welcome to NASA's Jet Propulsion Laboratory in Pasadena California I'm Veronica McGregor we had a date with a comment last night and things went exceptionally well we did have to wait a long time for those images to come down this morning though and that is why we are starting a little bit late and please accept our apologies for that so we are bringing you the latest images that are hitting the ground as we speak let me introduce the panelists for you now first we'll have dr. Ed Weiler he is NASA's associate administrator the
science Mission Directorate at NASA

headquarters tim larsen the stardust

next project manager from the Jet Propulsion Laboratory dr. Java verka the

Stardust next principal investigator

from cornell university in ithaca new york dr. down don brownlee the Stardust

next co-investigator from the University of Washington in Seattle and dr. Pete Schultz another Stardust next co-investigator and he's from Brown University in providence rhode island

and we will begin with dr. wyler Thank You Veronica five and a half years ago a
spacecraft named Deep Impact had a close encounter with a comet named Tempel 1

the mission was designed to drop off an 800-pound metal slug which would impact the comet at a high velocity and throw up a bunch of comet material the spacecraft's instruments would then look at that material and ejected a better understand the chemical makeup of these primordial bodies called comets in fact the principal scientist of that mission my doctor Mike Ahern from University of Maryland is in the audience today but that was yesterday's news in 2006 dr.
Joel Verka from Cornell sent a proposal

00:01:56,640 --> 00:02:02,250
to NASA with a rather novel idea to

00:01:59,519 --> 00:02:05,789
retarget a different spacecraft called

00:02:02,250 --> 00:02:07,799
Stardust to revisit temple one Stardust

00:02:05,790 --> 00:02:09,509
is a 12 year old spacecraft having

00:02:07,799 --> 00:02:11,819
complete in its prime mission many years

00:02:09,508 --> 00:02:13,589
ago this was the second time actually

00:02:11,818 --> 00:02:15,988
that NASA would take advantage

00:02:13,590 --> 00:02:18,750
of an old mission for new science and

00:02:15,989 --> 00:02:21,269
exploration the first was comet Hartley

00:02:18,750 --> 00:02:24,769
encounter with a reused deep impact

00:02:21,269 --> 00:02:27,209
spacecraft renamed epoxy just last fall

00:02:24,769 --> 00:02:30,269
thanks to a great effort by the science

00:02:27,209 --> 00:02:32,459
team engineers navigators Lockheed JPL

00:02:30,269 --> 00:02:34,980
and NASA we are here today to show you
the results of humanity's first revisit to a comet to study how these objects evolved over time and it might add the results you will see in a few minutes were achieved for less than ten percent of the cost of a new discovery class mission before I turn over to Tim I have a message for any school kids out there who might be wondering how NASA can send a spacecraft billions of miles through the solar system and somehow wind up flying so close to a tiny comet only a few kilometers in diameter it's done with math so pay attention in math class
if you ever dreamed of being involved in this kind of real science discovery and exploration Jim thank you add again I'd like to reiterate this as exciting for us because it's the first time we've ever had the opportunity to visit a Jupiter class comet that goes its orbit goes out as far as Jupiter and in this case comes in as close to the Sun as the orbit of Mars and that's about where we met it last night with a spacecraft based on the data that we
brought down from the spacecraft we've been able to confirm that our flyby distance from the comet was 178 kilometers that's about 110 miles we went past the comet at the velocity of 10.9 km/h order of 24,000 miles per hour and our closest approach was right before 840 p.m. here in on the west coast on Valentine's evening our spacecraft telemetry shows that all of our sub systems operating exactly as we expected during the flyby the auto nav soft work which is the autopilot software that controls the the motion of
the mirror that keeps the comet in the

00:04:21,060 --> 00:04:25,639
image of field in the field of view of

00:04:23,129 --> 00:04:27,468
the camera worked exactly as planned and

00:04:25,639 --> 00:04:29,749
the comet exactly where was supposed to

00:04:27,468 --> 00:04:31,519
be all the way through the flyby oh all

00:04:29,749 --> 00:04:33,110
the desired data that we wanted to

00:04:31,519 --> 00:04:36,468
collect was all collected and stored on

00:04:33,110 --> 00:04:39,020
board that's 72 images and approximately

00:04:36,468 --> 00:04:40,819
three megabytes of dust data for a total

00:04:39,019 --> 00:04:42,408
of about seventy eight megabytes of data

00:04:40,819 --> 00:04:45,259
that doesn't sound like a lot to you but

00:04:42,408 --> 00:04:48,408
this is an old spacecraft the spacecraft

00:04:45,259 --> 00:04:50,330
is healthy after the flyby we were able

00:04:48,408 --> 00:04:52,848
to confirm that there is no noticeable

00:04:50,329 --> 00:04:54,188
degradation to the spacecraft to the
health or function of the spacecraft
despite the fact that we have detected several dust hits through the flyby and you'll hear a little bit more about that later so after the flyby we turned the high-gain antenna back to earth and began to downlink our data as planned at that point since the spacecraft was healthy and we really wanted to gain a little bit more margin in our downlink to make sure that we protected this data and got it down in one pass safely we decided to delay our downlink by about 45 minutes so that we could reconfigure
both the spacecraft and the Deep Space Network station to accommodate that so that was accomplished and that went very well next we had our plan on the playback was to send five images that bracketed the closest approach period of the flyby we wanted those five images to come down first in the queue when we started sending images back down to earth when we commanded that it turns out due to a software glitch that we had on board the images started coming down in the order that they were taken so this did not jeopardize any of the data
that we had on board all the data was safely stored in memory and was ready to be sent down we just had to wait a little bit longer for those images that all of us were really ready to see at that time so those images got down to the ground about between six and seven o'clock this morning you have already probably seen them out on the web and some very exciting findings coming out of those the spacecraft is continuing to send images down to earth we're at this point we're approximately 60 out of the 72 images are down on the
ground we'll continue doing this until

00:06:25,788 --> 00:06:30,110
mid afternoon once we've confirmed that

00:06:28,310 --> 00:06:32,209
all the images and all the data is on

00:06:30,110 --> 00:06:33,709
the ground and all the packets are

00:06:32,209 --> 00:06:34,659
complete no corruption to any of the

00:06:33,709 --> 00:06:36,639
data that would

00:06:34,660 --> 00:06:38,680
retransmit at that point we'll be able

00:06:36,639 --> 00:06:40,569
to reconfigure the spacecraft and get

00:06:38,680 --> 00:06:42,220
ready for our outbound imaging when we

00:06:40,569 --> 00:06:44,290
do that we'll spend one to two weeks at

00:06:42,220 --> 00:06:46,660
least of looking back at the comet as we

00:06:44,290 --> 00:06:48,490
go away from it and as long as the

00:06:46,660 --> 00:06:50,370
scientists can get useful information or

00:06:48,490 --> 00:06:52,480
that data will continue that process

00:06:50,370 --> 00:06:54,399
Joel leave it to you that tell us what
we found alright well let's see Tim a

few minutes ago said that he was excited

let me just say I mean more excited

there is a great science and if we could

have the first slide this shows us

selected for images taken around closest

approach and when I want to emphasize is

that we achieved all of our science

objectives we had four major science

objectives three dealing with imaging

and one with the dust experiments that

we have on board the three imaging goals

were first of all to look again at areas

on temple that we had seen before in
2005 a deep impact to for the first time see what changes occur on a comet when it comes close to the Sun and were those changes occur we also wanted to take the opportunity to look at the deep impact site were the Deep Impact min factor collided with the comet and finally we wanted to take the opportunity to extend our exploration and see areas on temple that we have not seen before so we had three imaging objectives and one objective having to do with analyzing collecting dust that dr. Bradley will talk about a dust i'll talk about
imaging and if you ask me was this
mission a hundred percent successful in
terms of the science i would have to say
no it was a thousand percent successful
and so i would like to just very quickly
go over some of the highlights what
we're looking at here are foreign
minister on closest approach and the way
we planned this encounter was on the way
in to see some of the old territory that
we had seen before in 2005 including the
leave a crater site and then on after
closest approach to see new parts of the
comet so behind me here we have the
approach images I just point out two
craters this is the area where the Deep
Impact impactor hit the covet up here
you could barely see in this image is a
region that was intriguing to us because
we expected that region to change
significantly in a five and a half years
between the encounters so let me first
of all show you one example the changes
in the next slide which is that area
that I pointed out before the smoothie
right this is a deep impact image of
here you see the region in 2005 this is
about two or three kilometers it extend
this is maybe three or four hundred
229
00:09:38,480 --> 00:09:45,810
sorry meters across here this is 2005

230
00:09:43,139 --> 00:09:47,698
this is 2011 this is the current

231
00:09:45,809 --> 00:09:50,578
situation and let me just point out a

232
00:09:47,698 --> 00:09:53,729
few things for example up here you see 3

233
00:09:50,578 --> 00:09:57,508
pits here you see one contiguous pit

234
00:09:53,730 --> 00:10:00,199
erosion on a scale of 20 30 meters of

235
00:09:57,509 --> 00:10:02,909
material has occurred in a 56 years

236
00:10:00,198 --> 00:10:04,500
since we took this picture also if you

237
00:10:02,909 --> 00:10:06,328
follow the outline of this of this

238
00:10:04,500 --> 00:10:08,278
boundary and compared to what we see

239
00:10:06,328 --> 00:10:10,078
today you will again see significant

240
00:10:08,278 --> 00:10:13,259
changes so we were successful in that

241
00:10:10,078 --> 00:10:15,208
objective we are seeing changes we have

242
00:10:13,259 --> 00:10:17,308
to spend time and quantifying those
changes until understanding what they mean our second goal if I could have the next slide okay this is just that shows us the two areas the area outlined here which changes occurred and also the boundary but what we're looking for is the following slide and that is not the following slide but how about the one but what do you get after that one you haven't anything after you there's no other site okay well then folks the way this is going to work is that we do in fact have a comparison of the deep impact area in 2005 and 2011 and in fact
does show an impact crater and

unfortunately I can't show it to you but

Pete Schultz in a few minutes apparently

if we are lucky he might actually have

that to comprehend comparison so we were

against successful we achieved their

objective we not only image the area of

the deep impact event but we have an

image of the crater that was produced

and finally the slider we have here is

to exemplify our third goal which was to

extend the exploration of temple to

areas we have not seen before so this is

the part in this picture the parts that
we have seen before are sort of behind

00:11:45,220 --> 00:11:52,418
up here and this is all new territory on

00:11:48,458 --> 00:11:55,868
the comet and it is simply amazing there

00:11:52,418 --> 00:11:58,568
are extensive areas of layering layers

00:11:55,869 --> 00:12:00,579
that have been deposited each layer a

00:11:58,568 --> 00:12:03,639
few meters thick maybe 10 meters thick

00:12:00,578 --> 00:12:06,488
we have to puzzle how does this happen

00:12:03,639 --> 00:12:08,100
we have large regions this is about a

00:12:06,489 --> 00:12:10,149
kilometer across where material

00:12:08,100 --> 00:12:13,480
apparently been sublimated from the

00:12:10,149 --> 00:12:15,818
surface and removed there are areas on

00:12:13,480 --> 00:12:19,928
here which looked like they're heavily

00:12:15,818 --> 00:12:21,818
pitted or heavily cratered again geology

00:12:19,928 --> 00:12:24,068
that we did not see on the others face

00:12:21,818 --> 00:12:25,208
of Temple and to understand how this
comment works we have to put everything together in closing I want to emphasize that to achieve these three imaging objectives we had to arrive at the comet that precisely the right time as I mentioned we planned it so that on approach we would see the deep impact area and then after closest approach we've seen you train that meant arriving precisely at the right time at the right place and to achieve that not only did we need first-class navigation but we need an information on a rotation state of the comet
we had an international effort over several years of monitoring the Comets rotation and predicting what the state that would be at encounter time how well did we do we got the longitude / which wanted to fly to plus or minus one or two degrees out of 360 degrees so that was a great achievement by our scientists so we're tremendously happy and I will now pass the discussion on to dr. Schultz who hopefully does have a picture of the crater yeah yeah joe aye aye sir hope I do yeah I make craters for a living but I've never had to wait
five and a half years to see the results

so if we can we have that first time

step up there and you can actually see

what Deep Impact saw and when the

close-up views this showed from the

probes perspective as resuming in to the

surface and where it was going to hit

around 9p temple 1 if we go to the next

time step this is why we need to go back

on the left hand side is an image from

one of the HRI images and on the right

is an image that EEP impacts all about

700 seconds afterwards you notice we

can't see the crater it's obscured by

all the ejecta that was tossed up by the

impact we never saw the Creator is one

by is there somewhere you know that

created a lot of mystery it also created

it helped to create this mission let's

take a look at the next time step I just

want to show you how well we can

correlate the different features on the

left is an image of from deep impact on

the right to start us next and you can

see those two craters those two

crater-like features each one of them

about 300 meters across almost thousand

feet where we were aiming was right in

between with deep impact that's where
that probe went in and if we take a look

at the next time step which is not that

now won't we skip that time step no

that's a nice picture yeah very nice

picture um I don't know yeah we're gonna

put that last one up okay is there

another one after this now there is not

there is no hey Joe guess what it's cool

hello not let me just jump this one just

you wait hey we saw the crater yeah

you wait hey we saw the crater yeah

really we really did see we saw the

creator and I'll tell you what I'll give

you a hug you stay with me here okay we

saw this crater it's subdued it's about
150 meters across and has a small central mound in the center it looks as if from the impact the stuff went up and came back down so we did get it there's no doubt and I think one of the bottom line messages is that this surface of the comet where we hit is very weak it's fragile so the crater partly healed itself so let me turn this over to down Bromley and see if you can give them some data huh do you have the picture of the crater dawn we had a lot we had thousands creators the comments unlike any other body in the solar
system are unique because when they're in the inner part of the solar system where the earth is they're literally coming apart and sending tons and tons of gas and rocks and dust out in space so last night this spacecraft Stardust went through this cloud of dust and rocks coming off the comet the second time is survived this it actually had a dozen impacts on the front leading edge of the spacecraft here called the Whipple bumper that went through the front that's a it's a graphite cyanate honeycomb sheet that's about as thick as
your finger and a dozen of those were

big enough almost millimeter size they

went puncture it into it and went into

the inside of the Whipple shield from

behind in addition to that we have a

instrument instruments on the front of

the spacecraft called a dust flux

monitor instrument and this was made by

a collaboration

chicago university of kent in england

and they have sensor to detect these

impacts that heck you to 5000 smaller

particles but one of the really

interesting things about just the impact

rate and i hope we hear the impact rate
in just a second was the nature of the impact weight when we flew past the previous comment built two years ago we were stunned that instead of having a slow rise in the impact rate and then peeking out when we got closest and then dropping off it came in sputters and starts never thought what on earth is going on what's going on this is the way it comets act they don't just spew off things in a uniform way they send out in berts and puffs and even more than that they send out clods of dirt and ice and rock that come apart and so a good
analogy of thinking of like a b-17 in World War two flying through flak and so

instead of being big Bing Bing Bing Bing

like that it's just bursts of things we

had sometimes a large number of impacts

in less than a tenth of a second so it's

a very dramatic environment do we have

the audio tape on that will heavily okay

if they don't all simulate it that's it

so weren't you glad you weren't on the spacecraft and this went on and on and

on it and that the roast impacts are

several minutes before the closest

approach to and they continue not but
thousands of impacts including on a firecracker size of burst so that was really exciting and from the common science is very interesting so there's two comets we've seen that behave this way but even more you know we've been to several comments now and comet Hartley didn't have a dust detector on it but it took these marvelous pictures of these snow and dirt balls coming apart in space after they admitted for from the LA coma so these clods come off disintegrate and then the spacecraft goes through
them the massage is detecting dust we

also had an instrument on the side of

the spice basically all called cited

made by Max Planck Institute in Germany

and this measures the chemical composition of dust and there are

several dozen particles that were analyzed last night during the flyby and

tuned to be very sensitive very small particles and also to measure organics

and the first factor i saw was very exciting because it showed peaks for

carbon and CN carbon bonded to two nitrogen so anyway it was a real thrill
to do this the whole mission was a real thrill and it's great to use one spacecraft to go to multiple targets with the same instruments ok we are going to open it up to questions in the meantime they are trying to find the images there they were going to roll and we're hoping also to have a flickr movie of the images all together all the images that we have so far but in the meantime let me go ahead and open it up to questions we'll start in the room first if there are any questions if not we do have some people on the phone are
there any questions from news media in the room yes go ahead and give us your name and affiliation sure stand in topton with KPCC you pointed to an image of i'm not sure what it was but it was a shape that you said had changed it had eroded over time can you explain a little more what that what caused that shape and what caused the changes how did that happen when we're know what caused the changes the surface of a comet is in part made of water ice when the comet comes close to the Sun the temperature of the surface increases
enough for the ISIS to start evaporating

that's why we see gases and thus coming from a comet and so what you saw are places where during the last five years ice has evaporated and carried with a dust into space it's a sublime feature sorry about that any other questions from news media in the room yes Alicia Chang Alicia Chang from AP Tim the reason why it took so long to download the pictures was that a result of commands that were already sent up to space spacecraft before or when you had to do the reconfiguration
during the mission oh that was yeah the
initial reconfiguration we did that that
configuration was planned ahead of time
we designed that as part of the
encounter what we wanted to make sure
that no matter what kind of contingencies happened during the
encounter we came on out on the other side of it in a known configuration that we could support with telecom that's why
we had that particular configuration
selected once we knew we were healthy
and could support a different decoder at the station we went ahead and asked for that because that gave us a little bit
more margin on our honor downlink just
to make sure we had more safety net
above above the signal that we had but
the fact that it took so long for the pictures to download was that a mistake
in the commands over Senta know that that initial one was driven purely by
physics because it required a command to the spacecraft and the round-trip flight
time is around 40 minutes the second
downlink issue that I talked about that was that is a software issue that we're looking into it was supposed to have put
the the five pre-selected images into
the downlink you first and we don't know

yet why it didn't

but those images are on the ground

they're all on the ground all right

we're going to take a question next from

the phone lines the LA Times is on the

line Mina Khan please go ahead with your

question I am thank you for taking my

call I have a couple of questions so you

mentioned that the cost would be about

ten percent of a new discovery type

mission how much is the actual cost of

this mission of the second question is

related to the surface of the comet yeah
I heard yesterday that there were some smooth areas that seem to suggest there then flows along the surface could you talk a little out that and what might have caused that yeah I'll take this is that while ur from now so the I'll take the first question the cost of a new discovery mission to do this kind of Sciences in the range counting a launch vehicle of perhaps three to four to five hundred million dollars this mission cost NASA exactly 29 million dollars so i was being conservative when i said ten percent it may be as little as six
percent the smooth walls that you're referring to were discovered on temple in 2005 by deep impact and they came as a surprise to come at scientists they have been interpreted as places were a very volatile gas from below the surface has erupted carrying with it small particles of ice and dust and while some of the stuff leaves into space some of it just flows downhill because the comet does have a little bit of gravity so what is surprising about those features is that they seem to be fairly recent and apparently they also change with time readily i guess that's where we
have seen the most obvious changes in
the comparison between 2005 and 2011 but
in short i mean they are they are
perimeter places where material from the
subsurface is erupted onto the surface
of a comet
we'll take another question from the
phone lines we have Denise Chow with
space.com please go ahead with your
question hi thanks for taking my
question um just had a question about
the deep impact crash site when you were
looking at the comparison images i
think it was maybe dr. Larson that said
that when the impactor had had a hit the

comment that it had all this material

that sort of obscure words of you in

2005 when you're looking at the images

from last night was there anything that

surprised you about the impact site yeah

I'll take that yeah there was a surprise

in the sense that you could have

expected a crater that's very very well

defined and the crater was more subdued

than I think some of us thought but it

was still basically what the kind of the

size that we expected and I think the

real point is is that it's consistent
with what we saw in 2005 with the ejecta
go up and then a component coming
down and so in a way it partly buried
itself and I think we saw that very clearly and the images you didn't see
trust us okay we're going to put up an image it is the image that we do have in
our broadcast system you can tell us if it's the image you want and just so everyone's clear the image that they wanted will be posted to the internet no matter what so you'll all see it does this one work for you yeah right now can talk to the speed please there's several
things in the Simmons I wanted to point

00:27:01,109 --> 00:27:05,579
out one of them is that these are the
two craters we are talking about the

00:27:05,579 --> 00:27:09,839
other thing is notice this feature is

00:27:07,289 --> 00:27:11,670
here if you notice over here that

00:27:09,839 --> 00:27:13,829
feature is gone even though many other

00:27:11,670 --> 00:27:16,259
features you can identities alee

00:27:13,829 --> 00:27:18,990
identify the interesting thing is that

00:27:16,259 --> 00:27:21,599
these concentric circles represent our

00:27:18,990 --> 00:27:23,490
estimate of the crater rim and then the

00:27:21,599 --> 00:27:26,159
inner circle is an estimate of the

00:27:23,490 --> 00:27:28,079
crater floor you can barely see this but

00:27:26,160 --> 00:27:30,300
there's a little lit area on that side

00:27:28,079 --> 00:27:32,460
and a dark area on the other and that's

00:27:30,299 --> 00:27:36,089
the central mound where we think the
material came down so we think we see
the crater with a sunlit rim on that
side or sonicwall on that side a small a
little bit of a shadow there
we see the mound on the floor this is
kind of what you would expect for an
oblique impact at an angle of 30 degrees
we have a lot of material that went up
and came back down so the picture on one
side is a deep impact yeah that's the
deep impact view over here and that's
the start us next it's about 150 meters
across is what the current estimate that
you know stay tuned all right we're
going to go to another question on the

please go ahead okay thank you very much

this is for Pete Schultz I guess Pete

I’m sure glad you’re convinced is the

mutant nature of this crater more muted

than when you would have expected and

are you anticipating finding our kind of

mantling all over the comet’s nucleus

due to all the dust and debris that was

ejected well you know the two questions

first is that yeah one of the reason for

going back to see what the crater looked

like you know there were some thoughts
that maybe the credit would simply bury

itself or that it would sort of collapse

because of its formation in terms of the

ejecta if that was all ice that could

have supplemented away very quickly and

completely by the time we got back to it

so I think when we look at this estereo

we can see this feature and we can see

it in multiple images and so on think I

feel very confident that we actually did

find the site

okay thanks we have one more question on

the phone lines Leo in right from Eyres

television please go ahead thanks very
much I was just wondering about this

671
00:29:24,099 --> 00:29:29,949
lobate feature that has been mentioned

672
00:29:27,099 --> 00:29:31,419
several times is this advancing or

673
00:29:29,950 --> 00:29:34,380
retreating I think that was one of the

674
00:29:31,420 --> 00:29:36,430
questions that you wanted to answer

675
00:29:34,380 --> 00:29:37,750
that's an excellent question the

676
00:29:36,430 --> 00:29:40,450
question is about the little bait

677
00:29:37,750 --> 00:29:42,730
feature we talked about is it eroding or

678
00:29:40,450 --> 00:29:44,860
increasing at the present time it is

679
00:29:42,730 --> 00:29:51,339
roading so it was formed at some time

680
00:29:44,859 --> 00:29:52,779
past and since then has been eroding do

681
00:29:51,339 --> 00:29:57,849
we have any more questions from the news

682
00:29:52,779 --> 00:29:59,170
media here at JPL no I'm going to do one

683
00:29:57,849 --> 00:30:01,509
last check to see if we have any new

684
00:29:59,170 --> 00:30:03,070
images if the control room what can tell
me no we are done with those are all the images that we have but we will be posting new images and new products to the web all day long as those become available so please do visit w WN s a govt you'll find links there to all of the images from this comment encounter you want to thank all of you for joining us today goodnight you