the soil beneath your feet the food on your table the roof over your head these are luxuries on bars getting there isn't the problem it's surviving those lamps EGS program chief engineer their mind no constraints to launch [Music] and liftoff passing through vacuum accent dynamic pressure welcome to space welcome to the rocket range I'm Joshua Santora while our current focus is on the moon it is our stepping stone to the red planet
in this episode we'll sit down with
scientists and engineers exploring our
planetary neighbor and preparing for the
survival of those who brave the journey
first up a trajectory analyst plotting
million mile journeys to the Red Planet
and beyond
next we'll hear from to plant
researchers who are figuring out how to
grow food in space and on alien planets
and finally we'll dig deep into the
daunting challenges that still lie ahead
before humans can set foot on Mars in
sight is a Mars Lander designed to give
the Red Planet its first thorough checkup since it formed 4.5 billion years ago it is the first outer space robotic Explorer to study in depth the inner space of Mars its crust mantle and core a few days before the insight launched Kennedy's Amanda Griffin sat down with trajectory analyst Callie Burke and NASA's launch services program to find out what it takes to send a spacecraft to the Red Planet tell us a little bit about your role for insight my role is the trajectory analyst here at the launch services program and so my
job is to make sure that the rocket

drops the spacecraft off at the right place and time in space and so we get these targets from the spacecraft team who look at where they're going and what the capabilities of the rocket is and so I'm there to make sure that that rocket performs as it needs to together with a launch vehicle company and that sounds like a lot of math to me is there's a lot of equations those who are familiar with him and figures she developed a lot of math that we use in our computer programs but we have to consider these really complex journeys you know it's
it's not just doing an equation once

we're always trying to make it as optimal as possible and so there's all these levers you have to push you know I think of it as planning a summer vacation you know how many different summer vacations out there there's millions of ideas and so you have to kind of tailor it down to a reasonable one say like okay we're going in a camping trip and we're gonna go in the summer you start paring it down and finding the best one so speaking of all these
possibilities

I understand inSight has a lot of launch attempts and that's a paring down from like an endless seemingly endless possibility there are the Jet Propulsion lab they do these things called pork chop plots and so they consider many months they could launch in many months they could land on Mars and they look at different conditions they're saying okay you know how fast is the rocket need to get the spacecraft going how fast is it if we arrive at Mars you don't want the
spacecraft crashing like an egg and
braking on Mars yeah we want a little bit softer landing what's the weather
conditions gonna be like when they get there do we have we want to get right satellites in place or are we looking back at Earth at that time and the line in sight there's all these considerations they put into and then they get it down to what they consider their ideal number of launch days and so we have 35 days we're looking at that we're launching but only one day that...
we're gonna land and so that was all

101 00:03:44,939 --> 00:03:50,310 pared down but then once we get there we

102 00:03:48,330 --> 00:03:52,920 don't have just 35 opportunities you

103 00:03:50,310 --> 00:03:55,019 know one per day we actually have a

104 00:03:52,919 --> 00:03:57,988 two-hour window that we're able to do on

105 00:03:55,019 --> 00:04:01,489 each day and so that's 25 opportunities

106 00:03:57,989 --> 00:04:05,280 so there's 875 possible ones we analyzed

107 00:04:01,489 --> 00:04:06,870 Wow yes and so a couple of those we've

108 00:04:05,280 --> 00:04:09,000 already said that they don't meet the

109 00:04:06,870 --> 00:04:10,890 requirements which we have so many it's

110 00:04:09,000 --> 00:04:12,780 not not a problem to have a few that we

111 00:04:10,889 --> 00:04:15,479 lose I mean it's it's great to have

112 00:04:12,780 --> 00:04:17,699 large windows because if there's any

113 00:04:15,479 --> 00:04:19,349 weather conditions if the range is

114 00:04:17,699 --> 00:04:21,810 clearing if there's a mechanical issue
on the rocket we have time to possibly fix it so that we don't have to completely scrub that day but I know in Florida we often have weather conditions yeah but the insight is launching from the west coast mmm-hmm so you're talked about all the considerations you guys have to take into account so to launch from California what's different so if the trajectory analyst the main thing that I have to make sure is first of all I have to make sure my computer program puts us at the right launch Speight site that sometimes you get directory and
you're like hmm that's that's not in the right place but usually it's pretty obvious at that point but a big thing that's an indicator is what directions you can launch so each launch site we work at the range to figure out what are the safe directions we were doing dangers of public and so here from Florida we launched east safely and we can go somewhat to the north and somewhat from the south but from Vandenberg if they launched East they're flying over people and so we don't want that so we can launch to the southeast
as we are for insight and then we can continue going west and launch safely but we want to make sure that everything happens with a rocket we don't endanger anybody and nothing drops on somebody if it's a low risk as possible I'm sure we all appreciate that watching the first interplanetary mission in the West Coast and NASA's insight the first outer space robotic Explorer to study the interior of Mars speaking of risk go once you get to Mars or near Mars so we've heard a lot about planetary protection so what is that and
what is your team doing to try to help

00:05:53,370 --> 00:05:57,060
me to get that it Mars so we have

00:05:55,228 --> 00:06:00,538
somebody here at NASA he's called the

00:05:57,060 --> 00:06:02,129
planetary protection officer which after

00:06:00,538 --> 00:06:05,430
a nine-year-old applied I now jokingly

00:06:02,129 --> 00:06:07,408
it's the Guardian the galaxy that's why

00:06:05,430 --> 00:06:10,408
he said he'd be great but the planetary

00:06:07,408 --> 00:06:12,389
protection officer looks to both protect

00:06:10,408 --> 00:06:15,089
Earth from any microbes we bring from

00:06:12,389 --> 00:06:16,228
space and then we also consider Mars in

00:06:15,089 --> 00:06:18,418
Europa where we think there might be

00:06:16,228 --> 00:06:20,158
life we want to protect them from

00:06:18,418 --> 00:06:22,228
raining earth bugs and basically

00:06:20,158 --> 00:06:26,639
creating life somewhere as opposed to

00:06:22,228 --> 00:06:29,129
finding it so we do that with insight in
a couple different ways so one is the spacecraft which we plan to have land on Mars has been very specially clean there's a whole team that is working to make sure that there's as few microbes as possible if any but we don't do that with a rocket and so we actually aim the trajectory a little bit away from Mars we don't aim it straight at Mars so that if it doesn't perform as it should or even if the spacecraft doesn't perform as it should we don't pollute Mars and so what that means is the spacecraft has to carry
extra fuel to account for that
correction but they're already have to
do Corrections they just have more fuel
that they need to get closer to Mars
than if we could go straight at so many
things you have to think about so what
it's gonna land in November correct yes
so what
the next seven months have in store for
you so for me it's really about that's
90 minutes that starts at liftoff - when
we separate and that's it varies a
little bit day by day and time by time
but once insight separates followed
shortly by the Marko's you know I'm clapping and celebrating and the Marko's cube sets the markers there cube sets they're each the size of a briefcase and they're going along with insight to Mars they're gonna be doing communications with it as it goes through landing which is such a dangerous point that if something were to happen during landing we'd like as much data as possible so we can figure out what went wrong but once in sight and the markers separate then I'm gonna clap and cheer and I began a process of data analysis but all the
systems I'm involved with have flown and

have done their jobs so you can breathe

easy about an hour and a half yeah about

an hour and a half I'll breathe easy but

I'll really I'll breathe easy once I the

data and I do the calculation and we've

met the requirement but you know it's

tough if anything goes wrong at any part

of the system it's it's very it's it's

devastating but but you do want to check

you know that you're you've put it on

the right path and hopefully it doesn't

have to use a ton of fuel to correct for

launch vehicle errors because they do

the spacecraft has budgeted a certain
amount of their fuel for the launch

vehicle errors because we know they exist it's not gonna be a perfect shot

they're gonna have to make corrections

and so on launch day you're gonna be here at Kennedy watching I am so I do have a role I'll be flight dynamics for NASA but it's not a critical role and so I'm here at a hangar a gig in Cape Canaveral working on it so I'll be looking at the data I'll have my headset on and I can talk with the chief engineer and so I'm ready to make sure as we launch because we have all those
times that we can launch but the amount of fuel for each of them is a little different so we'll be looking at the weather conditions and all that stuff and making sure that for everything that's going on for that time we have enough fuel now for insight it's not that's not a big concern we have quite a bit of fuel on this mission but then after it launches I'm looking to see how all the different numbers and parameters look to what we call the nominal trajectory and so that's the one where everything is just as we modelled but
let's say we're off nominal I'm there to

let our chief engineer know you know if

we can recover if this is within the

bounds we've modeled that it's just it's

an off nominal day but the Rockets still

getting where it needs to all right well

let's all hope for a nominal day that'd

be great it lets you and insight thank

you thankfully all calls were nominal

and in sight successfully launched from

Vandenberg on May 5th and Callie was

able to relax just a few hours later at

the time of this recording the

spacecraft is already more than six

NASA Kennedy - Rocket Ranch Podcast E01_ Mars_rfMvVRTxTZI - transcript (automated).txt[15/09/2019 16:00:31]
millions of miles from Earth and is

scheduled to arrive at the Red Planet on

November 26 Happy Trails

we've seen the movie The Martian and

Mark Watney uses his botany skills to

save his life so that was our own Mark

Watney dr. Gioia Massa she's a scientist

here at Kennedy Space Center her

research is growing food in space and

also with us is Ralph Ritchie who works

on long-duration food production look

into what that means a little bit later

so Juliet tell us a little bit about

what you've been working on so we work
on food production to help grow food for

the astronauts we're growing fresh

vegetables right now on the

international space station to

supplement the astronauts diet you can

bring a lot of food with you when you go

and we do that on Space Station and the

packaged food is really good there's a

lot of variety but over time that

packaged food loses its nutritional

quality and so one of the things that's

really important is to figure out how to

grow fresh vegetables to supplement that

package diet and doing that without
gravity and without you know the Sun and all the other things we take for granted on earth this is kind of a challenge so how exactly do you do that in the space station as you know many of our listeners probably know is 225 250 miles above Earth so you know we have microgravity it doesn't have sunshine to the plant so how do you how do you take care of that well we do a lot of our growing in what we call controlled environments so we're actually controlling the light we use LEDs light emitting diodes to provide the light for
plants and we have a lot of research on
that here at Kennedy Space Center
figuring out what's the best light recipe to give the plants to get them to
grow well and to taste good and to be
very nutritious have you figured out but like recipe yeah it differs for every
single plant we grow so it's a big challenge actually we have to do a lot
of research the other thing that we're working a lot on is water delivery
delivering water to plants without gravity is a real challenge and plant roots don't just need water but they
also need oxygen and in space air and

00:12:02,149 --> 00:12:05,929
water just don't mix very well you may

00:12:04,279 --> 00:12:08,149
have seen the video of the astronaut

00:12:05,929 --> 00:12:10,159
wringing out the Wesch washcloth where

00:12:08,149 --> 00:12:13,459
the water crawls around his hand you

00:12:10,159 --> 00:12:14,839
know it's surface surface tension and so

00:12:13,460 --> 00:12:17,570
if you think of that as a plant root

00:12:14,840 --> 00:12:19,009
just gets drowned in water so we have to

00:12:17,570 --> 00:12:21,440
figure out the right way to do a lot of

00:12:19,009 --> 00:12:22,338
water and air balancing and actually

00:12:21,440 --> 00:12:24,230
that's one of the things we're working

00:12:22,339 --> 00:12:24,570
on with food production Ralph can talk

00:12:24,230 --> 00:12:27,690
more

00:12:24,570 --> 00:12:29,220
that yeah that's where I come in we have

00:12:27,690 --> 00:12:31,650
the plant scientists we also have
engineers and I think the real challenge is to take the knowledge that the scientists have and how to grow plants and kind of merge that with the engineering expertise that the talent we have here at KSC can provide it’s interesting that you get to a certain point with the plant scientists where their engineering skills tend to run out you’re at the fringe of their boundary of their knowledge and then you have the engineers come along and they really most for the most part in a little to nothing about plants unless they go on
a farm so it's trying to merge those two
cultures into a successful collaboration
that really enables us to push forward
in water delivery right now is our first
challenge you've had successes I've seen
astronaut two eating lettuce I know here
on earth we kind of had a lot of scares
with lettuce lately are there the same
concerns in space actually no there are
some food safety concerns in space
because we have to worry about what
microorganisms might be in the
environment just kind of floating around
but most of the lettuce concerns or the
food safety scares we have on earth are from things like animals getting into the field and so we don't really have any of those issues but we do have to you know do due diligence we don't want to put the astronauts at risk so we want to make sure that the food is safe to eat and we're also looking at new ways to clean the produce because you know it's just like it's hard to wash plant or to water plants it's also really hard to wash your vegetables in space so we have groups working on that as well so for the space station it makes sense
that you know we can send resupply

missions up often so they have a food

supply so when we go to further

destinations like Mars where it takes

six to nine months to get there why is

your work so important so right now I

think we're kind of really at the

benefit of having this close proximity

to the earth we don't worry so much

about the food that we are growing

because it's not really being required

to really supply additional calories and

nutrition to the crew right now it's

been primarily research and as an

additive just to demonstrate a
capability but the further away we go the more in critical having that food as part of that we grow as part of the system capability requirements it takes a lot of energy and a lot of money to get food sent from the ground up into deep space we know that crew is six one year stay on Mars it's 26,000 pounds of food cubic meters of volume and when I look at the next vehicle that we're planning on putting up in cislunar space the lunar orbital platform the Gateway that internal volume is only 51 cubic meters
so if we think about the amount of space required in the weight required to get off the ground to get to Mars to get on the surface of Mars to feed crews we're not going to be able to sustain that we really for the long haul need to be able to come up with a bio regenerative capability where we can really truly start looking at earth independence and so you're gonna see a transition from the pick and eat type of crops that we grow now into the staple crops which really supply calories so we can kind of offload that weight penalty for bringing
things from Earth so pick and eat so joy

can you talk about the difference between those yeah so pick and eat or

your fresh vegetables things that you can pick and eat directly so your salad

crops we work a lot with leafy greens

small fruits like tomatoes and peppers

maybe some herbs like basil that you could add to the packaged food maybe

even some crops like a radish or a carrot those are a little harder because

you know without gravity it gets to be a challenge to harvest the roots well and

you mentioned growing fast and in
flavors and I know Ralph you guys have been testing microgreens managers and microgreens is it doesn't take much in the way of resources to grow them and they are very dense in the nutrition they require less light so everything with more growing microgreens is pretty much a positive so far they have a lot of flavor you can add them to the diet is an augmentation to meals and I hear that the astronauts really love things that have a little punch of flavor yeah and we can anything that you can grow as your typical salad crop can be grown as a micro green you just harvest it
earlier we've been experimenting with wasabi things that have a real kick to them there's also some microgreens that we grow that taste like green apples so we can add a lot of variety of flavor as well as the nutrients into the diet by growing something that's simple it doesn't take up much space and doesn't require much of the consumable resources that we have to bring more agen seeds are quite light seeds are light when it compared to some of the hardware components that we have to bring up yeah and we can pack a lot
of them in a small space so one of the

things we have to figure out is how

seeds do over long durations especially

when they're exposed to some of the

radiation we may get on the middle the

way to Mars big thing radiation yeah

radiations big everything we've done in

terms of growing plants for food and in

recent years has all been done in low

Earth orbit and the protective

environment of the radiation belts that

we have here the Van Allen belts we

don't know what the effect of that

radiation environment cosmic rays are
going to have long term on the seeds or

the plants that we grow so we're going
to be looking at multi-generational

studies to really observe those effects

and that's why we need to start that

kind of research as soon as we can and

why we're really hoping to get something

incorporated on to the gateway what

would like a greenhouse look like on

Mars like given the radiation concerns

well you'll probably be underground you

know I think you'll want to be protected

somehow so maybe in the early period you

know when you're just there you might be

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in a habitat something that would launch

on a rocket and maybe you'll have you

know a habitat that's outfitted just for

plant growth that could provide those

those crops for the crew but later on

you'll probably be either pile dirt over

the top of it or you'll be going over

your being maybe a lava tube caves so

you'd protect the crew and the plants

from from the radiation that's hitting

the surface it would also protect from

things like dust micro meteorite impacts

you know there's a lot of hazards on on

on the planet and then you know you'd be

using either electric light like LEDs or
maybe you can use some light piping

where you have a concentrating mirror

like a parabolic shaped mirror that will

concentrate the Sun and pipe it

underground through fiber optics but you

got to remember the Sun on Mars is 43 percent of what it is on earth so and

that's even without a dust storm so you

know you'd have to have a lot of area

that you concentrate to get enough Sun

to grow plants

so I read the Martian I saw the movie

I'm sure you have too mark what was

that movie mark Watney you know grew
potatoes in that regolith our potato is a good option so when it comes to what he did in terms of growing the potatoes and Mars once again Hollywood takes a lot of liberties we appreciate their efforts in showing the potential possibility but no you couldn't grow potatoes or pretty much of anything with straight-up Martian regolith the way he used it regolith contains perchlorates and other things that are not conducive to plant growth or human consumption so we would have to remediate those things get those things out of the regolith
before you could actually even consider adding nutrients to the regolith that would facilitate plant growth so the way it's depicted in the movie not so much but potatoes are a good candidate crop there are very nutritious they're very productive and we actually have worked for a long time here at Kennedy Space Center on potatoes especially our colleague dr. ray wheeler who's a potato expert you know right now on space station we don't have any way to cook anything we don't even have a microwave so we're really just focusing on things
you can pick and eat fresh but as soon

557
00:20:13,710 --> 00:20:17,909
as we had a microwave or an oven or a

558
00:20:15,450 --> 00:20:20,729
way to cook crops like white potato and

559
00:20:17,909 --> 00:20:23,249
sweet potato become a really good source

560
00:20:20,729 --> 00:20:25,499
of food and they're easy to grow and and

561
00:20:23,249 --> 00:20:27,419
they're they're kind of fun so can you

562
00:20:25,499 --> 00:20:29,069
speak a little bit about the

563
00:20:27,419 --> 00:20:30,720
psychological benefits of growing things

564
00:20:29,069 --> 00:20:32,579
like when you're going on a six to

565
00:20:30,720 --> 00:20:33,960
nine-month mission to Mars like how

566
00:20:32,579 --> 00:20:36,239
important is that to see something green

567
00:20:33,960 --> 00:20:38,249
growing well I think it would be really

568
00:20:36,239 --> 00:20:40,499
important but I'm a little biased you

569
00:20:38,249 --> 00:20:43,019
know we don't really know we don't have

570
00:20:40,499 --> 00:20:44,759
great data on that yet but there are a
lot of anecdotal evidence from the astronauts saying how much they like growing the plant how much they really enjoy seeing them in that environment of the space station which is very synthetic it's all plastic and metal and cables and wires so I think having that little piece of Earth with you when you're living and working in a stressful environment especially when you're so far from home on Mars that you know it's just a dot in the sky I think that's going to be really important but then there's the the downside you know what
happens if you get too attached to your

plants and they die or you know you

have an insect or not insect a disease

out

hopefully we won't bring any insects

then you know then that could be

psychologically detrimental so we have

to look at all of that we're going to be

starting to collect some data on the

psychological benefit or not of plants

and space in the next couple of years on

ISS we'll be doing

questionnaires and surveys of the crew

and actually collect some data on this
so hopefully but you know you can do some extrapolation and this is not scientific at all but we know from the food technology folks in Houston who we kind of support in terms with our food production activities they're very concerned about the quality of the diet from a palatability standpoint is the crew gonna like whatever we grow so that they would eat it and they're very concerned from the perspective that the crew has to give up a lot of the comforts of home just going on spaceflight and so the thought of
sacrificing the quality and the
enjoyment they get from their diet with
that sense of taste is something that
they don't want to have to give up they
found that people eating the same diets
for long times get menu fatigue
unless it's my son he likes chicken
fingers every day there's our solution
we don't have chicken fingers you know
you might get a little bored eating the
same diet you're and you're out you know
maybe a two-week cycle even though it's
a really good diet and so having this
fresh produce to make it more
interesting to give you more options of
things that you can make could be really
good too and that's another interesting
challenge we have we're constantly
approached by people who have potential
food production solutions but the
product that they're developing is not
something that you would traditionally
find appealing let's say in a regular
diet even though it might be highly
nutritious we've seen articles in the
press recently about cockroach milk yeah
it might be really good for you but how
do you provide that to someone and have
them eat it and I understand you're also
working with kids to help you decide the next crops to grow yeah we have a wonderful program with the fairchild tropical botanic garden in miami and they have about a hundred and fifty or more middle schools and high schools and those students are involved with testing new crops for us for space hi my name is Giselle and I'm a 12th grade student at biotech high school my question is for Ricky if you could grow any food plan is what would it be well if I had my choice it would be a barbecue plant but since they don't exist on earth I'll have to
go with a some kind of fresh fruit so if

you can get you know 100 schools to grow

one type of plant really well when you

have some kids watering not enough and

some over watering in some classrooms

cold and some hot if that plant grows

really well and that many schools it's

probably a really good candidate for

space so we're really excited there's

generating a lot of data they're feeding

it to us on Google sheets they have

statistician involved as well and so

we're actually going to be flying two of

the species that they down selected on


the international space amazing yeah

00:24:07,740 --> 00:24:12,509
good to get to be part of you know yeah

00:24:09,319 --> 00:24:14,149
so valuable time so it sounds like you

00:24:12,509 --> 00:24:18,089
guys have so many challenges between

00:24:14,150 --> 00:24:19,500
oxygen and water and radiation and what

00:24:18,089 --> 00:24:21,359
kind of soil you grow tin in space

00:24:19,500 --> 00:24:23,849
didn't it without more solved by next

00:24:21,359 --> 00:24:27,089
week it's no problem we have a lot of

00:24:23,849 --> 00:24:29,490
interns so that helped I love it so my

00:24:27,089 --> 00:24:31,589
last question you guys would you go to

00:24:29,490 --> 00:24:35,309
Mars and be that crazy botanist on Mars

00:24:31,589 --> 00:24:37,349
a few years ago I might've but now I

00:24:35,309 --> 00:24:39,240
think I'm pretty earth bound you know I

00:24:37,349 --> 00:24:41,789
would like to go to space at some point

00:24:39,240 --> 00:24:44,160
but I'd I think Mars is a little a
little far away from me well I am

strangely drawn to Mars but I'm not a botanist so I guess you can still go

project managers just don't open the airlock

Kennedy Space Center is one of world's premier space ports but we also envision space ports on other planetary surfaces and beyond all right so I am here today in the booth with Rob Mueller Rob what's your official title here

I'm a senior technologist in the NASA
Kennedy Space Center swamp works

innovation environment essentially we're developing the technologies that are required to operate in space for humans.

to operate in space how about let me add my congratulations to Jim Bridenstine as the new administrator of NASA the reason we go to the moon is because we want to land Americans on the surface of Mars and the technologies the capabilities the Institute resource utilization that we developed for the moon will ultimately get us to Mars it's also why the Gateway is so important having an
orbital outpost around the moon gives us more access to more parts of the solar system than ever before.

Okay so we have rockets that can get people to Mars today, maybe not a lot of stuff with them, but so you're strapping in a rocket you got a space suit on you got some food and some water. How successful the mission is this to Mars, well first of all you have to realize this is not a short trip okay to compound that once you get there you can't come home right away if you had an emergency the planets aren't lined up.
the way the orbits work and so it's very
difficult to come back from Mars without
using a lot of propellant and so
essentially in the trajectory that we
have planned you would go there it's
called a conjunction class trajectory
and it would take you six to eight
months to travel to Mars and then you're
committed to being on Mars for one and a
half years then you can come back so
it's two and a half year round-trip
journey and that that's what you're
signing up for and and so that's that's
a big difference between the Moon and
Mars the moon is three days journey we
did it during the Apollo missions if

there's an emergency as

Apollo 13 black team of flight

controllers is now on station and

Mission Control Center looking at

possible alternate missions as we have

an apparent serious oxygen leak in the

cryogenic oxygen and the service module

you can come back home relatively easily

as compared to Mars so those are the big

differences between the Moon and Mars

then when you get to Mars there's an

atmosphere it's about 1% of the Earth's

atmosphere in density and you would
think that that's a good thing and it's

it's good and bad when you try to land

on Mars and you come into the atmosphere

it helps because it provides friction

which slows you down however that

friction creates heat and then that will

cause problems for your spacecraft and

so you need to heat shields and those

kind of things but the atmosphere isn't

dense enough to really slow you down so

you need more time in fact there's many

places on Mars where we cannot land

today because the altitude is too high

you don't have enough time to land the
parachutes open but you're still going too fast so we land in the valleys on Mars and low areas and that's just a reality of going to Mars with very many difficult things about going to Mars what kind of things do we have to consider before we go well let's start with what we can do today today the largest object we've landed on Mars at a roughly 1,000 kilograms a little bit under 1,000 kilograms so the Mars Science Lab that's what we're able to land on Mars today in the future the payloads we're going to have to land on
Mars for human exploration will be

between 20 and 40 metric tons so 20,000 kilograms per landing and

there will be multiple landings required so that's 20 to 40 times the capability of the systems we have today for landing on Mars then you have to consider the humans the humans need to survive that is important pretty critical and so we'd like to not only have them survive but really do well in space but we're still learning about that and that's one of the reasons we have the International Space Station when we have a journey to Mars it takes
six months in those six months when you land the first thing that could happen is you'll have to do rehab and so you spend four to six weeks doing rehab before you can ever walk on the surface of Mars but on the other hand you have to plug your spacecraft into the power plant right away or your batteries will run down so now in this dilemma you're too weak to do a spacewalk on Mars because there's a gravity environment because you've turned into some kind of jellyfish on the way to go into Mars and you have to do rehab so first we have to
figure out the biological and physiological issues with human health and that's what we're doing today in the international space station once we know a crew can be healthy and arrive at Mars and we have the landing systems and we have done all the technology development required to land on the surface of Mars reliably we have to land in the same spot every time so it's one thing landing on Mars it's another thing landing one spacecraft next to another spacecraft within let's say a hundred meters of each other and and we also
need propellant to come home one of the things about our Mars architecture is we need about 30 tons of propellant to come home and when it takes a gear ratio a ratio of eleven to one of the mass and low Earth orbit to the mass you land on Mars so it's it's not 30 tons anymore it's three hundred and thirty tons in low-earth orbit and it's it's even more on the surface of the earth on the launch pad so when you work out all the numbers you really it can't afford to bring all that propellant to Mars to come home so you have to make it on Mars
and how we make it is we make it from the water and the carbon dioxide in the atmosphere we combine the two using the Sabatier process and we make methane and oxygen and those are propellants for coming home from Mars so it's not just a pleasure cruise out there and it's not for fun this is really advancing science in the solar system so you talk about local resources I assume you mean things we'd find on the Moon or Mars what I know of Mars there's no active streams there's no trees growing so what does local resources mean and how useful is that
for us well it seems like that when you

first look at it

so are there trees on Mars there there's

absolutely everything that's in a tree

is on Mars okay so what you have to do

is you have to break everything down

into its fundamental elements we need

far more education and far more science

and technology in order to achieve the

pioneering goals we have to expand

civilization into space and so what you

have to think about is the periodic

table of elements so those are building

blocks so not trees anymore not bricks
we're talking like molecular level here

that's right

so if you think of the elements as being your trees and your rocks and everything else that they use to build things and so we can look at this at a maybe not molecular level yet but it certainly at an elemental level and then with the use of chemical engineering and other sciences we can take these elements we can use the the mineral so in space we have a lot of rocks that have minerals we can break down the minerals which are compounds
break down the compounds into elements

recombine them into new things and those are the resources we will use so what I like to say is we have a lot of energy

and space from the Sun we'll have a lot of resources in space

in all the rocks and minerals that we have out there or missing is the technology so we have to be clever we have to invent new technologies where we in that process how are we doing this yet are we just thinking about it where are we well at the beginning of the show you asked me where I work and I work in
a lab dedicated to doing this to

developing these technologies it's
called the swamp works and it requires a
lot of imagination a lot of creativity
and so you have to set up an environment
which is conducive to that
and is it's difficult you're really
pushing the envelope of what's feasible
what we're doing is we're looking at
ways of using these resources one good
example is 3d printing this is a new
technology that's
barely 20 years old and it's it's really
changing the world and it's allowing us
to look at new ways of manufacturing
objects and structures and so what we do is we actually use the local regolith which is the crushed rock covering the surface of planetary bodies and we use that crushed rock and we make a concrete material out of it and we actually 3d print with concrete and we also have reinforcements in there which are basalt fiber basalt glass fiber so by doing this suddenly all these things become feasible which before we're not feasible now where are we on that we can't do it yet today typically at NASA we have something called technology readiness
level and goes from one to nine

that one it's just a basic principle

that's observed or formulated at 9:00

it's been in space

so we call this the the ladder of

technology development and you have to

go from one rung of the ladder to the

next rung of the ladder and that's how

the technologies developed and usually

at TRL six we're ready for to be

considered for a flight that's when it's

developed for a flight

so typically from one to six here in the

lab and currently these technologies
like 3d printing with regular that's at TRL four I would say and that's happening in the lab once we've developed in the lab with proven that it works then we can go and make a real system out of it for space so just taken out one for instance obviously you can't predict the future but as as the pace is going and as things are developing when we when do you hope to see that technology in space I would say realistically it's five to ten years away a lot of it depends on the desire to do this if we made it a
priority then we would put more

resources or more people on it and we

work it harder so a lot of it just

depends on on how much of a priority it

is we'd like to see it happen we think

it's a game changer and so within five

to ten years we could do it and we would

probably test it on earth first and as a

nice side benefit of this a spin-off we

would be able to build houses on earth

quicker and cheaper and they

would be hurricane proof so these are

all very beneficial things here on earth

as well so this is technology not just

good for the Moon or Mars but it can be
used here as well absolutely it's it's

something where you can use local

materials anywhere you are and then make

a structure out of it and it also gives

the architects design freedom so now you

can make structures that aren't just

shaped like a square or a rectangle all

kinds of new shapes are possible new

combinations and so it frees the

imagination and this is what we call

design freedom and once you have that

you can also create structures that are

stronger so as we know the we have

severe weather events tornadoes
hurricanes earthquakes floods these will all require structures that are much stronger and can bear the brunt of these natural phenomena and so we can do this with new materials and new technologies and the cost will go down because of automation so you combine all those three things and you really have a completely new way of addressing the need for shelter and everybody needs shelter on earth awesome Rob thanks for being here today excited to see your progress in the coming years and excited to see the stuff get used on Mars
someday yeah we hope to use it very soon on earth and test it here and then we'll go out into the exciting solar system that's our show thanks for stopping by the rocket ranch and special thanks to our guests our Sherpa on our path to Mars Callie Burke our plant people dr. Gioia Massa and Ralph Ritchie and technology guru Rob Muller to learn more about all things Mars you can head to Mars NASA go there are also several NASA podcasts you can check out to learn more about the science happening all over our centers at nasa.gov slash podcasts a
shout out to my colleague Amanda Griffin

00:38:04,449 --> 00:38:06,519
who helped with the interviews our sound

00:38:06,130 --> 00:38:09,039
man

00:38:06,519 --> 00:38:11,309
Lauren May 3:10 entre Frankie Martin and

00:38:09,039 --> 00:38:13,438
our producer Jessica Lana

00:38:11,309 --> 00:38:15,329
tune in next month to hear our episode

00:38:13,438 --> 00:38:17,548
all about traveling to the Sun and

00:38:15,329 --> 00:38:18,620
remember on the rocket ranch even the

00:38:17,548 --> 00:38:28,150
sky isn't the limit

00:38:18,619 --> 00:38:28,150
[Music]