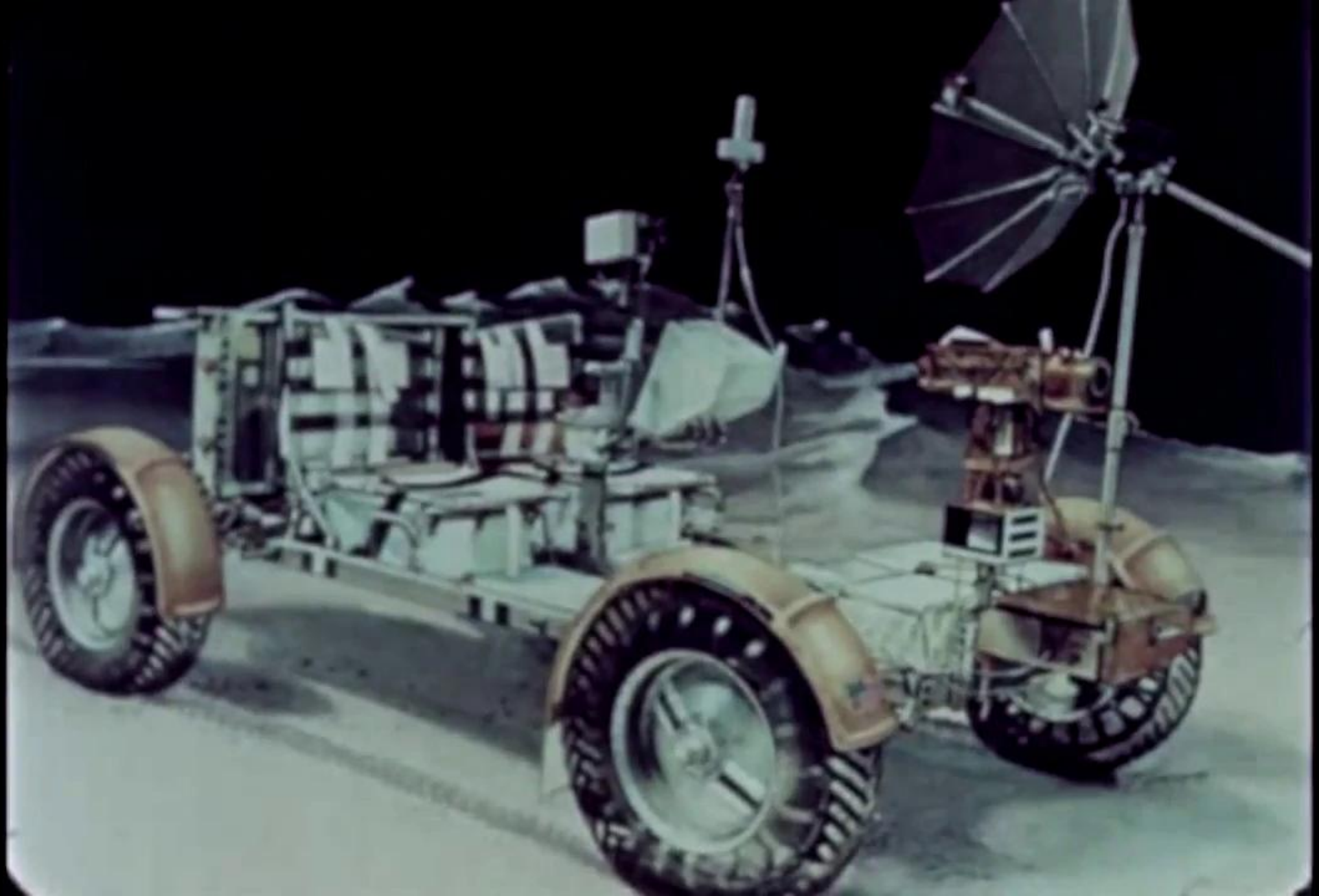

1
00:00:01,090 --> 00:00:22,150
[Music]

2
00:00:27,679 --> 00:00:25,009
during the early Apollo years NASA

3
00:00:29,960 --> 00:00:27,689
scientists and engineers anticipated the

4
00:00:32,959 --> 00:00:29,970
need for a vehicle to aid the astronauts

5
00:00:35,150 --> 00:00:32,969
in exploring the moon it was expected

6
00:00:37,220 --> 00:00:35,160
that bulky spacesuits limited life

7
00:00:39,590 --> 00:00:37,230
supplies and other inherent weaknesses

8
00:00:45,260 --> 00:00:39,600
would decrease man's mobility on the

9
00:00:47,690 --> 00:00:45,270
lunar surface in 1964 with conceptual

10
00:00:50,510 --> 00:00:47,700
design of the mobile laboratory or mo

11
00:00:53,240 --> 00:00:50,520
lab NASA began research on lunar surface

12
00:00:55,430 --> 00:00:53,250
vehicles over the next few years an

13
00:00:58,040 --> 00:00:55,440

entire spectrum of vehicles was designed

14
00:00:59,930 --> 00:00:58,050
and studied from these efforts came the

15
00:01:01,459 --> 00:00:59,940
knowledge that contributed directly to

16
00:01:03,830 --> 00:01:01,469
the development of the lunar roving

17
00:01:06,080 --> 00:01:03,840
vehicle its development required

18
00:01:07,490 --> 00:01:06,090
solution of many challenging technical

19
00:01:09,890 --> 00:01:07,500
problems for which there were no

20
00:01:13,070 --> 00:01:09,900
precedents in terrestrial vehicle design

21
00:01:15,380 --> 00:01:13,080
and operation for example the lack of an

22
00:01:18,499 --> 00:01:15,390
atmosphere on the moon the extremes of

23
00:01:21,230 --> 00:01:18,509
surface temperatures plus or minus 250

24
00:01:23,420 --> 00:01:21,240
degrees Fahrenheit the very weak gravity

25
00:01:25,730 --> 00:01:23,430
one-sixth of Earth's and the many

26
00:01:28,789 --> 00:01:25,740
unknowns associated with the lunar soil

27
00:01:31,039 --> 00:01:28,799
and topography all these factors imposed

28
00:01:32,679 --> 00:01:31,049
severe and unique requirements on the

29
00:01:35,210 --> 00:01:32,689
LRV

30
00:01:37,420 --> 00:01:35,220
the first manned landing on the moon

31
00:01:40,160 --> 00:01:37,430
Apollo 11 and subsequent missions

32
00:01:42,530 --> 00:01:40,170
confirmed the long recognized need for a

33
00:01:45,170 --> 00:01:42,540
lunar vehicle a vehicle which would

34
00:01:46,760 --> 00:01:45,180
allow astronauts to cover more area to

35
00:01:49,190 --> 00:01:46,770
conserve energy and life support

36
00:01:51,889 --> 00:01:49,200
materials to transport additional

37
00:01:54,530 --> 00:01:51,899
equipment and to return with more lunar

38
00:01:57,639 --> 00:01:54,540

soil samples or even before these

39
00:02:00,319 --> 00:01:57,649
practical demonstrations in May of 1969

40
00:02:02,870 --> 00:02:00,329
NASA decided to proceed with the design

41
00:02:06,319 --> 00:02:02,880
and development of a lunar roving

42
00:02:08,690 --> 00:02:06,329
vehicle the Marshall Space Flight Center

43
00:02:10,669 --> 00:02:08,700
at Huntsville Alabama where the saturn v

44
00:02:12,770 --> 00:02:10,679
moon rocket had been developed was

45
00:02:13,900 --> 00:02:12,780
assigned overall direction of the LRV

46
00:02:16,730 --> 00:02:13,910
program

47
00:02:19,490 --> 00:02:16,740
prime contractor was the Boeing Company

48
00:02:23,180 --> 00:02:19,500
using facilities at Huntsville and Kent

49
00:02:26,860 --> 00:02:23,190
Washington major subcontractor was GM's

50
00:02:30,080 --> 00:02:26,870
Delco electronics division in California

51
00:02:33,800 --> 00:02:30,090
the LRV would be a two-man four wheeled

52
00:02:35,840 --> 00:02:33,810
vehicle 10 feet 2 inches long 44 inches

53
00:02:38,960 --> 00:02:35,850
high with a seven and a half foot

54
00:02:41,420 --> 00:02:38,970
wheelbase weighing 460 pounds earth

55
00:02:45,740 --> 00:02:41,430
weight and capable of carrying a total

56
00:02:48,860 --> 00:02:45,750
payload of 1080 pounds the LRV would

57
00:02:52,070 --> 00:02:48,870
have five major systems mobility cruise

58
00:02:55,760 --> 00:02:52,080
station navigation power and thermal

59
00:02:58,250 --> 00:02:55,770
control the mobility system which must

60
00:03:02,060 --> 00:02:58,260
be able to cross 12-inch high obstacles

61
00:03:04,970 --> 00:03:02,070
and 28 inch diameter craters consists of

62
00:03:07,760 --> 00:03:04,980
the wheels traction drive suspension

63
00:03:10,580 --> 00:03:07,770

steering and drive control electronics

64
00:03:13,280 --> 00:03:10,590
the system was designed developed and

65
00:03:15,050 --> 00:03:13,290
tested by General Motors the first

66
00:03:17,300 --> 00:03:15,060
assemblies were put through development

67
00:03:20,240 --> 00:03:17,310
tests to measure strength deflection

68
00:03:23,000 --> 00:03:20,250
endurance and other factors for example

69
00:03:24,830 --> 00:03:23,010
driven on a rolling road fixture the

70
00:03:27,640 --> 00:03:24,840
wheel assembly was tested under earth

71
00:03:30,050 --> 00:03:27,650
conditions and later in test chambers

72
00:03:33,290 --> 00:03:30,060
reproducing the environmental conditions

73
00:03:36,500 --> 00:03:33,300
of the moon the LRV tires are made of a

74
00:03:38,960 --> 00:03:36,510
woven mesh of zinc coated piano wire -

75
00:03:41,390 --> 00:03:38,970
which titanium threads are riveted in a

76
00:03:45,320 --> 00:03:41,400
chevron pattern to keep the wheels from

77
00:03:47,509 --> 00:03:45,330
sinking into the soft lunar soil long

78
00:03:50,270 --> 00:03:47,519
duration torture testing on this so

79
00:03:52,940 --> 00:03:50,280
called a carousel simulating the lunar

80
00:03:55,640 --> 00:03:52,950
surface verified the durability of the

81
00:03:58,100 --> 00:03:55,650
wheel design the test assembly was

82
00:04:00,620 --> 00:03:58,110
supported by Springs to relieve most of

83
00:04:05,630 --> 00:04:00,630
its weight thus simulating the one-sixth

84
00:04:07,400 --> 00:04:05,640
gravity of the moon a mobility test unit

85
00:04:11,900 --> 00:04:07,410
was used in early phases of development

86
00:04:14,240 --> 00:04:11,910
to validate the LRV mobility system the

87
00:04:17,870 --> 00:04:14,250
astronauts participated as they did in

88
00:04:20,360 --> 00:04:17,880

all aspects of LRV development to 36

89
00:04:22,790 --> 00:04:20,370
volt silver zinc batteries provide the

90
00:04:25,460 --> 00:04:22,800
vehicle's power each wheel is

91
00:04:26,810 --> 00:04:25,470
individually powered by a 1/4 horsepower

92
00:04:29,630 --> 00:04:26,820
electric motor

93
00:04:32,000 --> 00:04:29,640
a highly efficient harmonic drive system

94
00:04:34,160 --> 00:04:32,010
originally developed by the u.s. shoe

95
00:04:37,100 --> 00:04:34,170
Machinery corporation for other purposes

96
00:04:39,820 --> 00:04:37,110
is used with each motor eliminating the

97
00:04:42,740 --> 00:04:39,830
need for a transmission and it's gears

98
00:04:45,530 --> 00:04:42,750
the suspension consists of a damper or

99
00:04:48,500 --> 00:04:45,540
shock absorber supported by triangular

100
00:04:52,160 --> 00:04:48,510
arms that pass the suspension loads to

101
00:04:54,410 --> 00:04:52,170
torsion bars other systems were also

102
00:04:56,390 --> 00:04:54,420
being developed for example a simple

103
00:04:58,700 --> 00:04:56,400
navigation system which would allow

104
00:05:01,010 --> 00:04:58,710
astronauts to drive beyond sight of a

105
00:05:03,650 --> 00:05:01,020
lunar module and yet be able to return

106
00:05:05,690 --> 00:05:03,660
to it by the most direct route the

107
00:05:08,200 --> 00:05:05,700
system works by recording direction and

108
00:05:11,210 --> 00:05:08,210
distance traveled from a starting point

109
00:05:13,760 --> 00:05:11,220
in order to assure the proper physical

110
00:05:15,410 --> 00:05:13,770
relationship or interface between the

111
00:05:18,350 --> 00:05:15,420
vehicle and the astronauts in their

112
00:05:20,330 --> 00:05:18,360
pressurized spacesuits several so called

113
00:05:23,300 --> 00:05:20,340

crew station reviews were conducted

114
00:05:27,770 --> 00:05:23,310
first in normal gravity conditions and

115
00:05:29,690 --> 00:05:27,780
later in simulated 1/6 g the L RVs crew

116
00:05:32,450 --> 00:05:29,700
station consists of the control and

117
00:05:33,620 --> 00:05:32,460
display console seats and seat belts

118
00:05:36,380 --> 00:05:33,630
armrests

119
00:05:40,460 --> 00:05:36,390
foot rests hand and toe holds floor

120
00:05:42,470 --> 00:05:40,470
panels and fenders for other cruise

121
00:05:45,080 --> 00:05:42,480
station reviews and development testing

122
00:05:48,380 --> 00:05:45,090
an LR V mock-up was installed in a

123
00:05:51,350 --> 00:05:48,390
kc-135 aircraft which flew parabolic

124
00:05:53,570 --> 00:05:51,360
flight paths this provided brief periods

125
00:05:56,210 --> 00:05:53,580
of low gravity simulating lunar

126
00:05:58,610 --> 00:05:56,220
conditions one example of interface

127
00:06:02,900 --> 00:05:58,620
problems was the initial difficulty in

128
00:06:05,210 --> 00:06:02,910
getting onto and off of the LRV addition

129
00:06:08,500 --> 00:06:05,220
of a simple toehold plus astronaut

130
00:06:11,630 --> 00:06:08,510
training proved to be the solution

131
00:06:13,610 --> 00:06:11,640
another interface problem was the design

132
00:06:16,060 --> 00:06:13,620
of control switches which could be

133
00:06:18,410 --> 00:06:16,070
easily manipulated by a gloved hand

134
00:06:20,690 --> 00:06:18,420
similar problems were involved in

135
00:06:22,940 --> 00:06:20,700
operation of the uniquely designed hand

136
00:06:25,670 --> 00:06:22,950
controller located between the two

137
00:06:28,070 --> 00:06:25,680
astronauts which provides steering speed

138
00:06:30,560 --> 00:06:28,080

and banking commands to the vehicles

139
00:06:34,430 --> 00:06:30,570
drive control electronics and mechanical

140
00:06:36,560 --> 00:06:34,440
brake system a major milestone in the

141
00:06:39,440 --> 00:06:36,570
lunar roving vehicle development program

142
00:06:40,740 --> 00:06:39,450
was delivery by General Motors of the 1g

143
00:06:43,710 --> 00:06:40,750
trainer vehicle

144
00:06:46,170 --> 00:06:43,720
to be used for astronaut training though

145
00:06:47,910 --> 00:06:46,180
heavier and stronger than an actual moon

146
00:06:50,700 --> 00:06:47,920
rover since the crew and equipment

147
00:06:52,740 --> 00:06:50,710
weighs six times more on earth the

148
00:06:55,730 --> 00:06:52,750
trainer was practically identical in

149
00:06:58,320 --> 00:06:55,740
size shape and handling characteristics

150
00:07:00,810 --> 00:06:58,330
one simple difference was the use of

151
00:07:04,620 --> 00:07:00,820
ordinary pneumatic rubber tires because

152
00:07:07,620 --> 00:07:04,630
of the extra weight of the vehicle at

153
00:07:09,350 --> 00:07:07,630
the manned spacecraft Center the 1g

154
00:07:12,150 --> 00:07:09,360
trainer was operated using

155
00:07:14,850 --> 00:07:12,160
counterbalance Springs to simulate the

156
00:07:16,790 --> 00:07:14,860
moon's gravitational field through

157
00:07:18,690 --> 00:07:16,800
operation of the trainer in this mode

158
00:07:20,940 --> 00:07:18,700
astronauts were able to become

159
00:07:25,020 --> 00:07:20,950
accustomed to the LRV months before

160
00:07:26,940 --> 00:07:25,030
actual use during their mission storage

161
00:07:30,240 --> 00:07:26,950
and deployment of the vehicle provided

162
00:07:32,580 --> 00:07:30,250
major design challenges as shown here by

163
00:07:35,550 --> 00:07:32,590

this special test unit built to equal on

164
00:07:37,140 --> 00:07:35,560
earth the L RVs lunar weight the vehicle

165
00:07:40,110 --> 00:07:37,150
had to fit within the tight wedge-shaped

166
00:07:42,930 --> 00:07:40,120
confines of one small section of the

167
00:07:46,320 --> 00:07:42,940
lunar module about the volume contained

168
00:07:48,810 --> 00:07:46,330
in a family station wagon conversely on

169
00:07:51,150 --> 00:07:48,820
the moon the LRV has to essentially

170
00:07:53,850 --> 00:07:51,160
unfold itself by means of Springs and

171
00:07:56,460 --> 00:07:53,860
deploy to the lunar surface locked in

172
00:08:00,680 --> 00:07:56,470
its operating configuration all with

173
00:08:05,550 --> 00:08:03,150
further deployment tests were conducted

174
00:08:08,610 --> 00:08:05,560
using a full-weight l RV called a

175
00:08:10,920 --> 00:08:08,620
qualification test unit the vehicle was

176
00:08:13,080 --> 00:08:10,930
deployed from a lunar module mock-up at

177
00:08:16,770 --> 00:08:13,090
the Grumman aircraft company contractor

178
00:08:19,020 --> 00:08:16,780
for the lunar modules during these tests

179
00:08:21,270 --> 00:08:19,030
technicians manually assisted the

180
00:08:23,400 --> 00:08:21,280
vehicle throughout the procedure since

181
00:08:25,860 --> 00:08:23,410
the deployment mechanisms were designed

182
00:08:27,960 --> 00:08:25,870
for the moon's weaker gravity and could

183
00:08:30,180 --> 00:08:27,970
not overcome the stronger gravity of the

184
00:08:32,370 --> 00:08:30,190
earth the main purpose of the

185
00:08:34,560 --> 00:08:32,380
qualification test unit was to make

186
00:08:36,959 --> 00:08:34,570
absolutely sure that nothing had been

187
00:08:42,510 --> 00:08:36,969
overlooked in terms of clearances and

188
00:08:45,840 --> 00:08:42,520

hardware operation manufacturing of the

189
00:08:47,820 --> 00:08:45,850
first flight LRV proceeded concurrently

190
00:08:50,070 --> 00:08:47,830
with the rigorous testing of non flight

191
00:08:52,320 --> 00:08:50,080
units as evidenced in this wheel

192
00:08:54,330 --> 00:08:52,330
fabrication skilled in detailed hand

193
00:09:00,770 --> 00:08:54,340
crafting was involved in many

194
00:09:02,970 --> 00:09:00,780
the LRV components early in 1971

195
00:09:06,690 --> 00:09:02,980
production and testing of the first

196
00:09:08,430 --> 00:09:06,700
flight LRV neared completion vibration

197
00:09:10,530 --> 00:09:08,440
tests were conducted with the vehicle

198
00:09:13,920 --> 00:09:10,540
and both the folded and unfolded modes

199
00:09:15,930 --> 00:09:13,930
to determine critical frequencies other

200
00:09:20,280 --> 00:09:15,940
acceptance tests checked and rechecked

201
00:09:22,920 --> 00:09:20,290
every facet of the vehicle the first

202
00:09:25,170 --> 00:09:22,930
flight model LRV was formally delivered

203
00:09:29,640 --> 00:09:25,180
to NASA by the prime contractor Boeing

204
00:09:32,640 --> 00:09:29,650
on March 10th 1971 two weeks ahead of

205
00:09:35,520 --> 00:09:32,650
schedule it had been less than 18 months

206
00:09:38,190 --> 00:09:35,530
since inception of the LRV program only

207
00:09:40,950 --> 00:09:38,200
13 months since the prime contract was

208
00:09:43,470 --> 00:09:40,960
awarded an accomplishment reflecting the

209
00:09:47,090 --> 00:09:43,480
outstanding effort and dedication of the

210
00:09:49,500 --> 00:09:47,100
joint NASA industry development team

211
00:09:52,440 --> 00:09:49,510
after government acceptance of the

212
00:09:55,550 --> 00:09:52,450
vehicle it was folded covered and crated

213
00:09:59,520 --> 00:09:55,560

for shipment to the Kennedy Space Center

214
00:10:01,410 --> 00:09:59,530
after delivery to KSC the vehicle was

215
00:10:04,050 --> 00:10:01,420
unfolded and completely checked out

216
00:10:07,260 --> 00:10:04,060
again and another crew station review

217
00:10:09,540 --> 00:10:07,270
was conducted the LRV was then folded

218
00:10:11,370 --> 00:10:09,550
for the final time and installed in its

219
00:10:14,550 --> 00:10:11,380
flight position inside the lunar module

220
00:10:17,880 --> 00:10:14,560
of the Apollo 15 spacecraft several

221
00:10:20,760 --> 00:10:17,890
months before launch the LRV had

222
00:10:22,770 --> 00:10:20,770
received its final go while the rest of

223
00:10:27,140 --> 00:10:22,780
the Apollo and the saturn v launch

224
00:10:29,850 --> 00:10:27,150
vehicle would undergo further checkouts

225
00:10:32,550 --> 00:10:29,860
then the entire Saturn Apollo vehicle

226
00:10:35,010 --> 00:10:32,560
was moved aboard the giant transporter

227
00:10:37,980 --> 00:10:35,020
from the Vehicle Assembly Building three

228
00:10:39,900 --> 00:10:37,990
and 1/2 miles to the launch pad where it

229
00:10:45,360 --> 00:10:39,910
would undergo constant check and recheck

230
00:10:50,100 --> 00:10:45,370
right up until launch date on July 26

231
00:10:52,950 --> 00:10:50,110
1971 Apollo 15 carrying the first lunar

232
00:11:05,250 --> 00:10:52,960
roving vehicle aboard was successfully

233
00:11:11,050 --> 00:11:08,560
after a three-day translunar coast the

234
00:11:13,720 --> 00:11:11,060
landing site was spotted the rugged

235
00:11:15,670 --> 00:11:13,730
Hadley Apennine region a potentially

236
00:11:26,500 --> 00:11:15,680
hazardous but scientifically interesting

237
00:11:33,720 --> 00:11:26,510
area of the moon - one - one six percent

238
00:11:36,550 --> 00:11:33,730

fuel in feet - one eight feet - one

239
00:11:41,380 --> 00:11:36,560
contact the landing was successfully

240
00:11:43,600 --> 00:11:41,390
achieved Apollo 15 commander David Scott

241
00:11:46,540 --> 00:11:43,610
became the seventh man to set foot on

242
00:11:49,780 --> 00:11:46,550
the moon with live color TV coverage

243
00:11:52,000 --> 00:11:49,790
beamed back to earth lunar module pilot

244
00:11:54,220 --> 00:11:52,010
James Irwin followed soon afterward and

245
00:11:56,110 --> 00:11:54,230
they said about deploying the lunar

246
00:12:13,330 --> 00:11:56,120
roving vehicle for their first drive

247
00:12:15,820 --> 00:12:13,340
over the lunar surface with minor

248
00:12:19,740 --> 00:12:15,830
difficulty deployment and setup were

249
00:12:22,660 --> 00:12:19,750
successfully accomplished in 26 minutes

250
00:12:24,760 --> 00:12:22,670
during initial check out of the LRV

251
00:12:28,200 --> 00:12:24,770
astronaut scott discovered that the

252
00:12:31,180 --> 00:12:28,210
front steering mechanism was inoperable

253
00:12:34,060 --> 00:12:31,190
however the first lunar traverse of a

254
00:12:41,050 --> 00:12:34,070
scheduled three proceeded satisfactorily

255
00:12:43,230 --> 00:12:41,060
using only rear-wheel steering before

256
00:12:46,450 --> 00:12:43,240
the second Traverse the astronauts and

257
00:13:02,520 --> 00:12:46,460
LRV specialists on the ground succeeded

258
00:13:08,740 --> 00:13:06,190
in overall performance the LRV more than

259
00:13:09,340 --> 00:13:08,750
met its standards giving a total of

260
00:13:11,080 --> 00:13:09,350
three

261
00:13:13,720 --> 00:13:11,090
and two minutes of stop-and-go driving

262
00:13:18,570 --> 00:13:13,730
on the moon the vehicle traveled a total

263
00:13:21,070 --> 00:13:18,580

of 25 kilometers about 15 statute miles

264
00:13:23,890 --> 00:13:21,080
astronaut scott and urban covered almost

265
00:13:26,020 --> 00:13:23,900
four times as much lunar terrain as the

266
00:13:30,700 --> 00:13:26,030
total covered by the crews of the apollo

267
00:13:32,650 --> 00:13:30,710
11 12 and 14 missions before them the

268
00:13:35,410 --> 00:13:32,660
lunar soil proved much less troublesome

269
00:13:37,360 --> 00:13:35,420
than expected with the LRV wheel treads

270
00:13:40,300 --> 00:13:37,370
leaving tracks only about half an inch

271
00:13:41,110 --> 00:13:40,310
deep the suspension system worked

272
00:13:43,390 --> 00:13:41,120
extremely well

273
00:13:45,640 --> 00:13:43,400
the astronauts reported keeping the

274
00:13:47,830 --> 00:13:45,650
vehicle very stable even on several

275
00:13:51,160 --> 00:13:47,840
rather sharp turns to avoid lunar

276
00:13:54,280 --> 00:13:51,170
obstacles average speed was 9 kilometers

277
00:13:57,610 --> 00:13:54,290
about 6 miles per hour more than 1 mile

278
00:13:59,880 --> 00:13:57,620
an hour faster than planned the energy

279
00:14:03,640 --> 00:13:59,890
usage rate was much less than expected

280
00:14:07,540 --> 00:14:03,650
only about 52 app hours compared to

281
00:14:09,540 --> 00:14:07,550
anticipated usage of 102 the vehicle

282
00:14:12,220 --> 00:14:09,550
still had about 80 kilometers of driving

283
00:14:15,640 --> 00:14:12,230
capability remaining when it was parked

284
00:14:17,980 --> 00:14:15,650
after the final Traverse the navigation

285
00:14:19,810 --> 00:14:17,990
system performed well averaging a miss

286
00:14:22,300 --> 00:14:19,820
distance of only one tenth of one

287
00:14:25,390 --> 00:14:22,310
kilometer upon returned to the lunar

288
00:14:27,910 --> 00:14:25,400

module after each Traverse all in all

289
00:14:30,220 --> 00:14:27,920
the lunar roving vehicle proved to be in

290
00:14:35,980 --> 00:14:30,230
the words of astronaut scott about as

291
00:14:38,170 --> 00:14:35,990
optimum as you can build after almost 67

292
00:14:40,120 --> 00:14:38,180
hours on the moon scott and urban

293
00:14:42,220 --> 00:14:40,130
reentered the lunar module were their

294
00:14:44,770 --> 00:14:42,230
collection of scientific samples for the

295
00:14:46,960 --> 00:14:44,780
return to earth their liftoff in the

296
00:14:49,600 --> 00:14:46,970
ascent stage was photographed by the

297
00:14:54,490 --> 00:14:49,610
remote controlled television camera left

298
00:14:57,370 --> 00:14:54,500
behind on the LRV a spacecraft with

299
00:15:00,370 --> 00:14:57,380
wheels the lunar roving vehicle has

300
00:15:02,980 --> 00:15:00,380
proven itself invaluable an extending