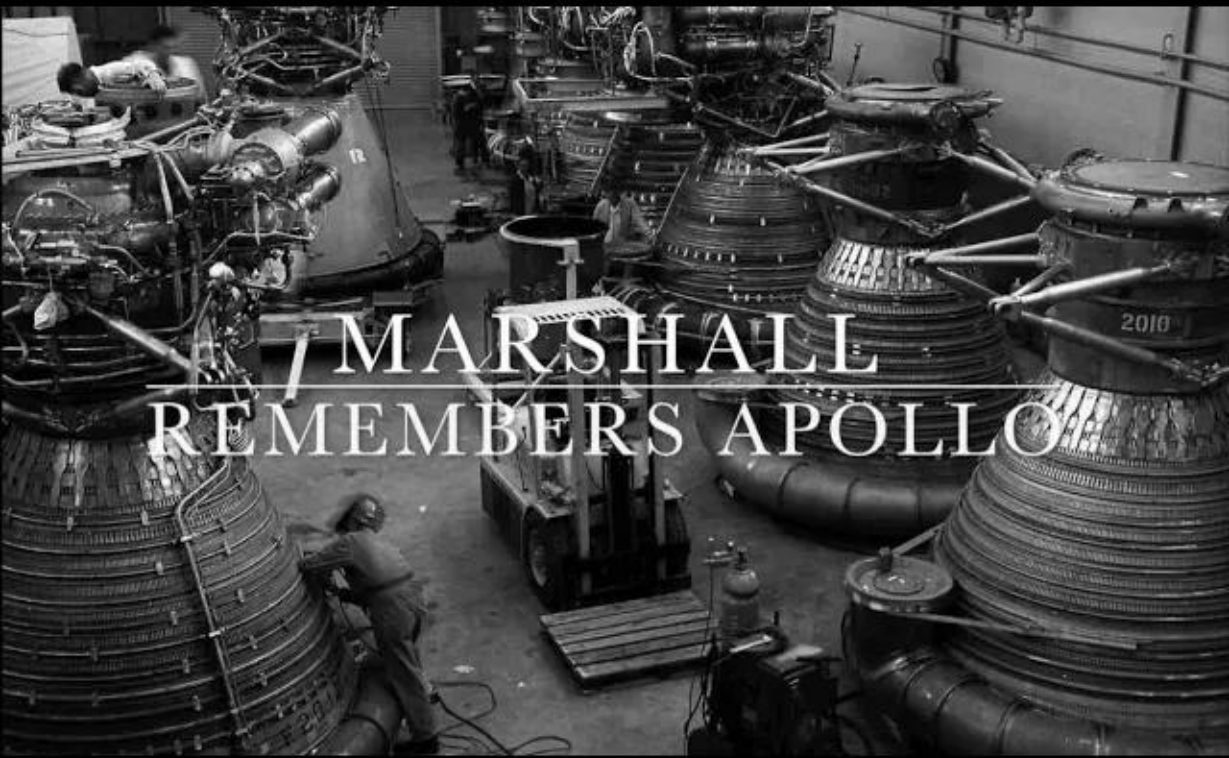
MARSHALL
REMEMBERS APOLLO

1
00:00:19,580 --> 00:00:16,930
[Music]

2
00:00:22,130 --> 00:00:19,590
well I was working up in Chattanooga I'd

3
00:00:24,670 --> 00:00:22,140
been there for years after getting out

4
00:00:27,260 --> 00:00:24,680
of Georgia Tech and I heard about the

5
00:00:30,350 --> 00:00:27,270
space not the space but the missile

6
00:00:33,889 --> 00:00:30,360
programs going on down here and I was

7
00:00:36,139 --> 00:00:33,899
curious came down for an interview just

8
00:00:38,000 --> 00:00:36,149
about the time that Explorer 1 was

9
00:00:41,060 --> 00:00:38,010
launched got hired a couple of months

10
00:00:44,030 --> 00:00:41,070
later went into the program coordination

11
00:00:47,509 --> 00:00:44,040
office and was there about a year and

12
00:00:51,139 --> 00:00:47,519
then transferred to the ARPA at the time

13
00:00:54,579 --> 00:00:51,149

was called ARPA NASA systems project

14
00:00:58,299 --> 00:00:54,589
office Saturn was building up from

15
00:01:02,209 --> 00:00:58,309
starting with the booster in 58

16
00:01:05,149 --> 00:01:02,219
from there on it went to the Silver

17
00:01:07,730 --> 00:01:05,159
Stein committee report recommending

18
00:01:10,340 --> 00:01:07,740
using liquid hydrogen for upper stages

19
00:01:16,520 --> 00:01:10,350
and we knew at that point we were headed

20
00:01:21,860 --> 00:01:19,610
there was something new all the time it

21
00:01:25,850 --> 00:01:21,870
was exciting

22
00:01:28,100 --> 00:01:25,860
the hardware was involved ABMA ABMA

23
00:01:34,039 --> 00:01:28,110
beforehand and then nasa after it was

24
00:01:40,430 --> 00:01:36,950
I got involved with the Saturn program

25
00:01:45,140 --> 00:01:40,440
when I joined the Saturn Systems office

26
00:01:49,430 --> 00:01:45,150
and and and stayed with it until I left

27
00:01:52,850 --> 00:01:49,440
in 1965 to go to MIT on a Sloan

28
00:01:58,430 --> 00:01:52,860
fellowship but during that time we

29
00:02:01,790 --> 00:01:58,440
worked on procurement packages I helped

30
00:02:05,570 --> 00:02:01,800
write the model specifications for the

31
00:02:08,660 --> 00:02:05,580
s4 stage than the s2 stage that led to a

32
00:02:11,390 --> 00:02:08,670
bidders conference and I was surprised

33
00:02:14,000 --> 00:02:11,400
at the end of the bidders conference my

34
00:02:21,380 --> 00:02:14,010
boss target announced that I would be

35
00:02:28,440 --> 00:02:23,610
well it was the first high

36
00:02:31,320 --> 00:02:28,450
in stage that NASA have entered into we

37
00:02:35,940 --> 00:02:31,330
had a procurement process after writing

38
00:02:39,509 --> 00:02:35,950

the model spec Douglas in Santa Monica

39
00:02:42,869 --> 00:02:39,519
won the contract though we had

40
00:02:45,210 --> 00:02:42,879
immediately after that the announcement

41
00:02:48,650 --> 00:02:45,220
that Douglas got the award we had a

42
00:02:51,270 --> 00:02:48,660
group of over 50 people from Marshall

43
00:02:56,250 --> 00:02:51,280
actually at the time it was a VM a it

44
00:02:59,550 --> 00:02:56,260
was in 59 what we went out to see the

45
00:03:02,000 --> 00:02:59,560
contractor facilities and and meeting

46
00:03:07,220 --> 00:03:02,010
the people that it was a real exciting

47
00:03:11,600 --> 00:03:07,230
trip out there and we saw a firsthand

48
00:03:14,369 --> 00:03:11,610
the what was going on in in the airforce

49
00:03:15,990 --> 00:03:14,379
contractor side of the house here

50
00:03:20,150 --> 00:03:16,000
locally we were involved with Chrysler

51
00:03:24,000 --> 00:03:20,160
and and Jupiter missile redstone missile

52
00:03:28,230 --> 00:03:24,010
so it was it was a it was a new event

53
00:03:34,260 --> 00:03:31,560
hydrogen liquid hydrogen and then it

54
00:03:38,370 --> 00:03:34,270
gets gaseous in a hurry because it's a

55
00:03:40,560 --> 00:03:38,380
it's at minus 423 degrees F it's very

56
00:03:44,670 --> 00:03:40,570
volatile it'll it'll the gas will go

57
00:03:46,890 --> 00:03:44,680
through anything the finest crack it and

58
00:03:49,800 --> 00:03:46,900
it was considered dangerous

59
00:03:53,280 --> 00:03:49,810
but convair out on the west coast had

60
00:03:57,780 --> 00:03:53,290
been working with a center stage with

61
00:04:00,540 --> 00:03:57,790
using the rl10 engine and they were

62
00:04:04,770 --> 00:04:00,550
having some successes but they had a lot

63
00:04:09,060 --> 00:04:04,780

of leaks well somehow or other and in

64
00:04:12,810 --> 00:04:09,070
our development of the s4 stage by

65
00:04:14,910 --> 00:04:12,820
Douglas we didn't have a lot of leaks it

66
00:04:18,900 --> 00:04:14,920
was pretty well contained but it was

67
00:04:24,360 --> 00:04:18,910
still volatile and you could start a

68
00:04:34,560 --> 00:04:29,730
s4 was the the first hydrogen stage that

69
00:04:40,500 --> 00:04:34,570
we had and the Saturn 5 came along

70
00:04:43,980 --> 00:04:40,510
during between 1960 and 1962 the the c5

71
00:04:46,980 --> 00:04:43,990
configuration was developed during that

72
00:04:50,280 --> 00:04:46,990
period it was decided that we're gonna

73
00:04:54,260 --> 00:04:50,290
have a third stage like the s4 but it

74
00:04:57,540 --> 00:04:54,270
had to have one j2 engine have a higher

75
00:04:59,430 --> 00:04:57,550
loading and have a lot of different

76
00:05:02,370 --> 00:04:59,440
different functions it was a natural

77
00:05:05,190 --> 00:05:02,380
choice for NASA to just say sole-source

78
00:05:08,190 --> 00:05:05,200
the s4 be because the experience that

79
00:05:11,790 --> 00:05:08,200
Douglas had in with the s4 I got

80
00:05:15,090 --> 00:05:11,800
involved with the s4 in the s2 with the

81
00:05:18,330 --> 00:05:15,100
source evaluation board which itself was

82
00:05:22,219 --> 00:05:18,340
an exciting thing it was man by Wernher

83
00:05:24,659 --> 00:05:22,229
von Braun Everhart Reis Willi motsek

84
00:05:30,090 --> 00:05:24,669
headquarters procurement people top

85
00:05:33,750 --> 00:05:30,100
level so there I was them I've I've kid

86
00:05:37,469 --> 00:05:33,760
about 33 at the time I think and I was

87
00:05:41,940 --> 00:05:37,479
hearing these guys talk about the

88
00:05:45,300 --> 00:05:41,950

contractors the capabilities and and and

89
00:05:48,990 --> 00:05:45,310
how we were going to distinguish which

90
00:05:51,420 --> 00:05:49,000
one was the better contractor to select

91
00:05:54,629 --> 00:05:51,430
and then recommendation was made to the

92
00:06:00,019 --> 00:05:54,639
NASA Administrator and choices were made

93
00:06:04,069 --> 00:06:01,969
well one of the criteria was that we

94
00:06:06,739 --> 00:06:04,079
make the interfaces between the stages

95
00:06:10,579 --> 00:06:06,749
simple and the only interfaces your

96
00:06:14,059 --> 00:06:10,589
structural tie downs and electronic

97
00:06:17,449 --> 00:06:14,069
commands from a guidance system to the

98
00:06:19,429 --> 00:06:17,459
engines for gambling for separation so

99
00:06:24,279 --> 00:06:19,439
the the the interfaces were relatively

100
00:06:27,169 --> 00:06:24,289
simple and that was I think made made

101
00:06:33,770 --> 00:06:27,179
integrating stages from different

102
00:06:41,290 --> 00:06:37,370
the s2 started out with the procurement

103
00:06:47,180 --> 00:06:41,300
packet package and I think it was 1960

104
00:06:50,360 --> 00:06:47,190
and no 61 and the selection was made but

105
00:06:54,790 --> 00:06:50,370
this was a year or two years that I

106
00:06:57,110 --> 00:06:54,800
guess two years before the the final c5

107
00:07:00,020 --> 00:06:57,120
Saturn five configuration was

108
00:07:02,660 --> 00:07:00,030
established so North American was

109
00:07:06,050 --> 00:07:02,670
selected I got to be acting program

110
00:07:10,160 --> 00:07:06,060
manager our project manager had to go

111
00:07:11,990 --> 00:07:10,170
ahead for a c3 configuration at that

112
00:07:15,980 --> 00:07:12,000
time knowing that we were going to

113
00:07:17,720 --> 00:07:15,990

evolve into the something bigger but the

114
00:07:19,880 --> 00:07:17,730
government wanted to get the contractor

115
00:07:23,450 --> 00:07:19,890
on board so he could have an advantage

116
00:07:28,940 --> 00:07:23,460
of the preliminary design in fact he

117
00:07:34,370 --> 00:07:28,950
helped NASA with ideas on on the Saturn

118
00:07:37,909 --> 00:07:34,380
5 configuration the Apollo program oddly

119
00:07:42,070 --> 00:07:37,919
enough was selected and given to North

120
00:07:45,950 --> 00:07:42,080
American Aviation as an ID at Downey

121
00:07:49,370 --> 00:07:45,960
about two months after the s2 was

122
00:07:52,130 --> 00:07:49,380
selected and we were all really aghast

123
00:07:56,020 --> 00:07:52,140
at that how can the government put two

124
00:08:00,920 --> 00:07:56,030
huge contractors contracts into into one

125
00:08:03,200 --> 00:08:00,930
contractor shop but it happened during

126
00:08:09,140 --> 00:08:03,210
the ensuing period that period leading

127
00:08:11,450 --> 00:08:09,150
up to the fall of 62 both contractors

128
00:08:13,940 --> 00:08:11,460
did a lot of preliminary design leading

129
00:08:16,810 --> 00:08:13,950
up to the Saturn 5 configuration it's

130
00:08:23,110 --> 00:08:16,820
this contractor that's an ID and Downey

131
00:08:26,840 --> 00:08:23,120
was harboring two major contractors

132
00:08:29,060 --> 00:08:26,850
within within a half a mile radius it

133
00:08:33,200 --> 00:08:29,070
was it was her and I was out there for a

134
00:08:36,290 --> 00:08:33,210
year after well well it was in 62 fall

135
00:08:39,529 --> 00:08:36,300
of 62 I went out for a year and I got a

136
00:08:44,300 --> 00:08:39,539
feel for the they not the confusion but

137
00:08:47,450 --> 00:08:44,310
the constraints that were involved in

138
00:08:51,080 --> 00:08:47,460

and in getting worked

139
00:08:53,240 --> 00:08:51,090
done by the contractor and it was pretty

140
00:08:54,380 --> 00:08:53,250
obvious that a lot of things were were

141
00:08:59,660 --> 00:08:54,390
slipping

142
00:09:02,230 --> 00:08:59,670
well the contracts proceeded from that

143
00:09:08,300 --> 00:09:02,240
point 62 and they were given to go ahead

144
00:09:12,710 --> 00:09:08,310
until 64 and progress was being made but

145
00:09:14,960 --> 00:09:12,720
it was slow and the schedule was

146
00:09:18,410 --> 00:09:14,970
obviously slipping costs were going up

147
00:09:21,680 --> 00:09:18,420
and these were cost plus fixed fee

148
00:09:24,620 --> 00:09:21,690
contracts so the contractor did what he

149
00:09:29,120 --> 00:09:24,630
had to do to get to meet the model spec

150
00:09:34,570 --> 00:09:29,130
requirements it was a it was a strange

151
00:09:38,200 --> 00:09:34,580
period and and during that period s to

152
00:09:42,830 --> 00:09:38,210
seal Beach facility had been constructed

153
00:09:45,800 --> 00:09:42,840
and and they had started building the s2

154
00:09:47,960 --> 00:09:45,810
bulkhead as well as the the other

155
00:09:52,430 --> 00:09:47,970
components that make up the tank when I

156
00:09:56,840 --> 00:09:52,440
left the program in 65 we had just

157
00:09:59,870 --> 00:09:56,850
completed or a quasi CDR it wasn't the

158
00:10:02,690 --> 00:09:59,880
kind of CDR as we've had since then but

159
00:10:06,620 --> 00:10:02,700
we accepted it because we wanted to get

160
00:10:09,710 --> 00:10:06,630
on with a program and other than the

161
00:10:14,680 --> 00:10:09,720
problems with having so many so much

162
00:10:18,050 --> 00:10:14,690
work done in one shop and the delays

163
00:10:20,300 --> 00:10:18,060

work work was it was really accomplished

164
00:10:24,710 --> 00:10:20,310
and by the way when I first got out

165
00:10:26,750 --> 00:10:24,720
there in 62 the contractor was cleanly

166
00:10:29,980 --> 00:10:26,760
aware of the problem and he suggested

167
00:10:33,050 --> 00:10:29,990
that the s2 be transferred for

168
00:10:38,090 --> 00:10:33,060
development in Tulsa they had a facility

169
00:10:41,240 --> 00:10:38,100
in Tulsa so immediately my boss Oswald

170
00:10:44,660 --> 00:10:41,250
longa took umbrage with that that to

171
00:10:48,440 --> 00:10:44,670
have the s2 selected on the basis of

172
00:10:50,810 --> 00:10:48,450
development in Los Angeles with the Seal

173
00:10:53,690 --> 00:10:50,820
Beach facility being built just strictly

174
00:10:56,360 --> 00:10:53,700
for the s2 it was unconscionable to move

175
00:11:00,470 --> 00:10:56,370
the s2 down there well a compromise was

176
00:11:01,200 --> 00:11:00,480
made we decided that I'll call it

177
00:11:03,270 --> 00:11:01,210
dumpster

178
00:11:05,640 --> 00:11:03,280
there's structures that don't have a lot

179
00:11:08,160 --> 00:11:05,650
of complicated electronics could be

180
00:11:10,650 --> 00:11:08,170
shipped or sent down there for design

181
00:11:14,070 --> 00:11:10,660
and manufacture these are the inter

182
00:11:16,470 --> 00:11:14,080
stages the thrust structure but as far

183
00:11:18,060 --> 00:11:16,480
as the cryogenic tanks they had to be

184
00:11:21,360 --> 00:11:18,070
kept and there the design and

185
00:11:23,790 --> 00:11:21,370
development had to be kept in in County

186
00:11:26,160 --> 00:11:23,800
in Los Angeles Seal Beach well we could

187
00:11:30,750 --> 00:11:26,170
observe the fact that they were making

188
00:11:33,500 --> 00:11:30,760

progress in design it was slow and the

189
00:11:36,210 --> 00:11:33,510
crunch didn't come until the

190
00:11:38,790 --> 00:11:36,220
manufacturing of the common bulkhead

191
00:11:44,130 --> 00:11:38,800
started and that was a difficult job in

192
00:11:46,670 --> 00:11:44,140
19 1964 general Sam Phillips who was

193
00:11:50,130 --> 00:11:46,680
headquarters head of the Apollo program

194
00:11:52,470 --> 00:11:50,140
was aware of the schedule slips that

195
00:11:56,550 --> 00:11:52,480
were impending they increased cost and

196
00:12:00,270 --> 00:11:56,560
he initiated a bunch of tiger teams we

197
00:12:03,350 --> 00:12:00,280
came out to Downey and we spent the

198
00:12:06,800 --> 00:12:03,360
better part of a month reviewing

199
00:12:09,870 --> 00:12:06,810
intimate details and and and

200
00:12:13,580 --> 00:12:09,880
organizations as well as design and

201
00:12:17,640 --> 00:12:13,590
development of the s2 and it was also

202
00:12:21,030 --> 00:12:17,650
being the Apollo spacecraft was also a

203
00:12:23,880 --> 00:12:21,040
part of that review small disciplinary

204
00:12:26,490 --> 00:12:23,890
teams would literally invade the

205
00:12:32,600 --> 00:12:26,500
contractor and evaluate the progress

206
00:12:36,810 --> 00:12:32,610
that effort in 65 ended up with a

207
00:12:42,410 --> 00:12:36,820
major-general Sam Phillips and George

208
00:12:47,370 --> 00:12:42,420
Muller to write a letter to the head of

209
00:12:51,090 --> 00:12:47,380
North American the result was the

210
00:12:53,550 --> 00:12:51,100
contractor assigned a new guy to head up

211
00:12:55,880 --> 00:12:53,560
the s2 program Heatley assigned a new

212
00:13:01,010 --> 00:12:55,890
guy to head up the Apollo program and

213
00:13:03,690 --> 00:13:01,020

and in progress well we had progress

214
00:13:06,240 --> 00:13:03,700
from then on but it was still extremely

215
00:13:11,740 --> 00:13:06,250
difficult really for the rest all most

216
00:13:19,360 --> 00:13:16,000
he was like a fighter pilot like John

217
00:13:22,840 --> 00:13:19,370
McCain he he news business

218
00:13:25,510 --> 00:13:22,850
he early on during World War two he and

219
00:13:28,650 --> 00:13:25,520
Bob Gilruth who headed up the Apollo

220
00:13:32,470 --> 00:13:28,660
program at Langley had solved a problem

221
00:13:38,650 --> 00:13:32,480
on the p-51 it was an air scoop problem

222
00:13:40,870 --> 00:13:38,660
and that that relationship I guess might

223
00:13:43,660 --> 00:13:40,880
have helped the getting the Apollo

224
00:13:46,390 --> 00:13:43,670
program assigned to him he was a unique

225
00:13:52,060 --> 00:13:46,400
guy and we had several meetings with him

226
00:13:57,610 --> 00:13:52,070
and he was solicitous help answered our

227
00:14:05,030 --> 00:13:57,620
questions and and sharp technically and

228
00:14:11,810 --> 00:14:09,230
well we were in that period in 68 64 and

229
00:14:17,360 --> 00:14:11,820
65 when Sam Phillips is known as his

230
00:14:20,750 --> 00:14:17,370
work with the review teams and and NASA

231
00:14:24,650 --> 00:14:20,760
had and announced the possibility an

232
00:14:27,379 --> 00:14:24,660
opportunity for to get a nomination of

233
00:14:30,230 --> 00:14:27,389
people who would go to MIT on Sloan

234
00:14:32,210 --> 00:14:30,240
program and I volunteered well I had to

235
00:14:34,490 --> 00:14:32,220
make the application I went through

236
00:14:38,439 --> 00:14:34,500
interviews with the head of the program

237
00:14:44,569 --> 00:14:38,449
at MIT and eventually I got selected

238
00:14:47,420 --> 00:14:44,579

well that was a an inflection point of

239
00:14:53,509 --> 00:14:47,430
the program the following Sam Phillips

240
00:14:55,730 --> 00:14:53,519
initial operation out there and I I was

241
00:14:59,689 --> 00:14:55,740
given an opportunity to either stay on

242
00:15:02,389 --> 00:14:59,699
the s2 or or go to MIT well I wasn't

243
00:15:07,009 --> 00:15:02,399
gonna miss that opportunity while I was

244
00:15:10,610 --> 00:15:07,019
gone I read in the newspaper events that

245
00:15:14,360 --> 00:15:10,620
occurred of the s2 program one of which

246
00:15:18,769 --> 00:15:14,370
was the destruction of the structural

247
00:15:22,220 --> 00:15:18,779
test vehicle at Seal Beach for me being

248
00:15:23,809 --> 00:15:22,230
up in Massachusetts it was a shock but I

249
00:15:25,990 --> 00:15:23,819
could do nothing about it other than

250
00:15:28,460 --> 00:15:26,000
just absorb the fact that it happened

251
00:15:31,009 --> 00:15:28,470
but I learned more about it when I got

252
00:15:34,939 --> 00:15:31,019
back there a year later the accident

253
00:15:36,410 --> 00:15:34,949
occurred the the the the tank broke had

254
00:15:38,660 --> 00:15:36,420
water in there to simulate the

255
00:15:41,620 --> 00:15:38,670
propellant loads and of course there

256
00:15:45,170 --> 00:15:41,630
were actuators to apply loads to it and

257
00:15:49,639 --> 00:15:45,180
the tank broke at one hundred and forty

258
00:15:53,650 --> 00:15:49,649
four percent of the load the design

259
00:15:58,790 --> 00:15:53,660
requirement was one point for which the

260
00:16:02,800 --> 00:15:58,800
difference between that was negligible

261
00:16:06,170 --> 00:16:02,810
and the test was evaluated as being

262
00:16:09,559 --> 00:16:06,180
acceptable even in spite of the failure

263
00:16:14,269 --> 00:16:09,569

and it demonstrated that the s2 tank was

264
00:16:21,130 --> 00:16:14,279
extremely efficient but it was getting

265
00:16:29,840 --> 00:16:25,280
it was tremendous pressure and

266
00:16:32,840 --> 00:16:29,850
excitement to do to get things done you

267
00:16:35,660 --> 00:16:32,850
could hardly talk too long to people

268
00:16:40,450 --> 00:16:35,670
about like I wanted to know what

269
00:16:43,460 --> 00:16:40,460
happened and everybody was too busy

270
00:16:48,530 --> 00:16:43,470
trying to get the ahead of the schedule

271
00:16:53,030 --> 00:16:48,540
and and get to get the project on track

272
00:16:58,519 --> 00:16:53,040
it was a rather more than exciting

273
00:17:11,029 --> 00:17:02,930
one of the other problems that s2 faced

274
00:17:13,399 --> 00:17:11,039
was the lunar lander program grumman was

275
00:17:14,510 --> 00:17:13,409
overweight and there was nothing that

276
00:17:19,429 --> 00:17:14,520
could be done about it

277
00:17:21,439 --> 00:17:19,439
so s2 is selected to take weight out of

278
00:17:25,069 --> 00:17:21,449
the structure in order to increase or

279
00:17:30,500 --> 00:17:25,079
allow the added weight in the lunar

280
00:17:32,630 --> 00:17:30,510
module well in doing so they would go

281
00:17:36,140 --> 00:17:32,640
from one vehicle to another one

282
00:17:39,440 --> 00:17:36,150
redesigned just to squeeze out weight in

283
00:17:42,440 --> 00:17:39,450
fact an example in an extreme example

284
00:17:44,480 --> 00:17:42,450
was one of the sections of the common

285
00:17:49,510 --> 00:17:44,490
buck the upper facing that faced the

286
00:17:53,960 --> 00:17:49,520
hydrogen tank the hydrogen material that

287
00:17:57,649 --> 00:17:53,970
thickness was about 25 thousandths on on

288
00:17:59,539 --> 00:17:57,659

one section plus a minus five well that

289
00:18:01,279 --> 00:17:59,549
material started out about a hundred and

290
00:18:04,210 --> 00:18:01,289
twenty-five thousandths the upper the

291
00:18:07,070 --> 00:18:04,220
upper bulkhead on the common bulkhead

292
00:18:09,020 --> 00:18:07,080
and they had to have lands about the

293
00:18:12,200 --> 00:18:09,030
thickness of that material about a

294
00:18:15,740 --> 00:18:12,210
hundred twenty-five thousand so they

295
00:18:19,220 --> 00:18:15,750
went to chemical mill operation where

296
00:18:22,760 --> 00:18:19,230
you take a caustic solution and the

297
00:18:24,980 --> 00:18:22,770
leach out the material very carefully to

298
00:18:27,430 --> 00:18:24,990
get it down to the the dimension that

299
00:18:31,010 --> 00:18:27,440
you want like the twenty five thousands

300
00:18:34,010 --> 00:18:31,020
that is an extreme of how they saved

301
00:18:36,710 --> 00:18:34,020
weight on the s2 it was a critical

302
00:18:39,350 --> 00:18:36,720
operation and it was done very carefully

303
00:18:44,090 --> 00:18:39,360
from stage to stage and as the program

304
00:18:48,289 --> 00:18:44,100
developed s2 was able to he got a little

305
00:18:50,270 --> 00:18:48,299
more weight each time and fortunately we

306
00:18:52,340 --> 00:18:50,280
had no problems with the common bulkhead

307
00:18:58,700 --> 00:18:52,350
other than learning how to make it and

308
00:19:06,019 --> 00:19:02,149
the combat bulkhead initially started on

309
00:19:08,960 --> 00:19:06,029
the s4 stage and it was a spheric

310
00:19:13,340 --> 00:19:08,970
spherical a hemispherical rather it was

311
00:19:16,340 --> 00:19:13,350
just to clamshells good with a phenolic

312
00:19:18,890 --> 00:19:16,350
: comb interface in between them the

313
00:19:21,940 --> 00:19:18,900

sandwich so to speak bonded together a

314
00:19:25,399 --> 00:19:21,950
rigid struck a very rigid structure so

315
00:19:28,600 --> 00:19:25,409
the common bulkhead was initially

316
00:19:32,380 --> 00:19:28,610
started by Douglas in the case of the s2

317
00:19:38,899 --> 00:19:32,390
north american proposed a half ellipsoid

318
00:19:42,649 --> 00:19:38,909
shape so that the the height of the dork

319
00:19:45,590 --> 00:19:42,659
head was shorter and of course the s2 is

320
00:19:49,539 --> 00:19:45,600
33 feet in diameter and that bulkhead

321
00:19:53,389 --> 00:19:49,549
had to be carefully this kind for

322
00:19:55,909 --> 00:19:53,399
tolerances to made up with the hydrogen

323
00:19:58,610 --> 00:19:55,919
tank above it and the and the oxygen

324
00:20:01,279 --> 00:19:58,620
tank below it there was the interface

325
00:20:04,100 --> 00:20:01,289
between that those two proponents of

326
00:20:08,990 --> 00:20:04,110
course thermally there's no problem

327
00:20:13,210 --> 00:20:09,000
one was minus 423 and the other - 296

328
00:20:17,419 --> 00:20:13,220
about 26 degrees difference but it was

329
00:20:24,150 --> 00:20:17,429
critical if it broke the whole whole

330
00:20:33,090 --> 00:20:28,230
in terms of time it was all crunch time

331
00:20:36,870 --> 00:20:33,100
in 1965 we felt we had completed the

332
00:20:41,159 --> 00:20:36,880
design the contractor had built a common

333
00:20:44,789 --> 00:20:41,169
bulkhead he had built the stage at Seal

334
00:20:47,430 --> 00:20:44,799
Beach the first one well the first one

335
00:20:51,240 --> 00:20:47,440
off the line was asked to structural

336
00:20:55,590 --> 00:20:51,250
vehicle as to s and that failed the next

337
00:20:58,470 --> 00:20:55,600
one off the line was the dynamic stage

338
00:21:02,909 --> 00:20:58,480

and then the all systems vehicle the all

339
00:21:06,060 --> 00:21:02,919
systems vehicle was a a flight type the

340
00:21:08,279 --> 00:21:06,070
first item off the line that was to be

341
00:21:10,740 --> 00:21:08,289
flight design because of all the

342
00:21:13,220 --> 00:21:10,750
problems that were reviewed in the

343
00:21:17,149 --> 00:21:13,230
Apollo program and particularly the s2

344
00:21:22,380 --> 00:21:17,159
it was decided a rather major decision

345
00:21:27,840 --> 00:21:22,390
to have the MTF in fact the it was

346
00:21:31,919 --> 00:21:27,850
started back in 63 naa was directed in I

347
00:21:35,299 --> 00:21:31,929
guess it was January of 65 that the all

348
00:21:38,399 --> 00:21:35,309
systems vehicle would not be tested in

349
00:21:43,169 --> 00:21:38,409
San Santa Susana it would be shipped

350
00:21:44,760 --> 00:21:43,179
down to MTF all the subsequent flight

351
00:21:47,310 --> 00:21:44,770
articles would also go down there for

352
00:21:50,060 --> 00:21:47,320
being tested this was a major change

353
00:21:53,669 --> 00:21:50,070
from what was originally planned and and

354
00:21:56,250 --> 00:21:53,679
it was a it was quite an inflection in

355
00:22:02,279 --> 00:21:56,260
the program but it was it was intended

356
00:22:06,029 --> 00:22:02,289
to save it cost have the testing done at

357
00:22:07,980 --> 00:22:06,039
a NASA facility that was that was the

358
00:22:11,669 --> 00:22:07,990
first inflection in the program that

359
00:22:16,200 --> 00:22:11,679
direction and then at the same time we

360
00:22:20,210 --> 00:22:16,210
had Sam Phillips reviews and all this

361
00:22:22,380 --> 00:22:20,220
time hardware was being built the SS 2

362
00:22:25,640 --> 00:22:22,390
asked the structural vehicle was

363
00:22:30,390 --> 00:22:25,650

completed and tested and and destroyed

364
00:22:33,270 --> 00:22:30,400
the all systems test vehicle the first

365
00:22:36,810 --> 00:22:33,280
flight type off the line to be tested

366
00:22:37,529 --> 00:22:36,820
was in process and being built in fact

367
00:22:40,859 --> 00:22:37,539
it

368
00:22:50,849 --> 00:22:40,869
was delivered in the summer of 65 down

369
00:22:56,060 --> 00:22:50,859
to MTF but by May in 1966 it blew up at

370
00:23:00,029 --> 00:22:56,070
MTF but it was it was not a an accident

371
00:23:03,659 --> 00:23:00,039
involving cryogens it was it happened at

372
00:23:08,249 --> 00:23:03,669
night somebody on the on the first shift

373
00:23:11,159 --> 00:23:08,259
had left some vowels and switches in the

374
00:23:15,539 --> 00:23:11,169
wrong position or in a position that and

375
00:23:18,269 --> 00:23:15,549
and the night crew had not been notified

376
00:23:21,739 --> 00:23:18,279
or didn't get the word and they over

377
00:23:26,849 --> 00:23:21,749
pressurized the hydrogen tank with

378
00:23:28,950 --> 00:23:26,859
gaseous helium and it blew but the

379
00:23:31,769 --> 00:23:28,960
saving grace there was the time that it

380
00:23:34,499 --> 00:23:31,779
had spent down at MTF they had run a

381
00:23:38,009 --> 00:23:34,509
number of short duration runs with with

382
00:23:42,570 --> 00:23:38,019
the oil systems vehicle and about a week

383
00:23:45,839 --> 00:23:42,580
before it blew up at night they had run

384
00:23:49,849 --> 00:23:45,849
a full duration test on the s2 there was

385
00:23:54,509 --> 00:23:49,859
some confidence there that it would work

386
00:23:57,330 --> 00:23:54,519
but again you lose a stage you lose a

387
00:24:00,629 --> 00:23:57,340
lot of testing that you you want to get

388
00:24:02,669 --> 00:24:00,639

information from so the next item to be

389
00:24:06,269 --> 00:24:02,679
tested as MTF was the first flight

390
00:24:09,419 --> 00:24:06,279
article s tube one and fortunately it

391
00:24:12,930 --> 00:24:09,429
went through the preliminary tests and

392
00:24:18,899 --> 00:24:12,940
the final full duration and will ship

393
00:24:27,570 --> 00:24:23,100
the s4 and the s4b stages and internal

394
00:24:31,889 --> 00:24:27,580
insulation its construction had they

395
00:24:35,129 --> 00:24:31,899
made waffle hog outs cutouts on the

396
00:24:40,769 --> 00:24:35,139
inside of the the tanks that was it was

397
00:24:42,810 --> 00:24:40,779
an exact follow up of what Douglas had

398
00:24:45,810 --> 00:24:42,820
done with the Thor vehicle how they

399
00:24:50,669 --> 00:24:45,820
built the this structure so they had

400
00:24:53,249 --> 00:24:50,679
these pockets in the inside about an

401
00:24:55,110 --> 00:24:53,259
inch deep and they put insulation in

402
00:24:57,720 --> 00:24:55,120
there and then they covered all these

403
00:25:01,080 --> 00:24:57,730
pockets with a with a with a membrane

404
00:25:03,389 --> 00:25:01,090
and and unmonitored and the idea was

405
00:25:07,560 --> 00:25:03,399
that liquid hydrogen on the inside of

406
00:25:09,960 --> 00:25:07,570
the tank would clearly penetrate that

407
00:25:12,509 --> 00:25:09,970
because hydrogen will go through almost

408
00:25:14,549 --> 00:25:12,519
anything it's most correct and the

409
00:25:17,840 --> 00:25:14,559
theory was that in that space where they

410
00:25:21,629 --> 00:25:17,850
had this insulation you'd have two-phase

411
00:25:24,149 --> 00:25:21,639
hydrogen close to the outer skin it

412
00:25:26,820 --> 00:25:24,159
would definitely be gas close to the

413
00:25:30,779 --> 00:25:26,830

inside of the membrane that separated

414
00:25:32,850 --> 00:25:30,789
the or the the space in between the

415
00:25:36,480 --> 00:25:32,860
where they had the foam it would be a

416
00:25:39,210 --> 00:25:36,490
two-phase with liquid on the inside and

417
00:25:42,830 --> 00:25:39,220
gas on the outside it was it was a

418
00:25:46,619 --> 00:25:42,840
rather rudimentary my method of

419
00:25:50,070 --> 00:25:46,629
insulating hydrogen but that was the

420
00:25:52,470 --> 00:25:50,080
Douglass proposal well s2 came along and

421
00:25:56,700 --> 00:25:52,480
they decided going to have external

422
00:26:02,639 --> 00:25:56,710
insulation and their plan was to make

423
00:26:04,529 --> 00:26:02,649
panels of similar material of a foam and

424
00:26:06,320 --> 00:26:04,539
it would be bonded to the outside of the

425
00:26:10,919 --> 00:26:06,330
tank and then covered with a membrane

426
00:26:11,279 --> 00:26:10,929
and the idea there again was inside the

427
00:26:15,299 --> 00:26:11,289
tank

428
00:26:19,820 --> 00:26:15,309
you had liquid hydrogen at minus 423 the

429
00:26:26,029 --> 00:26:19,830
design for the s2 was to purge that

430
00:26:30,629 --> 00:26:26,039
those panels with which had well

431
00:26:32,560 --> 00:26:30,639
honeycomb that was perforated so that

432
00:26:35,080 --> 00:26:32,570
the hydrogen gas

433
00:26:37,450 --> 00:26:35,090
flow up through it and the idea there

434
00:26:40,570 --> 00:26:37,460
was like similar to what Douglas had on

435
00:26:44,919 --> 00:26:40,580
the inside by the outside of the skin

436
00:26:49,210 --> 00:26:44,929
tank it was minus 23 for 23 outside

437
00:26:50,799 --> 00:26:49,220
these one-and-a-half inch panels you you

438
00:26:53,049 --> 00:26:50,809

didn't have atmosphere air on the

439
00:26:57,430 --> 00:26:53,059
outside and of course it would be cold

440
00:26:59,680 --> 00:26:57,440
but you wouldn't have minus 423 on the

441
00:27:03,519 --> 00:26:59,690
outside but it would be cold enough that

442
00:27:05,950 --> 00:27:03,529
the atmosphere would Frost up on the

443
00:27:08,799 --> 00:27:05,960
outside of the tank well it was a more

444
00:27:11,320 --> 00:27:08,809
efficient thermal design and the reason

445
00:27:14,619 --> 00:27:11,330
they did it was because the aluminum

446
00:27:16,240 --> 00:27:14,629
alloy that was used in the tanks both in

447
00:27:22,899 --> 00:27:16,250
the s4b

448
00:27:28,060 --> 00:27:22,909
and in the s2 was 2014 t6 alloy and at

449
00:27:30,399 --> 00:27:28,070
minus 423 it was a lot stronger it was

450
00:27:33,419 --> 00:27:30,409
it reached its maximum strength and and

451
00:27:39,720 --> 00:27:33,429
the higher strength you can calculate

452
00:27:45,749 --> 00:27:39,730
the less material you needed for for the

453
00:27:48,999 --> 00:27:45,759
design of the skin and it was a very

454
00:27:52,149 --> 00:27:49,009
very efficient structurally as long as

455
00:27:57,340 --> 00:27:52,159
the material was four minus four it was

456
00:28:01,899 --> 00:27:57,350
was hydrogen temperatures but on the s4

457
00:28:03,580 --> 00:28:01,909
be that skin was not that cold so it was

458
00:28:05,769 --> 00:28:03,590
a less less efficient structure

459
00:28:10,289 --> 00:28:05,779
insulation for the SUV evolved from

460
00:28:12,999 --> 00:28:10,299
these panels to foam they found out that

461
00:28:16,690 --> 00:28:13,009
when these panels fell off a cook way of

462
00:28:18,999 --> 00:28:16,700
fixing was to use spray-on foam and they

463
00:28:22,330 --> 00:28:19,009

were coming off every time you you fill

464
00:28:26,409 --> 00:28:22,340
the tank and empty the tank doing prior

465
00:28:29,499 --> 00:28:26,419
launch pre launch operations and it was

466
00:28:32,289 --> 00:28:29,509
later used on the e tank and then the

467
00:28:39,850 --> 00:28:32,299
and the later stages that were launched

468
00:28:46,149 --> 00:28:43,180
well my wife and I went down to the cave

469
00:28:48,370 --> 00:28:46,159
for seven months to get the Skylab ready

470
00:28:51,370 --> 00:28:48,380
for launch and during that period the

471
00:28:54,789 --> 00:28:51,380
next to the last flight I think it was

472
00:28:56,350 --> 00:28:54,799
the 17th flight it was it was a night

473
00:28:59,200 --> 00:28:56,360
flight it was in fact it was the only

474
00:29:03,370 --> 00:28:59,210
night flight and while we were building

475
00:29:07,870 --> 00:29:03,380
up the Skylab in the VAB it was being

476
00:29:10,169 --> 00:29:07,880
prepared and we we got our passes to go

477
00:29:17,740 --> 00:29:10,179
out to see it and we got out on the

478
00:29:22,110 --> 00:29:17,750
highway adjacent to the the a B my wife

479
00:29:24,970 --> 00:29:22,120
my daughter her husband and we just

480
00:29:27,580 --> 00:29:24,980
enjoyed seeing it all that fire that

481
00:29:29,710 --> 00:29:27,590
would I might I might launch is

482
00:29:33,759 --> 00:29:29,720
something else you have all this fire

483
00:29:37,590 --> 00:29:33,769
the whole sky lights up so it was it was

484
00:29:40,269 --> 00:29:37,600
an exciting time but then after I guess

485
00:29:42,460 --> 00:29:40,279
five six months later we launched the

486
00:29:49,400 --> 00:29:42,470
Skylab and had some problems with it

487
00:29:54,950 --> 00:29:52,250
or a number of concepts that were

488
00:29:57,020 --> 00:29:54,960

brought up the first one

489
00:30:00,710 --> 00:29:57,030
the initial idea and it really started

490
00:30:01,850 --> 00:30:00,720
before I got there was get man in space

491
00:30:05,810 --> 00:30:01,860
how do we do it

492
00:30:09,830 --> 00:30:05,820
the s4b is going to be in space because

493
00:30:11,960 --> 00:30:09,840
it's your third stage let's make a hatch

494
00:30:13,840 --> 00:30:11,970
that can be opened they actually

495
00:30:16,910 --> 00:30:13,850
designed a hatch at the top of the

496
00:30:19,970 --> 00:30:16,920
hydrogen tank with the idea that maybe a

497
00:30:22,340 --> 00:30:19,980
man in a spacesuit could get into the

498
00:30:24,530 --> 00:30:22,350
high into the tank and and do something

499
00:30:27,410 --> 00:30:24,540
I mean there was a rather primitive idea

500
00:30:31,720 --> 00:30:27,420
but that was one of the first ideas and

501
00:30:34,400 --> 00:30:31,730
quickly discarded but the hatch idea

502
00:30:37,850 --> 00:30:34,410
continued because that was necessary

503
00:30:40,480 --> 00:30:37,860
when we had the full full of Skylab you

504
00:30:43,360 --> 00:30:40,490
had a access to the s4b

505
00:30:46,940 --> 00:30:43,370
hydrogen tank which became actually our

506
00:30:49,670 --> 00:30:46,950
space station to go from the airlock

507
00:30:51,890 --> 00:30:49,680
module into the orbital workshop it was

508
00:30:54,590 --> 00:30:51,900
called then there were other ideas that

509
00:30:58,760 --> 00:30:54,600
one of the prime ideas was the Sun

510
00:31:02,030 --> 00:30:58,770
telescope that became and it was a now

511
00:31:04,760 --> 00:31:02,040
in-house project Marshall did so there

512
00:31:08,420 --> 00:31:04,770
was a lot of effort inside the senator

513
00:31:11,240 --> 00:31:08,430

toward developing that telescope the

514
00:31:14,660 --> 00:31:11,250
interior or the workshop from the time I

515
00:31:17,660 --> 00:31:14,670
got involved until then a lot of ideas

516
00:31:20,690 --> 00:31:17,670
were developed designs produced for the

517
00:31:24,880 --> 00:31:20,700
interior of the orbital workshop we

518
00:31:28,850 --> 00:31:24,890
looked at what the submarine what

519
00:31:30,770 --> 00:31:28,860
submarine life was for people in in a

520
00:31:34,250 --> 00:31:30,780
confined area for a long period of time

521
00:31:37,520 --> 00:31:34,260
we even visited one of the atomic subs

522
00:31:40,220 --> 00:31:37,530
of in San Diego just to see what the

523
00:31:43,360 --> 00:31:40,230
situation was to live in a in a confined

524
00:31:48,320 --> 00:31:43,370
area for in that case was 90 days but

525
00:31:52,220 --> 00:31:48,330
our plans on the Skylab the first

526
00:31:55,130 --> 00:31:52,230
mission was to be 28 days the second 60

527
00:31:58,580 --> 00:31:55,140
days in the third 84 days three

528
00:32:05,520 --> 00:31:58,590
different separate missions so it wasn't

529
00:32:05,530 --> 00:32:08,430
well

530
00:32:13,250 --> 00:32:10,529
a lot of people were contributing ideas

531
00:32:18,149 --> 00:32:13,260
and they said well Raymond Loewy

532
00:32:21,419 --> 00:32:18,159
invented the coke bottle shape and he's

533
00:32:25,710 --> 00:32:21,429
reputed to have invented the the shape

534
00:32:28,860 --> 00:32:25,720
of the early Studebaker that was the

535
00:32:31,409 --> 00:32:28,870
news and and he had a reputation for

536
00:32:36,779 --> 00:32:31,419
designing you he was a rather flamboyant

537
00:32:38,730 --> 00:32:36,789
individual and so that NASA hired him to

538
00:32:42,690 --> 00:32:38,740

come down and look at what we were doing

539
00:32:44,279 --> 00:32:42,700
on Skylab and he spent three or four

540
00:32:47,610 --> 00:32:44,289
days there

541
00:32:48,389 --> 00:32:47,620
I even had a picture taken with his

542
00:32:51,149 --> 00:32:48,399
ideas

543
00:32:55,019 --> 00:32:51,159
we're good and we implemented most of

544
00:32:59,000 --> 00:32:55,029
them such as the interior surfaces of

545
00:33:04,100 --> 00:32:59,010
the workshop were were coated with the

546
00:33:07,320 --> 00:33:04,110
plastic material over insulation and not

547
00:33:10,649 --> 00:33:07,330
that was applied on the inside he wanted

548
00:33:13,620 --> 00:33:10,659
it colored pale yellow to make it a

549
00:33:19,200 --> 00:33:13,630
little more easy on the eyes he gave us

550
00:33:21,570 --> 00:33:19,210
a lot of ideas for wardroom the table in

551
00:33:23,730 --> 00:33:21,580
the middle of the wardroom had

552
00:33:26,279 --> 00:33:23,740
restraints where astronauts could

553
00:33:28,830 --> 00:33:26,289
straddle their restraints ether food

554
00:33:31,889 --> 00:33:28,840
read books whatever water room was a

555
00:33:34,200 --> 00:33:31,899
place to relax and and eat and we even

556
00:33:37,230 --> 00:33:34,210
had a window in there he didn't make a

557
00:33:43,249 --> 00:33:37,240
lot of major changes but he he put on

558
00:33:47,419 --> 00:33:44,630
well

559
00:33:53,019 --> 00:33:47,429
the legacy of the Apollo program to my

560
00:34:00,100 --> 00:33:53,029
mind was that it was a just another

561
00:34:05,330 --> 00:34:00,110
event in human history where individuals

562
00:34:10,790 --> 00:34:05,340
human beings decided to go beyond the

563
00:34:15,589 --> 00:34:10,800

next he'll go over the ocean go to the

564
00:34:19,089 --> 00:34:15,599
moon it was it was an event I think that

565
00:34:25,310 --> 00:34:19,099
it was typical of human the human beings