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00:00:00,546 --> 00:00:02,226

[Josh Byerly] Hi everybody.

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00:00:02,226 --> 00:00:04,856

Josh Byerly here at NASA's
Johnson Space Center in Houston.

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00:00:04,856 --> 00:00:06,746

We're standing inside what we call the dome.

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00:00:06,746 --> 00:00:08,826

This is the facility that the astronauts train

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00:00:08,936 --> 00:00:13,096

in to do all kinds a robotics operations while
they're onboard the International Space Station

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00:00:13,416 --> 00:00:17,276

and any time a visiting vehicle is coming up
there this is actually where they practice.

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00:00:17,276 --> 00:00:20,706

Now we've got the SpaceX Dragon flight
coming up here in just a few short days.

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00:00:21,096 --> 00:00:23,166

The crews trained inside this very facility.

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00:00:23,166 --> 00:00:26,006

We've actually got two of the
trainers here who trained those crews.

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00:00:26,006 --> 00:00:26,706

We've got Jeff.

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00:00:27,236 --> 00:00:28,686

Good to see you and we've got Graham.

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00:00:29,006 --> 00:00:31,016
Now Jeff you train the crews on what

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00:00:31,016 --> 00:00:33,806
to do whenever Dragon actually
gets up to the capture point.

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00:00:34,186 --> 00:00:36,956
And Graham you train them on how to
actually go get it and latch onto it

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00:00:36,956 --> 00:00:38,036
and bring it into the station, right?

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00:00:38,456 --> 00:00:41,316
Talk a bit about what you guys have done
with the crews to get ready for Dragon.

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00:00:41,556 --> 00:00:41,646
[Jeff Tuxhorn] Okay.

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00:00:41,786 --> 00:00:44,736
Well for the rendezvous Dragon
approaches station from below

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00:00:45,226 --> 00:00:49,376
and the crew will start monitoring it from here
in the cupola at a range of about one kilometer.

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00:00:49,866 --> 00:00:53,206
And they'll be positioned here at the robotic
workstation where we have three monitors

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00:00:53,206 --> 00:00:55,976
which with they can look at
video from the station cameras.

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00:00:56,606 --> 00:01:00,636
And on top of that video we'll overlay some
telemetry data that we're receiving from Dragon

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00:01:00,706 --> 00:01:04,676

to show them things like range, range rate, vehicle mode and so forth.

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00:01:05,186 --> 00:01:08,816

But it also depicts graphically the approach corridor that Dragon has to remain

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00:01:08,816 --> 00:01:10,586

within as it's coming up to space station.

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00:01:10,586 --> 00:01:12,166

[Josh] Basically, the box that it has to fly within.

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00:01:12,166 --> 00:01:12,516

[Jeff] That's right.

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00:01:12,986 --> 00:01:17,656

And so they'll compare the video image to the limits that is based on the telemetry

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00:01:17,836 --> 00:01:20,706

and make sure all that lines as is expected during the approach.

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00:01:21,116 --> 00:01:22,626

[Josh] So once it gets up there and everything is checked

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00:01:22,626 --> 00:01:25,626

out they'll actually go use the station's arm which has been critical

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00:01:25,626 --> 00:01:28,046

in assembling the station to reach out and grab onto it.

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00:01:28,046 --> 00:01:29,746

Talk about how you train them to do that.

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00:01:29,946 --> 00:01:32,836

[Graeme Newman] Yeah, so Dragon's final position will be capture point hold

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00:01:33,216 --> 00:01:38,416

and the SSRMS end effector will be about five meters away from the grapple fixture on Dragon.

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00:01:39,126 --> 00:01:42,646

The arm operator will go into manual control mode, actually fly in

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00:01:42,946 --> 00:01:46,736

and track any misalignments that Dragon has to go in for grapple.

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00:01:46,736 --> 00:01:48,736

[Josh] So you talked about the manual control mode.

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00:01:48,736 --> 00:01:51,056

You can actually program the arm to do different things.

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00:01:51,116 --> 00:01:54,496

But Don Pettit is actually going to be actually flying this thing himself while he's looking

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00:01:54,496 --> 00:01:55,436

at those monitors, right?

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00:01:55,666 --> 00:01:57,146

[Graeme] Yeah, absolutely and you're right.

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00:01:57,146 --> 00:01:59,436

We can program the arm and do ground control.

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00:01:59,726 --> 00:02:02,946

But the free flyer captures
like this are so time critical

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00:02:03,546 --> 00:02:08,286

and because we're not really exactly sure the
final position of Dragon or how it's going

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00:02:08,286 --> 00:02:10,586

to move after we send it to free drift.

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00:02:11,326 --> 00:02:15,836

Then we kind of need to put a human in the loop
to make sure that the arm stays well aligned

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00:02:15,836 --> 00:02:17,396

and we can go in and grapple it successfully.

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00:02:17,766 --> 00:02:19,246

[Josh] Now Don Pettit is going
to be the one doing this.

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00:02:19,276 --> 00:02:23,566

Dan Burbank also practiced this quite a bit
'cause it was going to be him doing this.

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00:02:23,566 --> 00:02:25,466

He's going to be home by
the time this thing arrives.

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00:02:25,976 --> 00:02:28,576

So talk a bit about, you know, how do you
train the crew both here on the ground

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00:02:28,576 --> 00:02:30,596

and then once they get up
there to kind of take on a task

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00:02:30,686 --> 00:02:32,836

that maybe they didn't think
that we're going to have to do.

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00:02:32,946 --> 00:02:35,856
[Graeme] Right, well Don knew that he
was going to be involved in the capture,

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00:02:35,886 --> 00:02:39,786
but more from the helper perspective for Dan.

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00:02:39,986 --> 00:02:44,686
But Don did definitely get some
training in that role that Dan was in.

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00:02:44,756 --> 00:02:47,466
And we're actually doing a little
bit of training right now onboard.

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00:02:48,046 --> 00:02:52,316
We have a simulator on space station,
as well as flying the real arm,

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00:02:52,536 --> 00:02:55,856
so that Don can get comfortable in
that new role for him and Dragon.

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00:02:56,456 --> 00:02:57,496
[Josh] Now I think a lot
of people don't realize,

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00:02:57,496 --> 00:02:59,256
there's actually two robotics workstations.

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00:02:59,256 --> 00:03:00,936
There's one in Destiny which they've used a lot.

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00:03:01,266 --> 00:03:03,126
There's one inside the cupola
which they love to use

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00:03:03,126 --> 00:03:04,726

because of obviously the windows back behind you.

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00:03:04,726 --> 00:03:06,956

That's actually where they're going to be, right, inside the cupola?

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00:03:06,956 --> 00:03:08,416

But they've been practicing inside Destiny.

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00:03:09,426 --> 00:03:10,146

Are they the same?

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00:03:10,286 --> 00:03:11,206

Are they the same layout?

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00:03:11,206 --> 00:03:11,636

Or what are they?

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00:03:12,096 --> 00:03:14,606

[Graeme] Well, they're actually; they're a slightly different layout.

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00:03:14,606 --> 00:03:16,476

You can tell the cupola is a little bit more cramped.

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00:03:16,786 --> 00:03:20,256

And they do have the window views which the crew likes a lot, especially for the rendezvous

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00:03:20,306 --> 00:03:22,546

so they can see the vehicle coming up.

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00:03:23,066 --> 00:03:25,876

And actually we've been doing a little bit of onboard training for the crew

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00:03:25,876 --> 00:03:28,296

in the cupola these past couple of weeks.

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00:03:28,296 --> 00:03:31,716

So they've actually got a lot of practice,
you know, working through their coordination

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00:03:31,716 --> 00:03:35,516

and figuring out how they want to layout the
cupola so they have a successful capture day.

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00:03:36,206 --> 00:03:40,636

[Josh] So this looks, back behind you guys, like
the world's fanciest video game in space, right?

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00:03:40,726 --> 00:03:43,736

So let's turnaround and let's see
actually what the crew's going

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00:03:43,736 --> 00:03:47,106

to be doing whenever they actually
pilot this thing and grab on to Dragon.

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00:03:48,186 --> 00:03:50,936

[Graeme] Okay, so now we've
got Dragon at the capture point

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00:03:51,386 --> 00:03:53,526

and the arm is about five meters away.

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00:03:53,526 --> 00:03:55,496

So I'm going to start maneuvering the arm in

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00:03:55,626 --> 00:03:58,006

and maintaining alignment with
Dragon in this center view.

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00:03:58,006 --> 00:04:03,326

And once I'm over the grapple fixture pin I'll

pull the trigger which will grapple Dragon.

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00:04:03,736 --> 00:04:05,036

So I'm going to start moving in closer.

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00:04:05,036 --> 00:04:07,106

[Josh] Now the crew's actually going to be seeing live views.

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00:04:07,106 --> 00:04:08,186

They're not going to see an animation of it.

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00:04:08,186 --> 00:04:09,706

It's actually going to be the real deal, right?

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00:04:09,916 --> 00:04:12,206

[Graeme] Absolutely, these would all be real camera views.

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00:04:12,296 --> 00:04:14,756

So we have some external camera views on station.

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00:04:15,126 --> 00:04:17,336

We also have some camera views on the arm itself.

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00:04:17,996 --> 00:04:21,286

So this particular camera is actually looking from the end effector

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00:04:21,286 --> 00:04:22,686

of the arm straight out at Dragon.

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00:04:23,556 --> 00:04:25,556

[Josh] Is there a target that they're trying to line up with?

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00:04:25,556 --> 00:04:26,406

Or how do they know?

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00:04:26,976 --> 00:04:30,506

[Graeme] There's actually an overlay target on this camera view,

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00:04:30,686 --> 00:04:33,356

as well as a target on the grapple fixture itself.

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00:04:33,436 --> 00:04:37,916

So once those two line up then the crew is in tolerance to actually do a grapple.

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00:04:37,916 --> 00:04:46,616

So, moving in a little closer here.

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00:04:48,496 --> 00:04:50,716

I'm about two meters away from Dragon right now.

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00:04:51,386 --> 00:04:55,986

[Josh] So the readouts you're looking at tell you how far away you are

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00:04:56,046 --> 00:04:57,506

from it, how fast you're approaching it?

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00:04:58,006 --> 00:04:58,156

[Graeme] Yep.

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00:04:58,316 --> 00:05:01,476

There's a lot of telemetry on here that the crew is monitoring to make sure

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00:05:01,476 --> 00:05:02,826

that they have a successful capture.

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00:05:03,146 --> 00:05:05,176

[Josh] How do you know when

you've gotten close enough.

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00:05:05,176 --> 00:05:06,176

Does it give you an alert?

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00:05:06,176 --> 00:05:07,156

Or what does it do?

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00:05:07,476 --> 00:05:10,266

[Graeme] Well, basically if you can tell, there's a white line

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00:05:10,266 --> 00:05:12,346

on this target here that's coming into view.

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00:05:12,646 --> 00:05:16,256

Once it goes between the two red lines on either side then you know

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00:05:16,256 --> 00:05:18,066

that you're close enough to actually pull the trigger.

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00:05:18,066 --> 00:05:18,286

[Josh] Okay.

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00:05:19,116 --> 00:05:29,066

[Graeme] So right now I'm about half a meter away; a little closer; on over the pin.

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00:05:29,066 --> 00:05:32,716

And then I'm in tolerance now, so I'll trigger.

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00:05:32,716 --> 00:05:36,906

And then the crew will start watching telemetry on this overlay here.

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00:05:37,516 --> 00:05:41,676

They can find that the snares have now closed

around the grapple fixture pin on the LEE.

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00:05:42,106 --> 00:05:46,976

And the entire structure is kind of
rigidizing back to secure Dragon and make sure

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00:05:46,976 --> 00:05:48,346

that we've got a good firm hold on it.

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00:05:48,816 --> 00:05:49,956

And that's just finished.

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00:05:50,496 --> 00:05:52,406

So that would be considered
a successful capture.

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00:05:52,826 --> 00:05:53,386

[Josh] Just like that.

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00:05:53,706 --> 00:05:53,856

[Graeme] Mmm-hmm.

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00:05:54,936 --> 00:05:56,046

[Josh] So talk about the snares.

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00:05:56,046 --> 00:05:57,956

A lot of people, you know,
don't understand that the end

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00:05:57,956 --> 00:06:02,216

of the robotic arm actually has three sort of
wires that are shaped kind of like a triangle.

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00:06:02,616 --> 00:06:06,276

And they just kind of, you know, tighten
down on whatever the target is, right?

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00:06:06,456 --> 00:06:09,906

[Graeme] Absolutely, when the

operator pulls the trigger

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00:06:09,906 --> 00:06:12,246

on the arm it will actually exercise the snares.

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00:06:12,536 --> 00:06:13,306

There's three of them.

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00:06:13,666 --> 00:06:17,666

And they'll basically wrap around the grapple fixture pin to get a good hold on it.

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00:06:17,956 --> 00:06:20,066

And then the entire structure will start to pull back.

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00:06:20,066 --> 00:06:24,406

And that will put tension on those snares and also bring Dragon flush with the end effector.

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00:06:24,406 --> 00:06:27,466

[Josh] And then once that's done, they just maneuver it back up and put it

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00:06:27,466 --> 00:06:30,216

on the bottom side of the Harmony node and that's, that's it, right?

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00:06:30,396 --> 00:06:30,556

[Graeme] Yep.

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00:06:30,596 --> 00:06:31,406

That's basically it.

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00:06:31,626 --> 00:06:33,706

[Josh] It sounds so easy.

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00:06:33,816 --> 00:06:36,256

You know, but I mean these guys

train for hours to do this.

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00:06:36,256 --> 00:06:40,536

Talk about on a difficulty scale, you know, is it something that's challenging for them?

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00:06:40,536 --> 00:06:42,276

Or what are the hardest parts of it?

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00:06:42,746 --> 00:06:44,666

[Graeme] The hardest part is probably the grapple itself,

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00:06:44,666 --> 00:06:48,036

I would say because the Dragon is moving so you actually have

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00:06:48,036 --> 00:06:50,366

to track a moving target as you go in.

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00:06:50,556 --> 00:06:53,736

And then from there you would do a couple of maneuvers to take it

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00:06:53,736 --> 00:06:56,356

down to right above Node two nadir.

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00:06:56,626 --> 00:06:58,646

And then you would do a maneuver to berth it in.

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00:06:59,086 --> 00:07:01,816

So they do get a lot of training to make sure that we can do it successfully.

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00:07:01,816 --> 00:07:05,036

[Josh] Now they're going to be watching it very closely, whenever it comes up that kind

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00:07:05,036 --> 00:07:06,696

of approach corridor for lack of a better word.

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00:07:07,226 --> 00:07:10,046

If there is anything out of position or,

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00:07:10,176 --> 00:07:13,556

can they still grapple it even though
it may be turned the wrong way,

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00:07:13,556 --> 00:07:14,776

or if anything like that happens?

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00:07:14,776 --> 00:07:16,776

I mean is that; is that something
they can still do?

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00:07:17,996 --> 00:07:19,846

[Jeff] Well during the approach
they'll definitely watch

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00:07:19,846 --> 00:07:21,076

and make sure it's at the right place.

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00:07:21,326 --> 00:07:24,216

They do have opportunities to
send commands to the vehicle

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00:07:24,216 --> 00:07:27,676

if they do see something before
reaching the capture point.

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00:07:27,676 --> 00:07:30,776

So they have some ways to deal with those
situations, and of course they'll be talking

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00:07:30,776 --> 00:07:32,826

with the ground about what
they're observing onboard.

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00:07:33,366 --> 00:07:36,466

But in terms of the actual capture
it's a little more difficult than that.

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00:07:36,466 --> 00:07:40,486

[Graeme] Yeah, the arm has a lot, the
particular configuration for the arm has a lot

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00:07:40,486 --> 00:07:43,626

of analysis behind it to make
sure that we can support capture

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00:07:43,626 --> 00:07:45,756

because it's a kind of stressful
thing for the arm.

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00:07:45,756 --> 00:07:47,486

We're going to putting a lot of loads on it.

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00:07:47,716 --> 00:07:50,456

Basically, you've got this big vehicle
out there with a lot of inertia

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00:07:50,456 --> 00:07:52,746

that you have to bring to a stop.

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00:07:53,006 --> 00:07:55,756

And so we need to have a good arm
config to be able to support that.

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00:07:56,476 --> 00:07:59,776

[Josh] Talk a bit about, you know, how exciting
is it that you guys are training these crews

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00:07:59,776 --> 00:08:02,516

for a brand new vehicle that has
never been up to the space station,

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00:08:02,726 --> 00:08:04,246

you know, it's a pretty historic flight.

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00:08:04,486 --> 00:08:06,456

And you guys are a key part of that.

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00:08:06,456 --> 00:08:07,416

Is it cool?

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00:08:08,436 --> 00:08:08,896

[Jeff] Absolutely.

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00:08:08,986 --> 00:08:09,226

[Graeme] It's an honor.

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00:08:09,226 --> 00:08:14,056

[Jeff] It's been great working with the SpaceX folks as they've been continuing the development

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00:08:14,056 --> 00:08:16,636

of their vehicle and kind of relaying the new things that we've learned

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00:08:16,636 --> 00:08:18,436

about it and changes to the crew.

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00:08:18,436 --> 00:08:19,306

So they're ready to go.

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00:08:19,816 --> 00:08:21,176

So it's definitely been a unique experience.

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00:08:22,046 --> 00:08:23,196

[Graeme] It's a complete honor.

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00:08:23,196 --> 00:08:25,276

And working with the crew, of course, is always fun too.