Michael Leinbach: It's an indescribably empty feeling.

That day that they didn't come home.

Knowing that the astronauts were gone and we failed them.

Launch Countdown Sequence: EGS Program Chief Engineer.

Verify no constraints to launch.

EGS Chief Engineer team has no constraints.

I copy that.

You are clear to launch.

Five, four, three, two, one, and lift-off.

All clear.

Now passing through max Q, maximum dynamic pressure.

Welcome to space.
Amanda Griffin: Welcome to the Rocket Ranch.

I'm NASA Kennedy's Amanda Griffin.

Shout-out to our host, Joshua Santora, who welcomed a baby girl into the world before the completion of this episode.

Congratulations, Joshua.

Here's wishing you a happy, healthy newborn and a good night's sleep.

As we prepare to launch humans into space on new American-made rockets and spacecraft,

it's more important than ever that we revisit what led to two of the most tragic days in NASA's human space flight history.

Michael Ciannilli: Winston Churchill said it, you know, "those who have failed to learn from history are doomed to repeat it."

And that's so true.

Amanda Griffin: In this episode, we're exploring not just the technical issues that brought
down the crews of both Challenger and Columbia, but the cultural environment that proved just as deadly.

What are the lessons we learned? And have we really learned them?

Joshua Santora (Host): All right, I'm back here in the booth with Michael Ciannilli and Michael Leinbach.

Uh, Michael Ciannilli, we're gonna call him Chach.

Uh, he bears a striking resemblance to Scott Baio-- at least, uh, back in the heydays of "Happy Days" he did.

And Michael Leinbach is a retired launch director for NASA, so--

Michael Leinbach: Right.

And Chach also worked with Mike on shuttle
flights, um, as a NASA test director.

So, really fast, can you give me a real quick overview of what does it mean to be a NASA test director?

Michael Ciannilli: Great question.

Um, the NASA test director is, if you think of an orchestra, right, like an orchestra has, um, all the different instrument players, and then you have the conductor who helps lead the orchestra.

Um, a test director's much like that.

Uh, we have the honor to be in the firing room and work with an amazing team of very talented folks who are–in this case, their instruments are their systems on the vehicle.

So they're watching over the systems and the health of the vehicle.

And we help, um, help guide them towards the countdown toward T-zero.

Host: What's your role as the launch director?
Michael Leinbach: You know, I'm glad Chach mentioned the, uh, the orchestra leaders as the analogy for the test director, 'cause that's the one I use all the time.

And I always like to describe the launch director as sort of the owner of the orchestra.

I get to sit back and watch the launch team perform.

And, um-- and just kinda make sure we're all on the same page at the same time.

And we felt good about problem resolution.

And-and then, ultimately, gave the final go for launch.

But it was a position that was created long, long ago in the early days of America's manned space flight program for-for one individual to intentionally have very little to do.
Uh, but it's a position of authority and responsibility, yes.

But it's one of sitting back and watching the team perform, just get the sense of if we're really ready to launch that day or not.

And it's been that way since the Mercury days.

And-and it, um, was created by a bunch of wise people back in the '60s, and-and it's, uh, it's a perfect way to, uh, to conduct a launch, I believe.

Yeah, certainly, uh, a long history of very excellent, uh, men, until now.

Now we have our first female launch director coming up here, Charlie Blackwell-Thompson.

Um, and so we're here today to talk about the idea of launching, from a historical context.

Really exciting month for NASA.

We announced crews for crew missions.
Announcer: Ladies and gentlemen, I present
to you our commercial crew astronauts.

77
00:04:07,408 --> 00:04:09,438
[ CHEERS AND APPLAUSE ]

78
00:04:09,438 --> 00:04:12,959
Host: I think it's been nine years since we
announced a crew.

79
00:04:12,959 --> 00:04:18,009
Um, and we want to talk today-- very sensitive
subject about-- uh, historically, when launch

80
00:04:18,009 --> 00:04:22,089
hasn't gone well, or when missions end in
tragedy.

81
00:04:22,089 --> 00:04:28,258
And-and what do we do as an agency, and as
a nation, to-to get smarter and be better

82
00:04:28,259 --> 00:04:29,800
to protect human lives?

83
00:04:29,800 --> 00:04:32,460
So I wanna start by looking back, uh, '86.

84
00:04:32,459 --> 00:04:34,459
Um, the Challenger tragedy.

85
00:04:34,459 --> 00:04:38,448
President Ronald Reagan: America will never
forget that terrible moment when our elation

86
00:04:38,449 --> 00:04:41,650
turned to horror, and then to grief and pain.

87
00:04:41,649 --> 00:04:46,269
Seven of our finest perished as they reached
for the boundaries of space.

88
00:04:46,269 --> 00:04:49,819
Where Earth ends and the path to the stars
begins.
Host: So, I'll kick it off.

Uh, who wants to kind of start in here-- kind of talking about, first, technically what happened?

We lost a space shuttle.

Um, but what happened?

And-and, culturally, what was going on for us as an agency?

Michael Leinbach: Well, gosh, maybe, you know, I'll start, and Chachi, you chime in anytime you want and correct me when I make a mistake.

Um, I was here.

I was a young engineer, a design engineer, working out of the headquarters building.

And-and I remember that morning very, very well.

I remember it like it was yesterday.

And it was just a frigid, frigid morning.
00:05:20.709 --> 00:05:24.930
Newscaster: Launch today is set for 10:38 a.m.

00:05:24.930 --> 00:05:32.269
Current weather, uh, conditions call for scattered clouds at 25,000 feet, with winds out of the

00:05:32.269 --> 00:05:34.639
northwest at 12 knots.

00:05:34.639 --> 00:05:37.408
Temperature at the pad right now is 24 degrees.

00:05:37.408 --> 00:05:47.430
Michael Leinbach: Uh, to the-to the extent that that our Firex system piping at the launch

00:05:47.430 --> 00:05:49.840
pad had frozen and burst, and we had icicles at the launch pad.

00:05:49.839 --> 00:05:52.359
In Florida--  icicles, two feet long in Florida.

00:05:52.360 --> 00:05:58.329
Host: Yeah, not a normal occurrence.

00:05:58.329 --> 00:06:00.500
Michael Leinbach: No, no, no.

00:05:58.329 --> 00:06:00.500
Um, and watched the launch proceed.
Launch Dialogue: We have main engine start.

Four, three, two, one... and lift-off!

Lift-off of the 25th space shuttle mission, and it has cleared the tower.

[INDISTINCT RADIO CHATTER]
Good roll program confirmed.

Michael Leinbach: Uh, we were standing on the deck of the launch-- as I say, I was an engineer.

I wasn't in flight operations.

I didn't know, uh, the abort scenarios at all.

But-but we watched lift-off occur.

Launch Dialogue: Challenger, go with throttle up.

Roger.

Go with throttle up.

Michael Leinbach: And then the big fireball,
Launch Dialogue: Flight controller's here looking very carefully at the situation.

Obviously a major malfunction.

Michael Leinbach: And I expected to see Challenger peel out of that fireball and land behind me at the shuttle landing facility.

Not the knowing, the abort scenarios like I got to know them later.

Michael Leinbach: And of course it never did.

Launch Dialogue: Uh, at that point we had an apparent, uh, explosion.

Subsequent to that, uh, the tracking, uh, crews reported to the flight dynamics officer that the vehicle, uh, appeared to have exploded.

And that, uh, we had an impact, uh, in the water, down range.

Michael Leinbach: And it turned out later that, um, uh, you know, the failure was was
due to, um, a failure in the solid rocket booster.

One of the two solid rocket boosters, uh, one of the seals between the joints, uh, in the booster failed.

An O-ring failed, which is a rubbery material to keep pressures inside the SRB--

Host: For those that aren't familiar, the SRB was stacked a giant cylinder that came to us in segments, and had to be assembled.

So this was at one of the joining points of those segments, correct?

Michael Leinbach: That's exactly right.

It came from, uh-- they were built and fueled out in Utah.

And got to us on a train system.

In four segments, we stacked them in the Vehicle Assembly Building.

00:07:24,959 --> 00:07:28,519
due to, um, a failure in the solid rocket booster.

00:07:28,519 --> 00:07:35,029
One of the two solid rocket boosters, uh, one of the seals between the joints, uh, in the booster failed.

00:07:35,029 --> 00:07:36,489
An O-ring failed, which is a rubbery material to keep pressures inside the SRB--

00:07:43,750 --> 00:07:44,750
Host: For those that aren't familiar, the SRB was stacked a giant cylinder that came to us in segments, and had to be assembled.

00:07:49,598 --> 00:07:52,188
Michael Leinbach: That's exactly right.

00:07:55,848 --> 00:07:59,718
It came from, uh-- they were built and fueled out in Utah.

00:08:01,870 --> 00:08:06,689
In four segments, we stacked them in the Vehicle Assembly Building.

00:08:06,689 --> 00:08:11,909
And then, uh, after the SRBs were stacked in the VAB, the external tank gets mated in between 'em, and then the orbiter gets bolted to the side of the external tank.

Well, for the Challenger mission, uh, the O-ring failed and let the gas of the solid rocket booster propellant escape at the one of these field joints. At one of the joints that we put together in the Vehicle Assembly Building. And a fire jet came out the side of the solid rocket booster and penetrated the, uh, external tank. And, uh, at the same time the SRB pivoted because it lost its aft attach-point. And, uh, the hydrogen tank at the bottom of the external fuel tank ruptured at about the same time as the top of the solid rocket booster collapsed into the liquid oxygen tank at the top of the external fuel tank.
Those two things combined caused the massive conflagration that we saw on TV that was unsurvivable.

Jesse Moore: With the explosion of the space shuttle Challenger, approximately a minute and a half after launch from here at the Kennedy Space Center...

I regret that I have to report that, based on very preliminary searches of the ocean where the Challenger impacted this morning, these searches have not revealed any evidence that the crew of Challenger survived.

Host: So, from a cultural perspective, what's going on with NASA at that point in time?

Obviously, we are in '86, so we're five years into the Shuttle program after a, uh, nine year break from the Saturn V program?

Um, the Apollo program to the Shuttle program, um, things seem to be going well, but, is there-- are there things happening behind the scenes that are creating problems for us?
Michael Leinbach: Well, that's that's a great question, and the answer is very much "yes."

Uh, at that point in America's space flight history, all of America's launches were going to go off of the space shuttle system.

We were going to retire the Atlases and the Titans and the Delta rockets-- all the expendable launch vehicles.

They were all gonna be retired.

Every launch that America conducted was gonna be on the shuttle.

And, uh, this-- the Challenger accident was the 25th shuttle flight.

Uh, and so we were still in the process of proving the system, even though we had declared it operational.

And that was just sort of a paper exercise, to declare it operational.

But all of our launch capability was gonna be devoted to the shuttle, and, uh,
the Department of Defense owned and paid for and owned Discovery.

And they were gonna launch Discovery by themselves out at the Vandenberg Air Force Base.

It was gonna be their shuttle, and so, from a big picture perspective,

the shuttle system almost had to succeed.

Because we were going down this path of retiring all the other expendable launch vehicles,

in favor of just the shuttle.

And so there was tremendous, um, desire, and I would say some pressure

to make sure the shuttle system worked, and worked well.

And that had something to do with the decision to, uh, to bury the debris,

I believe.

And just put that accident behind us as much as we could.

Tragic as it was, the loss of seven astronauts and the orbiter itself.
But the mood was, that was a one-time failure of the shuttle system.

It's a good system, it almost has to succeed, because of the posture we were putting ourselves in, with our launch capability.

And, um... and so the decision was to press on with the shuttle and, um, and bury the Challenger debris, and not look back.

In hindsight it was not the right decision.

At the point in time in America's space flight history, that's what the leaders decided to do.

So that-- at the time it was the right decision.

Looking back, I-- you know, we can second guess it.

Speaker: They were not only the crew of Challenger, they were friends and co-workers.

That brave crew of Dick Scobee, Mike Smith,
Ron McNair, Ellison Onizuka, Judy Resnik,

00:12:25.789 --> 00:12:34.439
Greg Jarvis, and Christa McAuliffe will always be in our memories.

00:12:34.440 --> 00:12:38.680
Michael Ciannilli: We have a new program called The Apollo Challenger Columbia Lessons Learned Program.

00:12:38.679 --> 00:12:40.179
And how this really started is, um, we're looking at where we are in our history, right?

00:12:40.179 --> 00:12:43.799
So, uh, NASA's in a very unique place where we are many years out from Shuttle now.

00:12:43.799 --> 00:12:48.719
We're about seven years and counting, out from the last loss of the space shuttle program.

00:12:48.720 --> 00:12:51.980
And we're developing new systems.

00:12:51.980 --> 00:12:53.779
So we got, um, brand new systems coming online.

00:12:53.779 --> 00:12:56.120
New vehicles, new designs coming.

00:12:56.120 --> 00:12:58.480
And we got a-a brand new workforce that's being brought on board.

00:12:58.480 --> 00:13:01.220
A lot of our shuttle folks have retired or moved on, so we've got a lot of, uh, brand new talent, which is exciting and great.
Um, new systems, which is great.

New missions, which is great.

But with that comes a lot of challenges, um, to make sure we're successful.

And, so we wanna make sure there's a way to transfer what we call "the tribal knowledge."

All the folks that were, um, that came before us.

All the Mercury, Gemini, Apollo, Skylab folks, and, of course, Shuttle now.

And take that knowledge, which we lost a lot during the Shuttle layoffs, and trying to-to

rebuild some of that.

Um, why we do certain things the way we do.

Right, so history teaches that.

We learned that from our ancestors.

Um, so we try to transfer that to the next generation workforce.

So that's the goal of this new program.
Host: So, thinking about kind of the Challenger era-- did we learn all of our lessons?

Michael Leinbach: Well, let's see, there-there are two major lessons learned from the Challenger accident.

One was the-the technical cause of the failure.

And that was the-the O-ring burned through, and-- and I should say that in-in the-in the flights before Challenger there were several missions where we saw scorching on the O-ring and didn't-and didn't, uh, redesign at that point in time.

So we knew we had an issue with those O-rings.

Um, and-and chose to press on anyway.

Um, the technical cause, we fixed.

You know, we put in another, uh, [INDISTINCT] solution to the joint problem.

Kinda technical, but--
Michael Leinbach: We fixed the technical problem.

The management problem that—that really—I would say was even a—a bigger culprit in the Challenger—the loss of the astronauts and Challenger was—you know, the night before the lift-off of Challenger, there were people, engineers from the Marshall Space Flight Center, who were responsible for the design of the solid rocket booster, lobbying not to launch the next morning because they knew it was gonna be too cold for the O-ring. Because it was gonna be very stiff, and-and wouldn't bend with the joint, so to speak, and-and flex with the joint as-as it was designed to do a little bit.

And these engineers were lobbying not to launch. But their-management overrode that-that technical concern, and chose to press on with launch anyway.

Newscaster: The ice inspection team, the red
crew out at the pad, has reported to the,

00:15:13,639 --> 00:15:20,019
uh, test conductors that, uh, there is no,
uh, solid ice buildup, uh, in those bags on

00:15:20,019 --> 00:15:21,120
the mobile launch platform.

00:15:21,120 --> 00:15:25,980
And, in fact, have characterized the contents
of those bags as "mush."

00:15:25,980 --> 00:15:29,960
Uh, it's been determined that that is not
a constraint for launch at this time.

00:15:29,960 --> 00:15:34,100
Michael Leinbach: That discussion the night
before the Challenger loss never made it to

00:15:34,100 --> 00:15:35,259
the launch director.

00:15:35,259 --> 00:15:40,480
Gene Thomas, rest his soul, never knew anything
about that discussion until after the accident.

00:15:40,480 --> 00:15:41,480
Host: Hmm... wow.

00:15:41,480 --> 00:15:45,821
Michael Leinbach: And-and-and so the technical
issue never made it to launch decision-makers.

00:15:45,821 --> 00:15:54,750
Host: Thinking about the written and unwritten
requirements of a launch, for instance, is

00:15:54,750 --> 00:15:59,079
it likely that we would try and accommodate
every single thing we can think of?

00:15:59,080 --> 00:16:03,030
Like, if the temperature falls below 20 degrees,
don't launch?

00:16:03,029 --> 00:16:06,789
And-and if that's-- if that's not appropriate
to do that, how do you deal with challenges

00:16:06,789 --> 00:16:07,819
like that?

00:16:07,820 --> 00:16:11,500
Where you have these experts saying, "we shouldn't
launch tomorrow, it's too cold."

00:16:11,500 --> 00:16:13,490
Michael Leinbach: Yeah, Josh, I'm glad you
asked that.

00:16:13,490 --> 00:16:17,690
That-that is the key management lesson learned
from the Challenger accident.

00:16:17,690 --> 00:16:22,420
Wh-wh-where there's a whole issue of undocumented
reasons to stay on the ground.

00:16:22,419 --> 00:16:27,789
Uh, the-the space shuttle system, we had 22,000
parameters that had to be correct to launch

00:16:27,789 --> 00:16:28,789
the shuttle.

00:16:28,789 --> 00:16:29,789
Host: Golly!

00:16:29,789 --> 00:16:31,879
Michael Leinbach: Twenty-two thousand temperatures,
pressures, voltages, all that-- the weather.

00:16:31,879 --> 00:16:33,110
All those things.

00:16:33,110 --> 00:16:34,110
Host: Wow.
Michael Leinbach: But beyond that there-there could always be something we didn't think about, or something that couldn't be automated, that you needed the-the human in the loop
to say, "well, here's a reason we shouldn't launch today."

I re-- one-one launch countdown we had a train about to penetrate the launch danger area.

Well, that-that wasn't in our-- it wasn't computerized!

We had to deal with that train.

The issue that-that came out of Challenger being too cold the night before, and that discussion, that was an undocumented reason not to fly.

It-it didn't turn out that way.

It-it--

Host: Right.
Michael Leinbach: It never made it to the launch decision authority.

00:17:10,449 --> 00:17:11,449
Host: Right.

00:17:11,449 --> 00:17:13,550
Michael Leinbach: But the thing that did come out of that was the creation of the Mission Management Team.

00:17:13,549 --> 00:17:14,549
Host: Gotcha.

00:17:15,549 --> 00:17:18,480
Michael Leinbach: And it was a group of senior managers from all the different elements--

00:17:18,480 --> 00:17:22,250
the orbiter, the external tank, and the solid rocket boosters, and the ground systems, and

00:17:22,250 --> 00:17:27,470
the safety and payloads-- everybody who would-needed to weigh in on launch day and say,

00:17:27,470 --> 00:17:31,250
"I don't know of any other reason out there to stay on the ground today.

00:17:31,250 --> 00:17:35,160
As long as you, the launch director, have met your 22,000, we're good to go."

00:17:35,160 --> 00:17:42,120
However, that-- the, uh, the example of the temperature of the night before

00:17:42,119 --> 00:17:44,619
Challenger, that was a reason to stay on the ground.

00:17:44,619 --> 00:17:50,279
It wasn't in documented procedures, but it was absolutely a valid reason not to launch the next day.

The creation of the Mission Management Team after Challenger solved that problem.

And it worked beautifully throughout the remainder of the Shuttle program.

I had to get a go from the Mission Management Team chairman on launch day to verify there were no other issues that were bothering anybody...

Host: Great.

Michael Leinbach: ...above and beyond the documented reasons not to fly.

So you have both.

And-and that-I would argue that's one of the reasons you're always gonna have to have the human in the loop.

'Cause you cannot foresee all possible reasons not to fly.

You can't computerize it all.
You need the human in the loop to rule on those things you just didn't think about before.

Um, so we fixed the technical issue on the solid rocket booster and we fixed the management issue of being open with our discussions and listening to dissenting opinions.

And I would say that worked well, uh, for about, um, I don't know the number of missions, but it worked well right after Challenger.

And it kind of eroded over time and we got ourselves in a similar situation for Columbia.

And I-- we'll get to Columbia, I know.

But the management issues surrounding the Columbia accident were very similar, from a decision-making authority, as they were to Challenger.
And that's troubling.

Host: I wanna kinda step back a second, because I am convinced that no one would make a decision to launch with the knowledge that it was gonna cost people their lives.

Michael Leinbach: It's called "normalization of deviance."

Host: Hmm.

Michael Leinbach: We had problems in flights leading up to Challenger.

Never the big problem.

And therefore, uh, they normalize that and assume that it was gonna be okay for Challenger.

Launch Dialogue: TLT, OTC.

Clear caution/warning memory.

Verify no unexpected errors.

OTC, TLT.

That didn't work.
We see no unexpected errors.

Michael Leinbach: We had a specification saying that you should never scorch an O-ring.

Host: Interesting.

Michael Leinbach: And-and yet we did, and--but it never caused the big problem, and-and so we accepted minor scorching to O-rings as-as-the new normal.

Fast forward to Columbia.

Uh, we had a specification in the shuttle program to never impact a tile during ascent--

or landing, for that matter.

But in particular, during ascent, um, we impacted tiles all the time, but it never got us in-in trouble.

And-and so we normalized that-that problem.

Host: Yeah.

Michael Leinbach: We had a specification for zero impact, and we hit tiles all the time.
Host: That just seems a little crazy to me.

Like, if there's something else going on too, other than just like the normalization of deviance-- there's gotta be.

Michael Leinbach: Well, subconsciously we were accepting, you know, failure, minor failures that never turned into the major failure.

Um, there were people-- you know, we discussed [INDISTINCT] tile hits on, uh, missions prior to Columbia, and-and just accepted the fact that minor hits were-were just a maintenance issue and a turnaround issue, something, you know, we could handle.

back here at KSC, but it would never really cause a major-a major problem, and-and we were wrong.

Now, I don't wanna indict the whole shuttle system.
Host: Sure.

Michael Leinbach: There were other problems on the shuttle that we stood down for and fixed, like wire shorts inside the orbiter.

Host: Mm-hmm.

Michael Leinbach: Uh, that caused the main engine controller to go out during ascent.

We stood down for almost a year and fixed tens of thousands of minor little wire problems.

And so that hardware was talkin' to us, and we fixed those problems.

We didn't fix the O-ring til it was too late, and we didn't fix the tile impact issue til it was too late.

Michael Ciannilli: And Mike does a wonderful job explaining that, um, normal-normalization of deviance.
Um, it's hard, right?

It sounds, in retrospect, easy, right, to identify something that's different.

I think one thing that makes it hard is life is constantly changing, right?

That's the only constant, they say, in life is change you can guarantee-- so-so life is constantly changing.

We're changing our opinions, our perspectives, our viewpoints on certain issues.

Our systems are changing.

So change is normal, and change is often good.

I think what makes, uh, normalization of deviance insidious and difficult to identify at times is kinda sneaks behind the good stuff, right?

So you got change that's normal, and then you got these little small things that kinda piggyback or get behind you, and they kinda creep in.
Host: Yeah, that's really good.

Michael Ciannilli: And-and as people, I humbly would say our-- in our DNA, we're kind of--

it's kinda goin' against us, right, 'cause we kind of accept that.

Michael Ciannilli: I think all of us can--

for myself-- I mean, um, I've had a-- you know, the point where we call it the-- you know, the light on your dashboard-- the idiot light, whatever you wanna call it.

That's been on, right?

And then you-you drive with it for so long, and then one day that light goes out-- it's

like, well, that's crazy.

The light's out.
Why is the light out?

Well, I would humbly suggest that nobody bought the car with the light on in the first place, right?

Host: I hope not.

Michael Ciannilli: But you get so-- I hope not.

You know, typically that wouldn't happen.

Or that thump in the tire.

The little noise in the engine.

Or something a little off-nominal, but we get so conditioned and used to as people that we accept that.

So, um, so it's very sneaky.

So we have to apply what Mike was saying, is that strong vigilance to watching for what is off-nominal, what's that little bit of difference, recognize it from the normal.
Um, it can be hard over time, um, to identify that.

Michael Leinbach: And-and it's very difficult to, uh, to take a-a problem that hasn't caused a big issue and stand down, in our case, the shuttle fleet to repair something that hasn't caused a major problem.

We did it for wires.

We didn't do it for tiles.

Remember, we were in the business to launch, not-- we weren't in the business to stay on the launch pad.

We were in the business to launch, and-and so a-a-as much as-as-- no one would launch in the face of a known issue that they would cause loss of life.

That's crazy to even think.

But it's these other issues that-that-- they're insidious.

That's the best word I've heard.
It— they're insidious, and twice it got us in trouble.

Host: Yeah.

Michael Leinbach: A few times it didn't because we listened to the hardware and fixed it first.

Host: Yeah.

Chachi, you mentioned the idea of fresh workforces, um, who may not have memory of Challenger.

And we've kind of talked briefly, kind of alluded to Columbia, a much more, uh, recent tragedy for us.

Mike, obviously this is a huge deal for you, 'cause you were launch director at the time,

right?

Michael Leinbach: Well, we'd had, uh, as I mentioned, we'd had issues with impacting foam and different areas of the launch system during ascent and during
landing, and, uh, and normalized all that as just the-- as the new normal, as the

new norm for this vehicle.

This particular launch, it was a, uh, January morning.

Beautiful launch.

Launch Dialogue: We have booster ignition and lift-off of Space Shuttle Columbia, with

a multitude of national and international space research experiments.

Michael Leinbach: We lifted off, and a piece of foam broke off of the external fuel tank

about the size of a carry-on suitcase you take on into an aircraft.

And it hit the leading edge, somewhere-- the leading edge of the wing, in between the leading

edge and maybe the first row of tiles, something like that.

We're not quite sure, because we've never had really good video of where it actually hit.
Host: Right.

Michael Leinbach: But caused some sort of a breach in the thermal protection system that we didn't know how bad it was until reentry.

I mean, we talked about that piece of foam hitting the orbiter throughout the mission, and accepted that it was going to be a turnaround issue.

We knew we'd probably damage the orbiter to a certain extent.

We didn't think we'd damage it nearly as badly as we did, obviously, or we would've done something different.

Um, and then during reentry, the hot plasma gas in the upper atmosphere, uh, got inside the wing and melted the wing from the inside out.

And the astronauts lost control, and the vehicle broke up.

Columbia Comm Dialogue: Flight, INCO.
I didn't expect, uh, this bad of a hit on comm.

00:25:53,740 --> 00:25:55,710
Columbia, Houston.

00:25:55,710 --> 00:25:57,670
Comm check.

00:25:57,670 --> 00:25:59,640
Columbia, Houston.

00:25:59,640 --> 00:26:02,590
UHF comm check.

00:26:02,589 --> 00:26:04,558
Columbia, Houston.

00:26:04,558 --> 00:26:07,519
UHF comm check.

00:26:07,519 --> 00:26:12,440
FDO, when you expecting tracking?

00:26:12,440 --> 00:26:16,370
One minute ago, Flight.

00:26:16,369 --> 00:26:18,339
GC, Flight.

00:26:18,339 --> 00:26:23,259
Flight, GC.
Lock the doors.

00:26:23,259 --> 00:26:24,259
Copy.

00:26:24,259 --> 00:26:30,849
Michael Leinbach: So we knew we had had hit the orbiter with a significant impact of foam.
Um, people on the ground, engineers that had-had--
it was their job to study ascent film and

video and look for issues, um, their mouths
dropped open.

They knew it was a big hit.

And they tried to get the attention of management
and-and-and to do more about it than we did.

Um, and so sort of like Challenger, where
the engineering teams were overridden, almost--

it was almost that bad, um, for Columbia.

The-the engineering-level folks knew there
were issues, and just couldn't get the attention

of management to, uh, to do something extraordinary
in the face of the unknown.

And that's what it was.

We didn't know how bad Columbia was damaged.

We made a bad assumption that it wasn't damaged
too badly for reentry.

Host: But some people will listen to
this and say, "well-well, Mike's the launch
Like, does this fall back on him?

Can you talk about kind of personally like, where did you fit in the picture of this,

Michael Leinbach: Yeah, well, the shuttle system was a-- had a very, very large management team, and it was basically split into two: the pre-launch folks and then the

And-and, um, so we were responsible here at the Kennedy Space Center to prepare the orbiters and the external tank and the solid rocket boosters for launch.

I was responsible for giving the final go for launch.

Um, as soon as we lifted off on launch day, then responsibility for the mission shifted to the Johnson Space Center and the flight control team out of JSC.
Launch Dialogue: Houston now controlling the flight of Columbia, the international research mission, finally underway.

Michael Leinbach: And at that shift in responsibility, the folks here at KSC, we were done.

We were done with Columbia's mission, essentially, and we were looking forward to its next mission.

We were going to modify Columbia after it came home to be able to fly 'til 2020.

Host: Wow, wow.

Michael Leinbach: So we were lookin' forward to Columbia comin' home and flying, uh, a good number of more years.

Um, so with that shift in technical responsibility for the mission came a shift in management responsibility as well, and that-and that- this group called the Mission Management team, we met, uh, pre-launch here to study issues, make sure we were good to fly in the first place.

And then during the mission, they met, and
it was some of the same people, but different

524
00:29:02,059 --> 00:29:04,839
people as well on the Mission Management team.

525
00:29:04,839 --> 00:29:10,419
They would review issues during the mission
and resolve issues as best they could while

526
00:29:10,420 --> 00:29:13,130
the orbiter is circling the Earth.

527
00:29:13,130 --> 00:29:20,200
Um, and so I don't wanna cast any
kind of responsibility, um, aspersions

528
00:29:20,200 --> 00:29:21,819
here at all.

529
00:29:21,819 --> 00:29:28,609
Um, the management process failed, and too
many people assumed that the damage wasn't

530
00:29:28,609 --> 00:29:30,339
as bad as it was.

531
00:29:30,339 --> 00:29:34,609
And we concluded so, and told the commander,
"you're gonna be fine to come home."

532
00:29:34,609 --> 00:29:41,529
And we just, as a group, made a wrong
decision, a wrong assumption, and it cost

533
00:29:41,529 --> 00:29:42,529
us.

534
00:29:42,529 --> 00:29:43,680
It cost seven folks.

535
00:29:43,680 --> 00:29:50,920
Speaker: Today we honor and remember seven
of my friends.
Rick Husband, Willie McCool, Mike Anderson, Laurel Clark, Dave Brown, Ilan Ramon, and Kalpana Chawla, or KC.

Host: Chachi, I’m sure this, like a number of tragic events in human history, is one of those moments, especially for the NASA family, where you know where you were.

Uh, you remember that moment vividly.

Um, so where-where are you at your career in this time, um, kind of with our NASA family?

Michael Ciannilli: I was, uh, working for United Space Alliance.

It was before I joined NASA.

And, uh, was actually, uh, working on Columbia.

I was on Columbia’s team, engineering team.

Um, so my role back then, um, I was getting ready to receive Columbia.

So as Mike said, you know, the vehicles were-different states.

Um, I was looking forward to Columbia coming
home after the mission.

Um, it was gonna be rolling in to the Orbiter Processing Facility, which is our big garage.

So when we get her home, uh, we process the vehicle and, you know, get all the fuels off and get her turned around to get ready for its next flight.

So I was actually, um, uh, pre-staging a sleep pattern 'cause I had to work throughout the following night to help offload the cryogenics off the vehicle, um, and the fuel cell systems.

So I was preparing for that.

It was, um, shock.

I mean, it was shock in a lot of ways.

There was discussions I had heard, a bunch of us heard.

Um, of course, we're at KSC, as Mike had mentioned, at Kennedy Space Center, so perhaps a little removed from some of the conversations, but I do remember conversations of a foam strike.

Um, and you know, this is such an amazing
team, such a diverse team.

00:31:24,640 --> 00:31:26,179
Different folks are workin' different problems.

00:31:26,179 --> 00:31:31,269
So-so our focus was not only on getting Columbia ready to come home, but we also had Discovery,

00:31:31,269 --> 00:31:32,490
Endeavor and Atlantis to work on.

00:31:32,490 --> 00:31:33,490
Host: Yeah.

00:31:33,490 --> 00:31:35,490
Michael Ciannilli: So they're getting ready.

00:31:35,490 --> 00:31:39,039
Michael Ciannilli: So our focus is multi-focus on different vehicles, so it wasn't different.

00:31:39,039 --> 00:31:40,039
appear any different.

00:31:40,039 --> 00:31:42,460
Columbia's coming home tonight-- or coming home this morning.

00:31:42,460 --> 00:31:47,059
Uh, we're gonna start processing her tonight, and we're gonna run to a full launch, uh,

00:31:47,059 --> 00:31:48,308
for the vehicle, hopefully.

00:31:48,308 --> 00:31:53,178
So, um, so when this tragic moment happened-- I can speak personally-- it was a tremendous

00:31:53,179 --> 00:31:55,920
shock, um, shock to the system.

00:31:55,920 --> 00:31:59,160
It-it's met with something I'll never wanna experience again.

00:31:59,160 --> 00:32:01,009
Um, it's a horrific feeling.

00:32:01,009 --> 00:32:07,210
Um, it's an emotional experience, uh, that you go through, um, and you go through a lot

00:32:07,210 --> 00:32:08,600
of emotional feelings.

00:32:08,599 --> 00:32:13,519
Um, you know, you go through your pain, you go through, uh, the devastating loss.

00:32:13,519 --> 00:32:16,279
Um, Mike touched on it very well-- for responsibility.

00:32:16,279 --> 00:32:18,769
I think all of us felt responsible.

00:32:18,769 --> 00:32:21,509
Um, I kept thinking of what didn't I sign?

00:32:21,509 --> 00:32:23,569
What paper did I sign that I shouldn't have?

00:32:23,569 --> 00:32:25,730
What did I do?

00:32:25,730 --> 00:32:29,789
And-and I think that was pretty systemic.

00:32:29,789 --> 00:32:35,789
So when this happened, our first responsibility,
I think, we felt was what did we do wrong?

587
00:32:35,789 --> 00:32:37,389
What could we have done better?

588
00:32:37,390 --> 00:32:42,980
That's the sense of bonding that the program and the team has for what they do.

589
00:32:42,980 --> 00:32:48,880
Host: So you would say that the immediate response is not whose job was this to get this right-- it's like, where did I mess up?

590
00:32:48,880 --> 00:32:51,080
Michael Ciannilli: Right, right.

591
00:32:51,079 --> 00:32:52,079
Host: And that's commonplace for people in this moment?

592
00:32:52,079 --> 00:32:53,659
Michael Ciannilli: You know, I can speak from my experience and talking to others.

593
00:32:53,660 --> 00:32:56,150
I think it was pretty widely felt.

594
00:32:56,150 --> 00:32:58,259
I mean, there's such a sense of ownership of responsibility, and love.

595
00:33:02,140 --> 00:33:03,560
We know the crews.

596
00:33:04,779 --> 00:33:05,889
We get to know the crews.
Um, they become part of our extended family.

And in a way-- and this may sound a little bit unusual, but, um, anybody that works on hardware can probably attest to this-- the vehicles became part of our family.

I mean, I probably spent more time with Columbia, um, onboard Columbia and living with Columbia, than I did with members of my own family at times.

Host: Yeah.

Michael Ciannilli: I mean, you were there working the vehicle.

Um, it was part of your family.

And it was-- so you felt a tremendous sense of not only loss, but ownership of it's me, it's me.

And I think that's what-- one of the things that makes this team so amazing, is that sense of ownership of I'm gonna do my job the best I can.
of p-pride and-and ownership of doing the

right thing.

Michael Leinbach: You know, the-the people that worked on the-orbiters, and the

tank, and the boosters, and the ground systems-- an amazing group of people.

And-and they-they would do anything they could to make the crew as safe as they possibly could be.

And-and the astronauts would walk around and shake hands and talk about their kids.

And so, when Chachi says we got to know the crew and love them, that is absolutely the truth.

And-and it-it created that atmosphere around the space center of we would do--we would
go to the extreme to make sure that vehicle's as best as it could be.

And then when we lost Columbia, we were just empty. I mean, I was standin' next to the runway. And-- as my job as the launch director, I was one of the few lucky folks who got to greet the crew when they came off the orbiter, and shake their hands, and welcome 'em back to Earth, and, you know, put my arm around 'em and steady 'em a little bit, and-and-and there we were, waiting for Columbia to come home, and it just didn't come home. And we didn't know where it was. We-we just didn't know where it was, and-and the emptiness-- and it couldn't have landed in anywhere else safely, and-and intellectually, we knew that.

Host: Right.
Michael Leinbach: And so we knew the worst had happened.

Um, but we just didn't have any information about what had happened at first.

And it was just a totally empty feeling.

Host: So as we look at things like the future with reusable hardware, are we creeping towards the same kind of failure, or are we smarter?

From my perspective, the problem we fell into in the shuttle program was based as much in human nature as the hardware itself.

We got to a point where we got comfortable with our success.

We got complacent.

And those feelings, um, traits, those feelings,
those issues, those, uh, characteristics,

00:35:57,309 --> 00:35:59,619
they-they-they're not unique to the shuttle
program.

00:35:59,619 --> 00:36:01,650
They're not unique to the Apollo program.

00:36:01,650 --> 00:36:04,410
They're not unique to Challenger or Columbia.

00:36:04,409 --> 00:36:09,730
They are human traits that the new entrants
are gonna have to deal with.

00:36:09,730 --> 00:36:10,730
Host: Yeah.

00:36:10,730 --> 00:36:15,409
Michael Leinbach: There are-there are people
that are re-flying hardware now, and they're

00:36:15,409 --> 00:36:21,440
gonna have to deal with these issues of-of,
uh, minor problems-- re-flying minor problems

00:36:21,440 --> 00:36:24,420
and assuming they're gonna be a minor problem
the next time.

00:36:24,420 --> 00:36:28,650
They're gonna have to deal with that.

00:36:28,650 --> 00:36:33,440
That's-that's the nature of hardware.

00:36:33,440 --> 00:36:37,960
The nature of the people dealing with it--
you've got to dig deep and-and make sure that

00:36:37,960 --> 00:36:39,960
when you give a go, or-or you disposition
a problem as not a major issue, that you've
thought of everything possible-- all the different ways it could fail, beyond the way it just failed this time.

You have to prove these vehicles are safe to fly.

Host: Yeah.

Michael Leinbach: Every time you go to a review, whether it's a minor review or a major review, you have to prove it's safe to fly-- not prove it's unsafe to fly.

You have to prove it's safe to fly.

And by-and by insisting on that mindset, it makes you delve into the systems and the problems even more deeply, and it makes you think about, well, what could go wrong if this minor problem occurred again?

How could it manifest itself on the next flight?

Could it be the major problem, or will it be the same outcome that you just experienced?
You have to prove it's safe to fly, and in doing so, it makes you dive into every system as deeply on the third flight of a vehicle, or the tenth flight of a vehicle, or the first flight of a vehicle.

You just need to prove it's safe to go every time.

Launch Dialogue: You're clear to launch.

I copy that.

Thank you, sir.

And attention, all personnel.

The countdown clock will resume in 30 seconds.

Host: Is there a sense to where becoming emotionally attached to a vehicle does that make you smarter, does that make you sharper?

Or does that cloud your judgment?

Michael Leinbach: Hmm, that's a great question.
Um...

00:37:59,920 --> 00:38:02,820
Host: Might be a little bit ambiguous, kinda existential question.

00:38:02,820 --> 00:38:04,960
Michael Leinbach: No, I-I get it.

00:38:04,960 --> 00:38:07,519
It probably hurts more than helps.

00:38:07,519 --> 00:38:13,460
I mean, we-we described how much we loved the the orbiters, and that's true, but we

00:38:13,460 --> 00:38:17,449
also- it probably clouds our-our vision a bit.

00:38:17,449 --> 00:38:22,129
I-I-I-- you should stand back-- when-when you're looking at a space flight and putting

00:38:22,130 --> 00:38:27,289
astronaut lives on the line, you need to-you need to separate the emotions out and look

00:38:27,289 --> 00:38:31,109
at the technical aspects and make sure you have done absolutely everything you could

00:38:31,108 --> 00:38:35,769
possibly do to make it safe, regardless of how-how cool it is, or how-how much you like

00:38:35,769 --> 00:38:37,048
the machine or anything else.

00:38:37,048 --> 00:38:39,119
You've gotta prove it's safe to go every time.

00:38:39,119 --> 00:38:44,769
I think getting into the emotion of-of-of loving the machines and working with the machines,
that's just j-- that's more job satisfaction.

Host: Hmm, sure.

Michael Leinbach: When it comes down to it, you've got to give a go or no go based on data.

Host: Yeah.

Michael Leinbach: And then, ultimately, machines can break.

I mean, and you can have all the best processes and management reviews and hardware in the world, and ultimately it's a machine and it can break.

And in that circumstance, well, you did all you could, and-and-and there you are.

Michael Ciannilli: Yeah, and Mike said it very well-- I mean, I think a sense of humility, uh, into what we're doing-- I mean, you know, when you think about it, um, and Mike alluded
to this before, it's like a ship.

You know, ships weren't made to sit in port.

The only place-- safe place for a ship is to sit in port at the dock.

Uh, but we don't do that, right?

Our car in our garage is the safest place for it.

Well, we take the car every day and go to the grocery store and places.

So we're meant to use vehicles to explore and to go places, and-and, uh, discover things.

So we have to accept that risk.

And Mike also touched on a thing which was very poignant, was the fact that our DNA, um, you know, we have good flaws, and we have potential challenges in our DNA.

We have to realize that, um, to get through it.
Michael Leinbach: And I get asked a lot, "what--
Mike, what are-what are-what are the major

And I kinda boil it down to-to two.

Um, one is-is kind of-kind of just technical--
it-it-it taught us how to live and work in

low Earth orbit for two weeks at a time.

Um, it was-it was the next evolutionary step
in America's manned space flight program to

an international space station, and then eventually

beyond.

But it-it was the first vehicle that taught
us how to live and work in low-Earth orbit

for two weeks at a time.

More so than that, it was the first reusable
spacecraft in the world.

Um, you look back to Mercury, Gemini and Apollo--
every astronaut that flew those vehicles flew

in a brand new spacecraft on a brand new rocket.
One time use each, period.

Michael Leinbach: Shuttle changed all that.

We dealt with reusability for the first time.

And we dealt with it extremely well in most circumstances, and we dealt poorly in at least two major circumstances.

And we have all those lessons learned and, uh, experiences to pass on to the next-the next generation of space flight providers.

And I just hope they ask us.

And I know they are, to an extent.

Um, we have a lot to share, and, uh, we ought to share it all together, not just in the United States, but internationally, as Chachi says, and you know, we owe it to the astronauts to do everything we possibly can to make their flight safe.
And-and that-- part of that is talking about problems with other systems, and-and, uh,

and-and understanding what-- how other systems got themselves in the-- in binds along the way.

And I just-I just really hope we can share both with the-the-- our corporate partners here in America and internationally.

It's-- there's-no- there's no better lesson learned than-than sharing the lessons learned we have from shuttle, and-and the rest of America's space flight history.

Host: Chachi, I wanna ask you, kinda thinking about the future, as we're kinda talking through these challenges, how are you, as part of this program you're working on, conveying this necessity of evaluating good and bad change to people?

Working SLS, Space Launch System, and the commercial crew program, as well as our commercial crew partners, because now we're expanding beyond NASA people into other companies, where
we can't dictate culture, we can't dictate a lot of what they do.

Uh, we have specific requirements, but we have to influence more than than control.

So how are you kind of approaching that with the people you speak with?

Michael Ciannilli: You pose a great question, Josh, is how do you reach out to industry?

It's a new relationship with NASA, it's a new future with us, with-- you know, it's-it's their rocket.

We're buying services on it.

Um, so we, of course, have, um, we have a relationship with them through our commercial crew offices.

Um, so we have input, to some degrees.

Um, but what we try to do is saying, "we wanna share our past with you."

We wanna share the good stuff, we wanna share the bad stuff.
We humbly suggest you don't do the bad stuff, but you do the good stuff."

And we have a lot to give.

You know, NASA has this amazing history of--

Host: Yeah.

Michael Ciannilli: A massive amount of knowledge.

We wanna share that with the folks, 'cause you want all these companies to be so successful they take us even further.

So it's more of a here's what we have to offer for you.

We're not asking anything in return, except for take the good stuff, don't take the bad stuff, and go further than we went.

That's our hope.

Host: --about competition between partners, between commercial and government.

The way you speak about it, this doesn't sound like a competition.
How do you evaluate the current state of things?

Michael Ciannilli: Well, um... you know, that's a good question.

Michael Leinbach: Yeah, Chachi.

Michael Ciannilli: You know-- thanks for that one, Josh.

Um, Mike, you wanna-- no.

Michael Leinbach: No.

Michael Ciannilli: Um, well, to be perfectly honest, you know, there's different providers that wanna provide different services, right?

So-so NASA wants to provide a service-- exploration, deep exploration, deep space exploration.

Of course, if you're providing a rocket service, you wanna be the rocket provider on record,
They wanna sell their services and provide a service to the nation.

Um, so I don't know if one could say, um--you know, in a perfect world, we wouldn't see it as competition, um, but being--but looking at the world the way it is, we're tryin' to say, hey, we want a rising tide lifts all boats approach.

Host: Sure, yeah.

Michael Ciannilli: Where if we can help this company A, company B's going to help, and if company A opens up about some challenges they're having, company B would be successful, and vice versa, right?

Somebody else has a bad day, and they help somebody else out.

So, um, it's an approach of we all help each other be successful, 'cause the bottom line, I'd humbly suggest, what NASA really wants to do is we want America to be successful, right?
Host: Yeah, absolutely.

Michael Ciannilli: And our international partners, so we want all of us to do great things in space, um, and that's our mission with the program, is NASA plus commercial.

You know, when we look back and-and look at some of the accidents that the, um, the Russians had in the '60s, and we look back at some of the incidents we had, in retrospect-- it would've been wonderful at the time, right-- it was a different situation with the Cold War, but--

Michael Ciannilli: If we had some insight into what the Russians were facing.

Host: Right.

Michael Ciannilli: Some of the face-- the issues we face on Apollo 1, they had seen similar things during their programs.
Host: Wow.

Michael Ciannilli: So we could've learned a lot and vice versa-- we probably could've supplied information to them-- of course, that wasn't the environment.

So now we're not in, uh, that type of environment.

So we're tryin' to show-- everybody helps each other out.

Host: So we're just about out of time.

Uh, appreciate you guys being here.

We've got some of the best and brightest minds working on human space flight systems.

How do you guys feel about that?

Are you guys optimistic about us pressing on for exploration?

Michael Leinbach: Personally, extremely optimistic about it, and-and-and I sit back and I watch the great things goin' on out here at the Kennedy Space Center and around the country.

NASA Kennedy - Rocket Ranch Podcast Episode 3_ Failure is Not an Option_y7r968V7RBE - transcript (human).txt[15/09/2019 16:00:38]
with the-with, uh, both the NASA launch systems and the commercial launch systems, and we're

about ready to start flying astronauts back to the international space station on American

rockets off American soil again.

I'm extremely confident that that will occur safely, and I'm very optimistic about it.

Y-you know, the thing that's true about failure is you learn a lot from failures.

And-and we did, in the space shuttle program.

And, um, a-as long as we keep our eyes open and-and don't repeat the same failures we

had in the past, we're-we're that much closer to having a-a-a much safer system, and, uh--

and with the designs of the new systems being less complicated and inherently safer, and

with escapability, man, I-I'm all over it.

They're-they're-they're gonna do great things, and I'm gonna be the first one to cheer

when we have a lift-off and a safe-- and a safe landing of the next crews.
Host: Yeah, I'll be with you.

848
00:46:31,108 --> 00:46:32,289
Michael Ciannilli: And I concur with Mike.

849
00:46:32,289 --> 00:46:35,619
I think, um, we got a beautiful opportunity ahead of us.

850
00:46:35,619 --> 00:46:36,619
Um, exciting future.

851
00:46:36,619 --> 00:46:39,559
Um, you know, the president just said we're going back to the Moon.

852
00:46:39,559 --> 00:46:40,559
We're going to stay.

853
00:46:40,559 --> 00:46:41,559
I think that's exciting.

854
00:46:41,559 --> 00:46:42,890
From there, we're going on to Mars.

855
00:46:42,889 --> 00:46:47,480
I mean, there's just so many cool things coming down the pike, um, that we're very excited about.

856
00:46:47,480 --> 00:46:48,480
And even-- you know, this is a very difficult conversation we've had today, but I'd humbly suggest there's also a beautiful silver lining in the conversation as well, because, uh,

857
00:46:52,829 --> 00:46:57,130
Mike and I, along with, you know, thousands of other folks, lived through a very dark
time.

And we still have those dark feelings and moments.

But, um, I think of the Challenger story now, and the Columbia story, even Apollo, uh, in many ways as a bright new story.

And that may sound strange to say, but I truly believe the crews of Challenger and the crews of Columbia and Apollo are still workin' for us.

We teach the lessons every single day with new people, and I can see the look in their eyes when they get it, when they see the lessons that we're sharing with them, why it's important, why they should go back to their jobs and do the very best they can.

Um, I've seen-- by thousands of folks.

Um, and when I travel around the country, having the honor to speak to folks, as I'm sure Mike has as well, um, you see it, you can feel it.
The comments you get back are, um, they're inspired based on what's happened in the past, and never let the darkness happen again.

Host: Yeah.

Michael Ciannilli: So I think if you, um, the American people, um, give us the honor to, uh, unleash the talents of what this team can do, um, you're gonna be surprised how far we can go.

Host: Awesome.

Michael Leinbach: Very well put.

Host: Awesome, yeah.

Mike Leinbach, Michael "Chachi" Ciannilli, appreciate you guys being in here today.

Uh, this is phenomenal.

Appreciate your honesty and forthrightness talkin' about this.

It's a tough subject, but it's one that we need to talk about.
Michael Leinbach: Sure, you bet.

Michael Ciannilli: Thank you so much.

Michael Leinbach: We learn—learn from our past.

Host: To learn more about NASA’s plans for human space flight, visit NASA.gov/HumansInSpace.

A special thanks to our guest, former shuttle launch director Michael Leinbach, and Columbia Research and Preservation Office curator and "Happy Days" star look-alike Mike "Chachi" Ciannilli As always, we have a fabulous crew here at the Rocket Ranch.

Our sound men, Glenn Benson and Dan Casper, Amber Jean Watson for her archival research,

our episode editor, Michelle Stone, producer, Jessica Landa, and the surely sleep deprived Joshua Santora.

If you're a fan of the Rocket Ranch, then tell a friend, and subscribe already!

Next month, we'll have a rocket roundup, y'all, with special guests who will break down today's
top launch vehicles, including the Delta II, about to lift off for the very last time.

Don't miss it.