back here next month for stem in 30