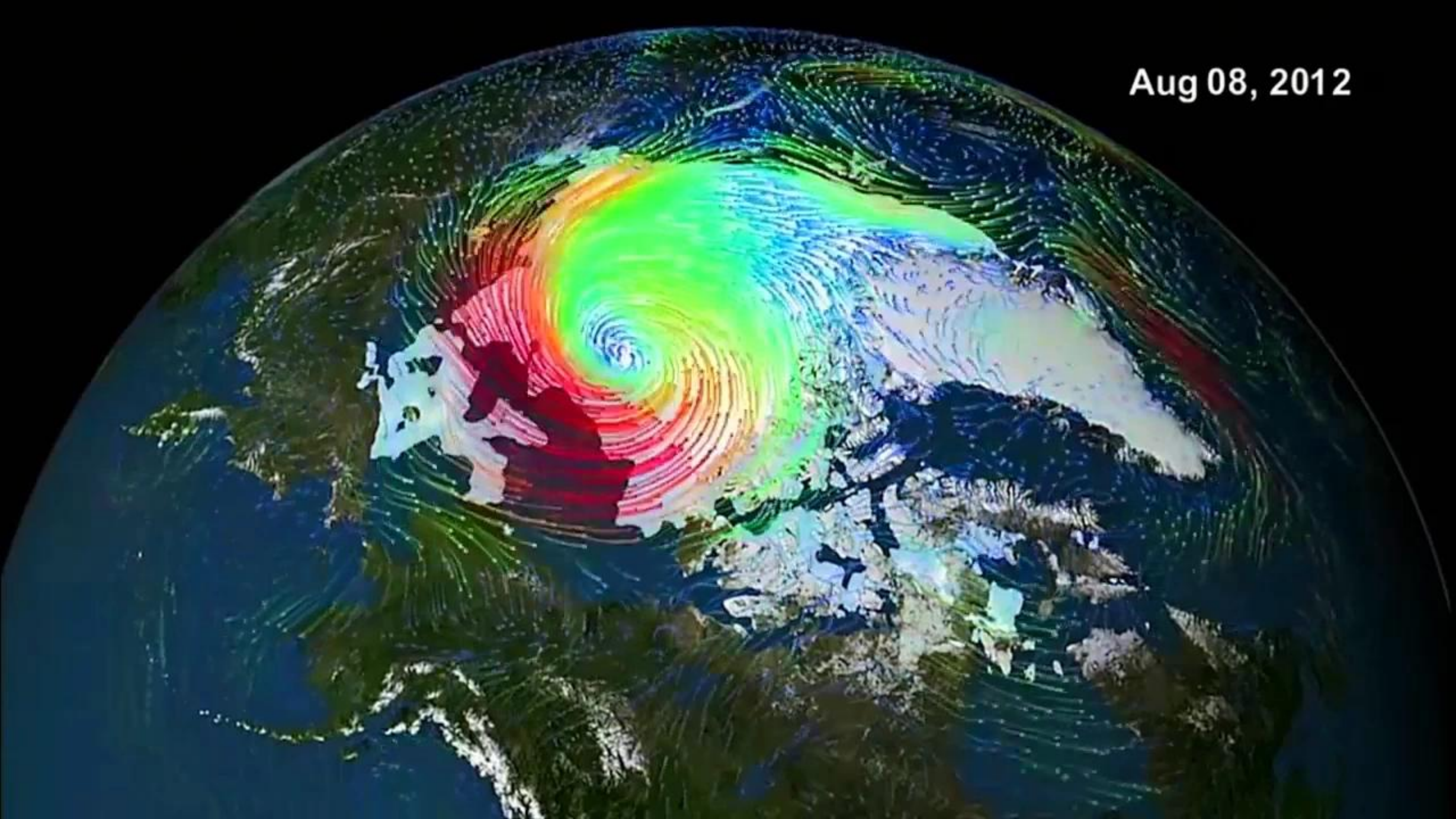
Aug 08, 2012

1
00:00:06,346 --> 00:00:08,836
You and I are living
in a very special time.

2
00:00:08,986 --> 00:00:10,796
The age of solar
system discovery.

3
00:00:11,216 --> 00:00:14,066
Our solar system is a
complex masterpiece.

4
00:00:14,066 --> 00:00:16,366
A work of art of which
we knew so little

5
00:00:16,366 --> 00:00:18,226
from our ground-based
observations.

6
00:00:18,596 --> 00:00:21,116
But within the span
of a single lifetime,

7
00:00:21,326 --> 00:00:25,056
NASA has spent space craft to
every planet and several moons

8
00:00:25,176 --> 00:00:26,466
within our solar system.

9
00:00:26,736 --> 00:00:30,276
Our first eyes to set upon
completely undiscovered lands.

10
00:00:31,026 --> 00:00:34,096
Before we endeavored on this
journey, everything we knew

11

00:00:34,096 --> 00:00:37,186
about Pluto could have
fit on a single file card.

12
00:00:37,356 --> 00:00:40,336
And now we down link
new data every day.

13
00:00:43,156 --> 00:00:48,216
We first televised picture of
our Earth from space in 1960.

14
00:00:48,736 --> 00:00:52,856
Soon after, we were celebrating
our first American orbits

15
00:00:52,956 --> 00:00:56,016
around the planet,
venturing outside

16
00:00:56,156 --> 00:00:58,006
to learn to walk in space.

17
00:00:59,536 --> 00:01:03,506
Pushing even further to reach
our moon all transmitted right

18
00:01:03,506 --> 00:01:04,586
into our living rooms.

19
00:01:05,036 --> 00:01:08,226
Watching our Earth rise up
over the moon's horizon.

20
00:01:09,166 --> 00:01:11,976
We learned to coexist
peacefully with each other

21
00:01:11,976 --> 00:01:16,716
in space while also

taking the time to revel

22
00:01:16,716 --> 00:01:18,276
in the simple joy of it all.

23
00:01:19,686 --> 00:01:22,546
Look at how far we have
come in our short history

24
00:01:22,646 --> 00:01:25,996
of space exploration, all
within a single lifetime,

25
00:01:26,236 --> 00:01:28,756
all broadcast right
to our homes.

26
00:01:31,386 --> 00:01:33,876
We've journeyed to the
very center of our system

27
00:01:34,256 --> 00:01:38,676
to observe solar flares peeling
off the sun in three-dimensions.

28
00:01:39,616 --> 00:01:42,326
We watched sunsets from Mars.

29
00:01:44,416 --> 00:01:47,046
We monitor storms even larger

30
00:01:47,046 --> 00:01:49,326
than the Earth itself
on Jupiter.

31
00:01:50,046 --> 00:01:53,306
We gaze at the wandering
rings of Saturn.

32

00:01:54,746 --> 00:02:00,376
We ponder the vast unknown as
Voyager 1 crosses the heliopause

33
00:02:00,506 --> 00:02:04,046
and enters interstellar
space after 35 years

34
00:02:04,516 --> 00:02:07,206
over 11.5 billion
miles from home.

35
00:02:09,196 --> 00:02:10,996
By reaching for these
new heights,

36
00:02:10,996 --> 00:02:14,706
we have revealed unknowns we
didn't even know to search

37
00:02:14,706 --> 00:02:16,256
for because we were looking

38
00:02:16,256 --> 00:02:19,826
at data no one has seen
before taken from regions

39
00:02:19,826 --> 00:02:21,436
where no one has been before.

40
00:02:22,246 --> 00:02:24,606
Space offers the
ultimate perspective.

41
00:02:24,966 --> 00:02:27,506
It is in our nature to explore.

42
00:02:27,806 --> 00:02:31,086
And the reward for exploration
is enhanced scientific

43
00:02:31,166 --> 00:02:33,736
and technical knowledge
to improve life

44
00:02:33,816 --> 00:02:35,366
for everyone here on Earth.

45
00:02:36,246 --> 00:02:38,726
Space communications
is our conduit

46
00:02:38,926 --> 00:02:41,326
for bringing this valuable
knowledge to the ground.

47
00:02:41,916 --> 00:02:43,606
It is our portal to evolve

48
00:02:43,606 --> 00:02:46,276
into a more enlightened
and healthy people.

49
00:02:46,836 --> 00:02:49,456
To improve our every day
lives by providing us

50
00:02:49,456 --> 00:02:50,936
with information, we need

51
00:02:50,936 --> 00:02:53,456
to make the correct
decisions about our planet.

52
00:02:54,026 --> 00:02:58,036
What we learn from space tells
us more about our own world

53
00:02:58,076 --> 00:03:00,896

and more importantly, what
it has in store for us

54
00:03:00,896 --> 00:03:03,526
in the future, so we
may respond accordingly.

55
00:03:05,286 --> 00:03:08,856
If the last couple centuries
focused on transporting energy

56
00:03:09,046 --> 00:03:12,876
and people, then this century
is about moving information,

57
00:03:13,256 --> 00:03:16,866
big data, sharing our hard
earned knowledge between us.

58
00:03:17,536 --> 00:03:22,036
Communication technology is the
unsung hero in delivering all

59
00:03:22,036 --> 00:03:24,676
of this information
to its destinations.

60
00:03:25,496 --> 00:03:30,196
NASA currently communicates with
over 100 spacecraft resulting

61
00:03:30,196 --> 00:03:33,536
in a down pour of data back
to Earth spanning everything

62
00:03:33,536 --> 00:03:36,816
from remote sensing,
disaster mitigation,

63
00:03:36,976 --> 00:03:41,276

interplanetary exploration,
and space weather forecasting.

64
00:03:42,036 --> 00:03:45,036
The space communications
and navigation program

65
00:03:45,036 --> 00:03:49,336
or SCAN operates a system of
terminals around the world

66
00:03:49,586 --> 00:03:51,466
to communicate with
the spacecraft

67
00:03:51,746 --> 00:03:53,696
and provide navigational
assistance.

68
00:03:53,806 --> 00:03:56,966
For missions requiring a
high degree of connectivity,

69
00:03:57,046 --> 00:03:59,536
SCAN utilizes a constellation

70
00:03:59,536 --> 00:04:02,286
of relay satellites
called the tracking

71
00:04:02,286 --> 00:04:05,296
and data relay satellite
system or TDRSS,

72
00:04:05,596 --> 00:04:09,956
which form a communications
ring around the planet and acts

73
00:04:09,956 --> 00:04:12,606
as an intermediate

connection node to the ground.

74
00:04:13,586 --> 00:04:17,106
The largest customer for TDRSS
is the International Space

75
00:04:17,106 --> 00:04:20,836
Station where it is
imperative to remain in contact

76
00:04:20,936 --> 00:04:23,506
with the astronauts and
cosmonauts on board.

77
00:04:24,466 --> 00:04:28,726
Interplanetary missions utilize
SCAN's deep space network

78
00:04:28,726 --> 00:04:29,616
or DSN.

79
00:04:29,976 --> 00:04:33,886
The DSN is a series of three
ground terminals featuring the

80
00:04:33,886 --> 00:04:37,476
very largest of NASA
antennas to reach out far

81
00:04:37,476 --> 00:04:39,946
out into the solar
system and beyond.

82
00:04:41,006 --> 00:04:45,006
The navigational assistance
provided by the DSN is so good,

83
00:04:45,206 --> 00:04:48,326
we can place multiple
spacecraft within proximity

84
00:04:48,326 --> 00:04:50,536
of each other during
critical events

85
00:04:50,706 --> 00:04:52,986
such as the Mars
Science Laboratory Entry,

86
00:04:52,986 --> 00:04:53,966
Descent, and Landing.

87
00:04:55,106 --> 00:04:58,046
This event was observed
by orbiting spacecraft

88
00:04:58,326 --> 00:04:59,216
and transmitted back

89
00:04:59,216 --> 00:05:01,806
to the Earth once the
rover was on the surface.

90
00:05:02,466 --> 00:05:05,106
The orbiters continue
to monitor the progress

91
00:05:05,456 --> 00:05:06,966
of the rover from high above.

92
00:05:07,326 --> 00:05:09,526
And together they form
a communications network

93
00:05:09,526 --> 00:05:14,396
of their own at Mars to work
signals back towards Earth.

94
00:05:15,126 --> 00:05:19,136

Despite all of our advances, we
actually need to do much better.

95
00:05:19,466 --> 00:05:22,706
It can take days, even weeks
to transmit images back

96
00:05:22,706 --> 00:05:24,756
to Earth due to limitations

97
00:05:24,756 --> 00:05:27,546
in the radiofrequency
communication systems.

98
00:05:28,116 --> 00:05:31,376
Currently, we're leaving
up to 95% of the data

99
00:05:31,376 --> 00:05:34,016
on our spacecraft
never to be recovered.

100
00:05:34,816 --> 00:05:38,956
The most important reason we
explore information is being

101
00:05:38,956 --> 00:05:42,146
limited by the communication
technologies we use today,

102
00:05:43,016 --> 00:05:46,556
how our universe is dynamic,
and one has to wonder,

103
00:05:46,816 --> 00:05:48,346
what are we leaving
on the table?

104
00:05:48,586 --> 00:05:51,746
What is the data

between the images?

105
00:05:52,236 --> 00:05:53,286
What are we missing?

106
00:05:53,896 --> 00:05:54,946
How can we get there?

107
00:05:55,826 --> 00:06:00,146
The current renaissance of laser
communication technologies can

108
00:06:00,146 --> 00:06:04,216
offer data rates 100 times
faster at a fraction of the mass

109
00:06:04,216 --> 00:06:06,526
when compared with
existing radiofrequency

110
00:06:06,526 --> 00:06:07,966
communication systems.

111
00:06:08,546 --> 00:06:11,066
By encoding information
onto a laser beam

112
00:06:11,456 --> 00:06:12,916
and transmitting
it back to Earth

113
00:06:12,916 --> 00:06:15,446
with a small telescope
instead of an antenna.

114
00:06:16,486 --> 00:06:18,866
This technology was
recently demonstrated

115

00:06:18,956 --> 00:06:21,686
with the lunar laser
communications demonstration

116
00:06:22,036 --> 00:06:25,626
where a spacecraft orbiting the
moon acquired a laser signal

117
00:06:25,626 --> 00:06:29,446
from Earth and received data
at 20 megabits per second.

118
00:06:30,216 --> 00:06:33,546
The spacecraft was then
able to transmit at a rate

119
00:06:33,546 --> 00:06:38,386
of 622 megabits per second
to an optical ground terminal

120
00:06:38,386 --> 00:06:41,306
on Earth, which was
six times faster

121
00:06:41,556 --> 00:06:44,856
at 25% less mass
than the RF system.

122
00:06:45,316 --> 00:06:48,286
Through the laser, we sent
an image of the Mona Lisa

123
00:06:48,286 --> 00:06:52,016
to the moon and returned it
back to the Earth error-free.

124
00:06:52,506 --> 00:06:54,586
At these rates, over 30 channels

125
00:06:54,586 --> 00:06:58,056

of high definition video may
be streamed simultaneously.

126
00:06:58,456 --> 00:07:00,626
And the current laser
communication systems

127
00:07:00,656 --> 00:07:03,406
under development promise
an even further increase

128
00:07:03,406 --> 00:07:04,426
in performance.

129
00:07:05,536 --> 00:07:08,546
The next step is to
evolve laser communications

130
00:07:08,546 --> 00:07:11,616
into an operational
system for missions to use.

131
00:07:11,936 --> 00:07:14,916
And the Glenn Research
Center's integrated radio

132
00:07:14,916 --> 00:07:16,936
and optical communications
project

133
00:07:17,286 --> 00:07:20,206
or IROC aims to do exactly that.

134
00:07:20,966 --> 00:07:22,946
IROC combines the robustness

135
00:07:23,346 --> 00:07:27,346
of the existing radiofrequency
network with the speed offered

136
00:07:27,346 --> 00:07:31,256
by developing laser technologies
into a single package

137
00:07:31,586 --> 00:07:34,026
to breakthrough today's
science data bottle neck

138
00:07:34,026 --> 00:07:35,446
and communicating with Earth.

139
00:07:36,476 --> 00:07:39,116
IROC's combination
of operational

140
00:07:39,116 --> 00:07:41,906
and emergent technologies
is analogous

141
00:07:41,906 --> 00:07:44,616
to the American combined
steam sail ships

142
00:07:44,616 --> 00:07:48,036
when boilers were first
being developed in the 1800s.

143
00:07:49,236 --> 00:07:52,126
At the front of the IROC
system is a combination

144
00:07:52,126 --> 00:07:53,766
of a radiofrequency antenna

145
00:07:54,006 --> 00:07:56,586
and an optical telescope
called a tele-tenna.

146
00:07:57,526 --> 00:07:59,756

You are looking at a
prototype tele-tenna

147
00:07:59,886 --> 00:08:03,426
for laboratory testing,
which aligns the laser beam

148
00:08:03,426 --> 00:08:07,966
down the center of
the RF pattern.

149
00:08:08,396 --> 00:08:11,466
The flight model for the
tele-tenna will be manufactured

150
00:08:11,466 --> 00:08:14,626
out of a very lightweight
material including gold plated

151
00:08:14,626 --> 00:08:18,796
molybdenum mesh from Northrop
Grumman Astro for the RF signal

152
00:08:19,246 --> 00:08:23,116
and composite optics developed
by Vanguard Space Technologies

153
00:08:23,486 --> 00:08:25,966
and NASA GRC for the laser beam.

154
00:08:26,786 --> 00:08:30,056
The full size of the completed
tele-tenna will span three

155
00:08:30,056 --> 00:08:33,386
meters in diameter and
attach to a compact,

156
00:08:33,386 --> 00:08:37,266
lightweight vibration isolation

platform being manufactured

157
00:08:37,266 --> 00:08:39,606
by Applied Technology
Associates.

158
00:08:39,946 --> 00:08:43,126
They're a small business
innovation research program.

159
00:08:47,496 --> 00:08:50,316
As anyone who has
given a presentation

160
00:08:50,316 --> 00:08:51,956
with a laser pointer
can tell you,

161
00:08:52,486 --> 00:08:55,336
aiming the beam very
accurately can be challenging.

162
00:08:55,556 --> 00:08:59,346
And this is especially true
for space layer communications.

163
00:08:59,856 --> 00:09:03,326
Over large distances, the
communication beam spreads

164
00:09:03,326 --> 00:09:07,256
to about the size of
Texas, which may seem large,

165
00:09:07,476 --> 00:09:09,676
but from Mars, this
is essentially trying

166
00:09:09,676 --> 00:09:11,566
to aim a point onto a point.

167
00:09:12,496 --> 00:09:13,516
Precise pointing

168
00:09:13,516 --> 00:09:16,626
of the tele-tenna requires
new technology development.

169
00:09:17,206 --> 00:09:21,096
And NASA GRC is working with
the Optical Physics Corporation

170
00:09:21,436 --> 00:09:25,086
to improve the accuracy of
small, lightweight star trackers

171
00:09:25,466 --> 00:09:27,056
to accomplish this challenge.

172
00:09:27,586 --> 00:09:31,056
The basic concept of star
tracking has been used

173
00:09:31,056 --> 00:09:34,666
since the beginning of
maritime navigation and adapted

174
00:09:34,666 --> 00:09:36,876
with modern optics
and electronics

175
00:09:36,936 --> 00:09:38,856
for increased fidelity in space.

176
00:09:39,736 --> 00:09:43,426
An IROC equipped craft
first acquires images

177
00:09:43,426 --> 00:09:45,956

of star fields using
improved hardware

178
00:09:46,116 --> 00:09:49,346
and then fuses them
together to form patterns.

179
00:09:49,546 --> 00:09:52,356
The resulting patterns
are combined

180
00:09:52,676 --> 00:09:55,616
with an onboard star
tracker catalog database

181
00:09:56,186 --> 00:09:59,176
to determine exactly where
the spacecraft is pointed

182
00:09:59,396 --> 00:10:02,876
and more importantly where
this communication's beam needs

183
00:10:02,876 --> 00:10:05,346
to be projected to
intercept Earth.

184
00:10:06,166 --> 00:10:08,096
Precise pointing actuation

185
00:10:08,096 --> 00:10:10,966
of the communications
payload is accomplished

186
00:10:10,966 --> 00:10:14,476
through a mechanical system
developed by Balcones Technology

187
00:10:14,626 --> 00:10:26,186
through an SBIR and small

fine pointing mirrors.

188
00:10:27,046 --> 00:10:30,066
Spacecraft data is
placed onto the laser beam

189
00:10:30,196 --> 00:10:33,636
in a process called
modulation, which is performed

190
00:10:33,636 --> 00:10:37,836
by IROC's optical software
defined radio or SDR.

191
00:10:38,236 --> 00:10:43,446
The SDR has heritage from
GRC's SCAN test bed project,

192
00:10:43,726 --> 00:10:46,376
which is currently
flying on the ISS.

193
00:10:47,256 --> 00:10:51,146
The SDR team is developing
the optical functionality

194
00:10:51,266 --> 00:10:53,396
to support varying
mission parameters,

195
00:10:53,846 --> 00:10:56,536
to prototype a digital
radio capable

196
00:10:56,536 --> 00:10:59,456
of software reconfiguration
based

197
00:10:59,456 --> 00:11:04,386
on a Harris Corporation platform

to evolve during the mission

198
00:11:04,386 --> 00:11:07,426
as new technology and
requirements are developed.

199
00:11:08,186 --> 00:11:11,246
The output of the optical
SDR places the data

200
00:11:11,416 --> 00:11:14,046
onto the laser beam,
which transmits the signal

201
00:11:14,046 --> 00:11:16,666
across the laboratory
to be evaluated

202
00:11:16,666 --> 00:11:19,296
for beam quality
and data integrity.

203
00:11:20,756 --> 00:11:24,386
IROC is helping to transition
NASA from having a series

204
00:11:24,386 --> 00:11:27,176
of individual point-to-point
communication links

205
00:11:27,596 --> 00:11:31,446
to realizing a solar system
intranet through the advancement

206
00:11:31,446 --> 00:11:35,396
of network protocols tolerant
to the delay, disruptions

207
00:11:35,486 --> 00:11:38,716
and disconnections inherent

in space communications.

208
00:11:39,426 --> 00:11:42,166
These protocols are being
prototyped in the laboratory

209
00:11:42,286 --> 00:11:46,116
and evaluated to optimize
parameters such as efficiency,

210
00:11:46,486 --> 00:11:51,856
reliability, security, quality
of service, and interoperability

211
00:11:52,096 --> 00:11:53,956
with our space faring partners.

212
00:11:55,576 --> 00:11:58,986
Data traffic is generated
by an instrumented robot

213
00:11:58,986 --> 00:12:00,726
in the laboratory and sent

214
00:12:00,726 --> 00:12:04,116
across the prototype IROC
communications system using

215
00:12:04,166 --> 00:12:05,966
orbital predicted connections

216
00:12:06,376 --> 00:12:10,316
to evaluate the delay tolerant
networking protocol's ability

217
00:12:10,666 --> 00:12:12,676
to successfully route
the information

218

00:12:12,676 --> 00:12:15,236
to the ground terminals
in an efficient manner.

219
00:12:15,996 --> 00:12:20,376
A version of DTN is now deployed
on the ISS and will continue

220
00:12:20,376 --> 00:12:23,416
to be utilized for most
all future missions.

221
00:12:26,046 --> 00:12:30,996
Over 93% of the nation witnessed
Neil Armstrong place our first

222
00:12:30,996 --> 00:12:33,716
steps upon the moon
as down linked

223
00:12:33,866 --> 00:12:35,846
through the Australian
tracking station.

224
00:12:36,376 --> 00:12:38,866
And then we left.

225
00:12:39,516 --> 00:12:49,046
[Audio from Video]

226
00:12:49,546 --> 00:12:52,666
Whether you were in the control
room back then pioneering

227
00:12:52,666 --> 00:12:56,576
through both tragedy or
triumph or working a console

228
00:12:56,616 --> 00:13:00,506
within space operations

today or watching the display

229
00:13:00,506 --> 00:13:05,176
at home waiting for the signal,
the experience is the same.

230
00:13:05,776 --> 00:13:07,006
Nothing changes.

231
00:13:07,766 --> 00:13:10,746
Watching, waiting for
the telemetry to arrive

232
00:13:11,396 --> 00:13:15,076
to to us the system is
OK, allowing us one more

233
00:13:15,366 --> 00:13:17,236
to experience the unknown.

234
00:13:17,386 --> 00:13:19,746
It is our charge to put

235
00:13:19,746 --> 00:13:23,106
into place unbridled
communications technologies

236
00:13:23,286 --> 00:13:25,426
which will enable
all of us to share

237
00:13:25,426 --> 00:13:30,956
in the first human
presence on Mars.

238
00:13:31,676 --> 00:13:34,326
Join us on our next journey
through the solar system.

239

00:13:34,976 --> 00:13:38,486
We have an opportunity to
learn so much more to continue

240
00:13:38,486 --> 00:13:42,016
to improve our lives here on
Earth and lay the foundation

241
00:13:42,016 --> 00:13:44,676
for the next generation
of discoveries.

242
00:13:45,236 --> 00:13:50,516
I would like to recognize
the NASA communication teams,

243
00:13:50,666 --> 00:13:53,916
industrial and academic
partners who strive

244
00:13:53,916 --> 00:13:56,766
to make this all
possible and emphasize

245
00:13:56,936 --> 00:13:59,736
that it takes all kinds
of people to pull it off

246
00:14:00,026 --> 00:14:04,296
from engineers, scientists,
mathematicians, technicians,

247
00:14:04,296 --> 00:14:08,736
operators, resource analysts,
managers, facilities, safety,

248
00:14:09,146 --> 00:14:11,496
legal, and of course outreach