
MISSION CONTROL CENTER
PAO

1
00:00:05,030 --> 00:00:03,189
hi welcome to the international space

2
00:00:07,190 --> 00:00:05,040
station flight control room this is

3
00:00:09,509 --> 00:00:07,200
where it takes place i am here today

4
00:00:11,589 --> 00:00:09,519
with al drew he's the astronaut he is

5
00:00:13,110 --> 00:00:11,599
also the habitat demonstration unit

6
00:00:15,430 --> 00:00:13,120
project lead for the advanced

7
00:00:17,430 --> 00:00:15,440
exploration systems program he's here

8
00:00:18,950 --> 00:00:17,440
with us to talk and connect with the

9
00:00:20,310 --> 00:00:18,960
distance learning network and we're

10
00:00:23,509 --> 00:00:20,320
going to be talking with some students

11
00:00:25,349 --> 00:00:23,519
at the zion lutheran school al first

12
00:00:26,950 --> 00:00:25,359
let's just go ahead and briefly just

13
00:00:28,950 --> 00:00:26,960

give a brief discussion so just so

14
00:00:30,710 --> 00:00:28,960
everyone knows what it is that you do

15
00:00:32,870 --> 00:00:30,720
explain a little about what you do as

16
00:00:34,389 --> 00:00:32,880
the habitat demonstration unit project

17
00:00:36,549 --> 00:00:34,399
lead okay

18
00:00:37,830 --> 00:00:36,559
the main thing is that we're looking at

19
00:00:40,549 --> 00:00:37,840
interplanetary and deep space

20
00:00:42,709 --> 00:00:40,559
exploration and these are marked by very

21
00:00:44,630 --> 00:00:42,719
long missions very deep far off into

22
00:00:46,709 --> 00:00:44,640
space and quite frankly you need a place

23
00:00:48,630 --> 00:00:46,719
to live and work and so we work on the

24
00:00:49,830 --> 00:00:48,640
places where people do their normal

25
00:00:52,310 --> 00:00:49,840
things that you might find on the space

26
00:00:53,910 --> 00:00:52,320
station or space shuttle and also where

27
00:00:55,830 --> 00:00:53,920
people would live you know where you

28
00:00:57,270 --> 00:00:55,840
sleep where you eat where you just play

29
00:01:00,310 --> 00:00:57,280
a game of cards or

30
00:01:01,990 --> 00:01:00,320
or hang out and watch the world go by

31
00:01:04,149 --> 00:01:02,000
really quickly how is deep space

32
00:01:06,070 --> 00:01:04,159
different than what we're doing now uh d

33
00:01:08,789 --> 00:01:06,080
space is different for one in that

34
00:01:09,910 --> 00:01:08,799
you're very far away from earth so

35
00:01:11,590 --> 00:01:09,920
now if we have a problem on space

36
00:01:12,789 --> 00:01:11,600
station today we can be on the ground

37
00:01:14,870 --> 00:01:12,799
within hours

38
00:01:16,469 --> 00:01:14,880

if you're halfway to mars it may take

39
00:01:18,550 --> 00:01:16,479
you months before you get back even if

40
00:01:20,870 --> 00:01:18,560
something goes wrong another big thing

41
00:01:22,310 --> 00:01:20,880
is that radiation in deep space the

42
00:01:24,630 --> 00:01:22,320
earth has a magnetic field around it

43
00:01:26,390 --> 00:01:24,640
that deflects a lot of really just bad

44
00:01:28,469 --> 00:01:26,400
amounts of radiation that are not far

45
00:01:30,870 --> 00:01:28,479
above us once we get what we call the

46
00:01:32,870 --> 00:01:30,880
van allen belts you were out in was in

47
00:01:34,870 --> 00:01:32,880
the in the deep space radiation galactic

48
00:01:36,310 --> 00:01:34,880
cosmic radiation is what it's called and

49
00:01:37,590 --> 00:01:36,320
you wouldn't live very long out there

50
00:01:39,429 --> 00:01:37,600
unless there's a lot of shielding around

51
00:01:40,630 --> 00:01:39,439
you so that's one of our big challenges

52
00:01:41,670 --> 00:01:40,640
is to figure out how much shielding you

53
00:01:43,109 --> 00:01:41,680
put around

54
00:01:44,789 --> 00:01:43,119
these vehicles and places where people

55
00:01:46,630 --> 00:01:44,799
live while we're out there in space

56
00:01:48,469 --> 00:01:46,640
another part is that

57
00:01:49,830 --> 00:01:48,479
i learned when i was on the job was that

58
00:01:51,030 --> 00:01:49,840
it's much much colder out there in deep

59
00:01:52,950 --> 00:01:51,040
space than it is right where the

60
00:01:55,190 --> 00:01:52,960
international space station is the earth

61
00:01:56,789 --> 00:01:55,200
is a very big very hot rock uh that

62
00:01:58,709 --> 00:01:56,799
keeps us warm uh these are our

63
00:02:00,389 --> 00:01:58,719

spacecraft warm to some degree when it's

64
00:02:01,270 --> 00:02:00,399
next to it the further you get away from

65
00:02:02,870 --> 00:02:01,280
the earth

66
00:02:04,550 --> 00:02:02,880
the less warming you get from that even

67
00:02:05,990 --> 00:02:04,560
the moon has a ability to warm you up so

68
00:02:07,429 --> 00:02:06,000
when you're in deep space

69
00:02:09,589 --> 00:02:07,439
keeping things warm and operating

70
00:02:11,990 --> 00:02:09,599
temperature is a much tougher challenge

71
00:02:14,150 --> 00:02:12,000
okay thank you so uh with that for that

72
00:02:15,430 --> 00:02:14,160
little that quick description um so with

73
00:02:17,110 --> 00:02:15,440
that let's go ahead and connect to the

74
00:02:20,229 --> 00:02:17,120
distance learning

75
00:02:25,030 --> 00:02:22,309
i am and zion lutheran is with us as

76
00:02:26,150 --> 00:02:25,040
well they are uh i'm sure happy to begin

77
00:02:43,110 --> 00:02:26,160
questions now

78
00:02:47,110 --> 00:02:44,390
uh

79
00:02:51,030 --> 00:02:47,120
what is the best rocket that can go to

80
00:02:55,270 --> 00:02:52,550
okay so that question is what is the

81
00:02:56,630 --> 00:02:55,280
best rocket that can go to mars

82
00:02:59,190 --> 00:02:56,640
what is the best rocket that can go to

83
00:03:01,430 --> 00:02:59,200
mars the best rocket that can go to mars

84
00:03:02,790 --> 00:03:01,440
is one that is most fuel efficient uh

85
00:03:05,270 --> 00:03:02,800
currently the big problem we have with

86
00:03:07,509 --> 00:03:05,280
going to mars is that for every pound of

87
00:03:09,190 --> 00:03:07,519
anything we take to mars be it you or

88
00:03:10,149 --> 00:03:09,200

your luggage or your food or your

89
00:03:12,550 --> 00:03:10,159
clothes

90
00:03:13,990 --> 00:03:12,560
we need a thousand pounds of fuel and

91
00:03:15,350 --> 00:03:14,000
that adds up very very quickly and

92
00:03:16,869 --> 00:03:15,360
especially if you're launching all that

93
00:03:19,030 --> 00:03:16,879
to orbit it at maybe fifty thousand

94
00:03:20,630 --> 00:03:19,040
dollars a pound so we need things that

95
00:03:23,830 --> 00:03:20,640
that are much more efficient than our

96
00:03:25,350 --> 00:03:23,840
current chemical rockets uh and the best

97
00:03:26,869 --> 00:03:25,360
fuel is a fuel that is light so

98
00:03:28,309 --> 00:03:26,879
electrons quite frankly is the best

99
00:03:30,390 --> 00:03:28,319
thing to use this exhaust from your

100
00:03:32,470 --> 00:03:30,400
rocket now we can either get that by way

101
00:03:34,949 --> 00:03:32,480
of nuclear sources so if you have a

102
00:03:37,430 --> 00:03:34,959
nuclear reactor it can spit out um that

103
00:03:39,670 --> 00:03:37,440
is the exhaust like like franklin chang

104
00:03:40,869 --> 00:03:39,680
diaz's vasim a rocket engine or you can

105
00:03:43,270 --> 00:03:40,879
actually use sunlight we have these

106
00:03:44,309 --> 00:03:43,280
solar electric uh propulsion motors that

107
00:03:45,910 --> 00:03:44,319
we're working on right now where you

108
00:03:47,750 --> 00:03:45,920
take solar arrays like you found the

109
00:03:50,149 --> 00:03:47,760
space station and you convert that into

110
00:03:51,670 --> 00:03:50,159
thrust and quite frankly that's free

111
00:03:52,949 --> 00:03:51,680
fuel and it's like you're using the sun

112
00:03:57,350 --> 00:03:52,959
to power yourself around the solar

113
00:04:02,070 --> 00:04:01,030

okay we'll take another question

114
00:04:04,869 --> 00:04:02,080
uh

115
00:04:05,750 --> 00:04:04,879
how much capacity can the average rocket

116
00:04:07,990 --> 00:04:05,760
hold

117
00:04:09,270 --> 00:04:08,000
how much capacity can the average rocket

118
00:04:11,030 --> 00:04:09,280
hold

119
00:04:12,070 --> 00:04:11,040
how much capacity can the average rocket

120
00:04:13,750 --> 00:04:12,080
hold

121
00:04:15,350 --> 00:04:13,760
well that depends on the rocket the uh i

122
00:04:16,310 --> 00:04:15,360
think the space shuttle please don't

123
00:04:19,030 --> 00:04:16,320
quote me

124
00:04:21,670 --> 00:04:19,040
it could take about 60 tons of mass to

125
00:04:23,830 --> 00:04:21,680
orbit over and above itself our current

126
00:04:25,990 --> 00:04:23,840
commercial rockets are somewhere closer

127
00:04:27,189 --> 00:04:26,000
to maybe 20 tons of mass they can take

128
00:04:28,950 --> 00:04:27,199
to orbit

129
00:04:31,030 --> 00:04:28,960
nasa is working on a rocket right now

130
00:04:33,830 --> 00:04:31,040
that they want to be able to take 130

131
00:04:35,030 --> 00:04:33,840
tons of mass to orbit and when we do

132
00:04:39,430 --> 00:04:35,040
that then we'll be able to do good

133
00:04:45,590 --> 00:04:42,710
we have another question

134
00:04:48,469 --> 00:04:45,600
um what will be the effects of

135
00:04:50,629 --> 00:04:48,479
heating a mars polar ice cap

136
00:04:55,270 --> 00:04:50,639
and what would it make the climate or

137
00:05:00,550 --> 00:04:57,189
and let's let's repeat that question one

138
00:05:05,430 --> 00:05:03,029

um what would be the effects of heating

139
00:05:08,710 --> 00:05:05,440
a mars polar ice cap

140
00:05:10,070 --> 00:05:08,720
and would that make the climate change

141
00:05:11,830 --> 00:05:10,080
what would be the effect of heating the

142
00:05:14,790 --> 00:05:11,840
mars polar ice caps then would that

143
00:05:17,110 --> 00:05:14,800
cause a the climate to change on mars

144
00:05:19,430 --> 00:05:17,120
that's a really profound question yes

145
00:05:21,590 --> 00:05:19,440
much of what mars's

146
00:05:24,070 --> 00:05:21,600
ice caps are are

147
00:05:26,310 --> 00:05:24,080
frozen carbon dioxide such dry ice and

148
00:05:27,990 --> 00:05:26,320
so if you were to

149
00:05:29,110 --> 00:05:28,000
liberate all that carbon dioxide in the

150
00:05:30,950 --> 00:05:29,120
atmosphere i imagine it would have to

151
00:05:32,710 --> 00:05:30,960
have some effect on the atmosphere you

152
00:05:34,070 --> 00:05:32,720
have a greenhouse effect

153
00:05:35,830 --> 00:05:34,080
one of the problems we have with mars

154
00:05:37,350 --> 00:05:35,840
atmosphere is they have had the reverse

155
00:05:38,870 --> 00:05:37,360
greenhouse effect that venus has had in

156
00:05:42,230 --> 00:05:38,880
that they don't have enough carbon

157
00:05:43,510 --> 00:05:42,240
dioxide and so mars is much colder

158
00:05:46,150 --> 00:05:43,520
than the earth would be if it was out

159
00:05:47,430 --> 00:05:46,160
there at mars orbiting radius so i

160
00:05:50,830 --> 00:05:47,440
imagine it would warm up mars a little

161
00:05:55,909 --> 00:05:50,840
bit which might make it a more habitable

162
00:06:00,710 --> 00:05:57,510
um how do you

163
00:06:04,070 --> 00:06:00,720

recycle water on the space station

164
00:06:05,590 --> 00:06:04,080
like what's the progress of that

165
00:06:07,350 --> 00:06:05,600
how do we recycle water on the space

166
00:06:09,270 --> 00:06:07,360
station uh it's also a very good

167
00:06:10,710 --> 00:06:09,280
question because if you're almost under

168
00:06:12,550 --> 00:06:10,720
every drop of water we get on the space

169
00:06:14,550 --> 00:06:12,560
station has to be imported

170
00:06:18,070 --> 00:06:14,560
we make none of our own so

171
00:06:20,070 --> 00:06:18,080
we have means of on the russian side of

172
00:06:21,270 --> 00:06:20,080
basically distilling that water and

173
00:06:23,909 --> 00:06:21,280
bringing it back through their different

174
00:06:25,270 --> 00:06:23,919
processors the united states has brought

175
00:06:26,870 --> 00:06:25,280
up some of their own water process

176
00:06:28,950 --> 00:06:26,880
equipment most famously the urine

177
00:06:30,870 --> 00:06:28,960
processor to be able to take our own

178
00:06:32,870 --> 00:06:30,880
urine and process that back again

179
00:06:41,749 --> 00:06:32,880
distilling it and turning it back into

180
00:06:48,469 --> 00:06:45,430
um in the movies they always have like

181
00:06:51,029 --> 00:06:48,479
dome-shaped houses on like mars

182
00:06:54,629 --> 00:06:51,039
so i was wondering if we wanted to make

183
00:06:55,589 --> 00:06:54,639
a colonization in on mars

184
00:06:57,029 --> 00:06:55,599
would that

185
00:06:59,670 --> 00:06:57,039
like

186
00:07:01,830 --> 00:06:59,680
be scientifically possible and if it

187
00:07:05,029 --> 00:07:01,840
would would that protect us from the

188
00:07:07,189 --> 00:07:05,039

constant sand storms and rain okay uh

189
00:07:09,589 --> 00:07:07,199
the the domes you see on planets in

190
00:07:10,790 --> 00:07:09,599
these in books and movies they're really

191
00:07:13,110 --> 00:07:10,800
nice there might be a place you might

192
00:07:14,950 --> 00:07:13,120
enter exit where you live if you were on

193
00:07:16,550 --> 00:07:14,960
mars but as a good friend of mine

194
00:07:18,150 --> 00:07:16,560
christopher stott once mentioned to me

195
00:07:19,749 --> 00:07:18,160
says you like same thing with the moon

196
00:07:21,110 --> 00:07:19,759
and mars you would not live on the

197
00:07:23,110 --> 00:07:21,120
surface of either of these planets you

198
00:07:24,790 --> 00:07:23,120
would live in those planets beneath the

199
00:07:26,150 --> 00:07:24,800
surface because the the ground around

200
00:07:28,390 --> 00:07:26,160
you would have to protect you from the

201
00:07:30,629 --> 00:07:28,400
radiation which would be much more of a

202
00:07:32,710 --> 00:07:30,639
problem for you than the sandstorms and

203
00:07:34,550 --> 00:07:32,720
winds you'd find on the surface of mars

204
00:07:36,469 --> 00:07:34,560
i understand the air at the surface of

205
00:07:38,469 --> 00:07:36,479
mars is very thin almost like what you'd

206
00:07:40,309 --> 00:07:38,479
find up at 100 000 feet above the earth

207
00:07:42,629 --> 00:07:40,319
so even it looks very dramatic to see

208
00:07:43,589 --> 00:07:42,639
the sands the the dust devils and winds

209
00:07:45,430 --> 00:07:43,599
out there

210
00:07:47,189 --> 00:07:45,440
it's really not that powerful in terms

211
00:07:48,950 --> 00:07:47,199
of its force like you'd find here on

212
00:07:54,309 --> 00:07:48,960
earth but the radiation would be a much

213
00:08:00,309 --> 00:07:57,189

i was wondering is it like hard to

214
00:08:02,869 --> 00:08:00,319
adjust to the life in space

215
00:08:04,390 --> 00:08:02,879
is it hard to adjust to life in space

216
00:08:06,309 --> 00:08:04,400
you do have to make some adjustment to

217
00:08:07,830 --> 00:08:06,319
it it usually takes a couple of days

218
00:08:08,869 --> 00:08:07,840
before you get to just the basic part of

219
00:08:10,469 --> 00:08:08,879
it just getting used to the fact that

220
00:08:12,309 --> 00:08:10,479
there is no up

221
00:08:14,230 --> 00:08:12,319
that your sunrises and sunsets come

222
00:08:16,790 --> 00:08:14,240
every 45 minutes apart

223
00:08:18,150 --> 00:08:16,800
and and you lose for me i lose a good

224
00:08:19,510 --> 00:08:18,160
sense of what time it is without my

225
00:08:21,510 --> 00:08:19,520
watches and clogs around me i'd be

226
00:08:23,029 --> 00:08:21,520
completely lost i'd be trying to radio

227
00:08:24,950 --> 00:08:23,039
friends and people like that from space

228
00:08:27,029 --> 00:08:24,960
that at all count all times a day and

229
00:08:28,230 --> 00:08:27,039
night and annoying them so

230
00:08:29,430 --> 00:08:28,240
and the other last thing you should get

231
00:08:32,230 --> 00:08:29,440
used to is

232
00:08:34,230 --> 00:08:32,240
just being when you you

233
00:08:35,990 --> 00:08:34,240
on on earth you're hauling your weight

234
00:08:37,509 --> 00:08:36,000
around and in space all you're hauling

235
00:08:39,990 --> 00:08:37,519
around is your mass and so you don't

236
00:08:41,350 --> 00:08:40,000
need your big muscles like quadriceps

237
00:08:42,790 --> 00:08:41,360
and biceps and things like that to move

238
00:08:45,030 --> 00:08:42,800

around you use your fingertips and your

239
00:08:46,550 --> 00:08:45,040
toes to push yourself around gracefully

240
00:08:48,230 --> 00:08:46,560
and for the first few days when you are

241
00:08:49,750 --> 00:08:48,240
pushing off your big muscles you take

242
00:08:51,190 --> 00:08:49,760
off too quickly and you knock things off

243
00:09:00,790 --> 00:08:51,200
the wall and people recognize that

244
00:09:06,710 --> 00:09:04,550
what kind of meals did you do you eat on

245
00:09:08,630 --> 00:09:06,720
the space station

246
00:09:10,630 --> 00:09:08,640
what kind of meals do we almost anything

247
00:09:12,630 --> 00:09:10,640
you could imagine having here on earth

248
00:09:14,949 --> 00:09:12,640
we have a food laboratory here at

249
00:09:16,870 --> 00:09:14,959
johnson space center that's been working

250
00:09:19,509 --> 00:09:16,880
continuously since we've had a space

251
00:09:21,750 --> 00:09:19,519
program on making uh really delicious

252
00:09:23,990 --> 00:09:21,760
food that's nutrition that's nutritious

253
00:09:25,990 --> 00:09:24,000
for us and they have been there they've

254
00:09:27,750 --> 00:09:26,000
let their imaginations just run wild

255
00:09:29,269 --> 00:09:27,760
i've had all kinds of cajun food like

256
00:09:31,110 --> 00:09:29,279
etouffee and jambalaya i've had

257
00:09:32,470 --> 00:09:31,120
spaghetti i've had steak i've had shrimp

258
00:09:33,750 --> 00:09:32,480
cocktail

259
00:09:36,150 --> 00:09:33,760
the only things we really try to avoid

260
00:09:38,150 --> 00:09:36,160
are things that are crumbly like popcorn

261
00:09:39,750 --> 00:09:38,160
or crackers because once you bite into

262
00:09:40,870 --> 00:09:39,760
them the crumbs don't just follow the

263
00:09:42,710 --> 00:09:40,880

floor they float around and get in

264
00:09:48,949 --> 00:09:42,720
people's eyes and hair and it gets to be

265
00:09:55,430 --> 00:09:50,949
what is the best energy power to go to

266
00:09:58,870 --> 00:09:55,440
mars nuclear wind or solar

267
00:10:02,069 --> 00:09:58,880
did you say nuclear wind or solar

268
00:10:03,910 --> 00:10:02,079
uh nuclear power wind or solar power

269
00:10:05,350 --> 00:10:03,920
okay well wind power i'm assuming you

270
00:10:06,630 --> 00:10:05,360
mean the solar wind using the pressure

271
00:10:08,710 --> 00:10:06,640
from the sun because otherwise there's

272
00:10:09,590 --> 00:10:08,720
no air in space to take you out to mars

273
00:10:12,389 --> 00:10:09,600
so

274
00:10:14,630 --> 00:10:12,399
they'd have to be very big more than a

275
00:10:15,670 --> 00:10:14,640
kilometer across to give you some of the

276
00:10:16,949 --> 00:10:15,680
thrust

277
00:10:19,030 --> 00:10:16,959
solar power is what i talked about when

278
00:10:20,550 --> 00:10:19,040
you take your solar radiation you pick

279
00:10:24,630 --> 00:10:20,560
it with a solar cell and you convert

280
00:10:25,829 --> 00:10:24,640
that into thrust and nuclear power

281
00:10:27,670 --> 00:10:25,839
simply takes the same thing rather than

282
00:10:29,350 --> 00:10:27,680
using solar energy you're using a

283
00:10:30,710 --> 00:10:29,360
nuclear source now

284
00:10:32,230 --> 00:10:30,720
aside from the problems you have with

285
00:10:33,910 --> 00:10:32,240
the nuclear source the radiation and all

286
00:10:36,069 --> 00:10:33,920
the shielding you have to have if you're

287
00:10:37,990 --> 00:10:36,079
going to go out much past mars in the

288
00:10:40,389 --> 00:10:38,000

solar system you probably need to have

289
00:10:42,470 --> 00:10:40,399
nuclear power because the sun's the

290
00:10:44,150 --> 00:10:42,480
power of the sun's light drops off with

291
00:10:45,670 --> 00:10:44,160
the square the distance so going twice

292
00:10:47,910 --> 00:10:45,680
the distance from the earth as you are

293
00:10:49,509 --> 00:10:47,920
right now the the power of the sunlight

294
00:10:51,509 --> 00:10:49,519
is now one quarter of what it would be

295
00:10:53,829 --> 00:10:51,519
going three times it make you give one

296
00:10:55,750 --> 00:10:53,839
ninth so going out to jupiter which is

297
00:10:58,389 --> 00:10:55,760
about nine times the distance from the

298
00:11:00,790 --> 00:10:58,399
sun is the earth you would have only one

299
00:11:01,829 --> 00:11:00,800
eighty first or about an 80th of the

300
00:11:03,509 --> 00:11:01,839
solar

301
00:11:04,870 --> 00:11:03,519
power that you have here near the earth

302
00:11:06,150 --> 00:11:04,880
and so you can imagine something like

303
00:11:08,150 --> 00:11:06,160
having the

304
00:11:10,310 --> 00:11:08,160
solar rays on the space station which

305
00:11:12,069 --> 00:11:10,320
are as an acre of solar arrays you would

306
00:11:14,470 --> 00:11:12,079
need 80 acres of solar rays to get the

307
00:11:16,150 --> 00:11:14,480
same amount of power out of it so once

308
00:11:17,269 --> 00:11:16,160
you get past mars which has about half

309
00:11:18,710 --> 00:11:17,279
the amount of sunlight that we get

310
00:11:20,550 --> 00:11:18,720
because of its distance

311
00:11:22,389 --> 00:11:20,560
you really need to go get the nuclear

312
00:11:23,910 --> 00:11:22,399
power simply because

313
00:11:26,470 --> 00:11:23,920

the size of the solar rays to get that

314
00:11:27,829 --> 00:11:26,480
energy gets to be um just ridiculous the

315
00:11:29,430 --> 00:11:27,839
same thing for solar wind too because

316
00:11:36,310 --> 00:11:29,440
that solar wind would drop off as well

317
00:11:41,030 --> 00:11:38,870
what new technology do you see for space

318
00:11:43,269 --> 00:11:41,040
travel to mars

319
00:11:45,750 --> 00:11:43,279
oh lots of new technologies out there a

320
00:11:47,670 --> 00:11:45,760
lot so we talked about the these

321
00:11:48,949 --> 00:11:47,680
solar electric and nuclear and power

322
00:11:50,310 --> 00:11:48,959
engines that those are new technologies

323
00:11:51,910 --> 00:11:50,320
that we really don't have right now you

324
00:11:53,670 --> 00:11:51,920
do have ion engines but they're very

325
00:11:57,190 --> 00:11:53,680
very

326
00:11:58,949 --> 00:11:57,200
satellites out and deep states with them

327
00:12:00,230 --> 00:11:58,959
in and your breath if you're just

328
00:12:01,509 --> 00:12:00,240
blowing against your hand will put out

329
00:12:03,030 --> 00:12:01,519
more thrust in those engines we're

330
00:12:04,550 --> 00:12:03,040
looking at things that put out

331
00:12:05,990 --> 00:12:04,560
real rocket type through us those are

332
00:12:07,829 --> 00:12:06,000
much bigger technologies there the other

333
00:12:09,990 --> 00:12:07,839
part is automation i'm sitting in

334
00:12:11,670 --> 00:12:10,000
mission control where we can control

335
00:12:13,910 --> 00:12:11,680
just about every aspect of the space

336
00:12:16,870 --> 00:12:13,920
station now we can turn its attitude its

337
00:12:18,629 --> 00:12:16,880
altitude uh the life support systems all

338
00:12:20,069 --> 00:12:18,639

in very much real time we have cameras

339
00:12:21,990 --> 00:12:20,079
that look over the astronaut shoulders

340
00:12:23,269 --> 00:12:22,000
as they work aboard the space station if

341
00:12:25,350 --> 00:12:23,279
you're near mars

342
00:12:27,509 --> 00:12:25,360
light takes can take up to 20 minutes to

343
00:12:29,430 --> 00:12:27,519
get back to earth from from where you

344
00:12:31,670 --> 00:12:29,440
are at mars another 20 minutes for you

345
00:12:33,509 --> 00:12:31,680
to go do a change from what you see and

346
00:12:35,430 --> 00:12:33,519
so we need to have automated systems

347
00:12:37,110 --> 00:12:35,440
almost like you take a mission control

348
00:12:39,509 --> 00:12:37,120
and all the brains and the ability that

349
00:12:41,030 --> 00:12:39,519
it has and try and make that put that in

350
00:12:42,949 --> 00:12:41,040
a box you know make an artificial

351
00:12:44,069 --> 00:12:42,959
intelligence system that'll let us

352
00:12:45,990 --> 00:12:44,079
make those type of decisions that

353
00:12:47,350 --> 00:12:46,000
mission control can make and keep

354
00:12:48,710 --> 00:12:47,360
astronauts out of trouble because it's a

355
00:12:50,550 --> 00:12:48,720
lot of information it's more than

356
00:12:52,069 --> 00:12:50,560
probably four people could handle we

357
00:12:53,670 --> 00:12:52,079
have rooms and rooms and very smart

358
00:12:55,430 --> 00:12:53,680
people here in mission control we look

359
00:12:56,949 --> 00:12:55,440
at all these different just streams of

360
00:12:58,629 --> 00:12:56,959
data coming back from the space station

361
00:13:01,110 --> 00:12:58,639
we won't have that luxury out by mars

362
00:13:03,910 --> 00:13:01,120
and so we need uh better computers

363
00:13:05,590 --> 00:13:03,920

smarter computers that can handle that

364
00:13:07,509 --> 00:13:05,600
yeah there's this i go through just

365
00:13:09,590 --> 00:13:07,519
pages and pages of new technologies that

366
00:13:10,949 --> 00:13:09,600
i'm pouring over every day to see how

367
00:13:12,629 --> 00:13:10,959
they can help me

368
00:13:15,590 --> 00:13:12,639
get things like deep space habitats out

369
00:13:19,670 --> 00:13:15,600
by mars late in the next decade

370
00:13:24,150 --> 00:13:22,150
um what is the best way to transport the

371
00:13:25,750 --> 00:13:24,160
most oxygen

372
00:13:27,750 --> 00:13:25,760
what is the best way to transport the

373
00:13:29,269 --> 00:13:27,760
most oxygen uh

374
00:13:30,790 --> 00:13:29,279
it depends on what you're trying to do

375
00:13:33,430 --> 00:13:30,800
if you just want to get it into as small

376
00:13:35,110 --> 00:13:33,440
a volume as possible then liquid oxygen

377
00:13:36,870 --> 00:13:35,120
is a very way to go a very good way to

378
00:13:39,670 --> 00:13:36,880
do that and we do done that on airplanes

379
00:13:41,189 --> 00:13:39,680
and spacecraft for a very long time

380
00:13:42,949 --> 00:13:41,199
however you need to keep it very cold

381
00:13:44,550 --> 00:13:42,959
and that takes a lot of power it can

382
00:13:45,829 --> 00:13:44,560
also be very dangerous liquid oxygen

383
00:13:48,629 --> 00:13:45,839
when it mixes with things can be

384
00:13:49,670 --> 00:13:48,639
explosive from time to time and so you

385
00:13:51,189 --> 00:13:49,680
want to

386
00:13:53,590 --> 00:13:51,199
find ways to keep oxygen from being

387
00:13:55,350 --> 00:13:53,600
dangerous well then you can tie it up in

388
00:13:56,550 --> 00:13:55,360

different types of

389
00:13:57,750 --> 00:13:56,560
compounds

390
00:13:58,870 --> 00:13:57,760
i'm not sure what difference like

391
00:14:00,389 --> 00:13:58,880
there's metals like lithium and other

392
00:14:03,269 --> 00:14:00,399
ones that you can bind up the oxygen

393
00:14:05,269 --> 00:14:03,279
it's not quite as densely liquid oxygen

394
00:14:06,870 --> 00:14:05,279
but it's very close and then you can

395
00:14:08,710 --> 00:14:06,880
heat those things up or have a catalytic

396
00:14:10,710 --> 00:14:08,720
reaction and release those in fact a lot

397
00:14:12,710 --> 00:14:10,720
of the new aircraft you'll see out there

398
00:14:14,790 --> 00:14:12,720
flying around now have what are called

399
00:14:16,790 --> 00:14:14,800
onboard oxygen generating systems or

400
00:14:18,230 --> 00:14:16,800
obogz and that's exactly what it does it

401
00:14:20,069 --> 00:14:18,240
takes oxygen that's bound up in a

402
00:14:21,910 --> 00:14:20,079
compound with a metal and you can heat

403
00:14:24,069 --> 00:14:21,920
up and release that oxygen and then it

404
00:14:25,829 --> 00:14:24,079
comes back out that way and so it just

405
00:14:26,629 --> 00:14:25,839
depends on what application you're

406
00:14:27,829 --> 00:14:26,639
trying

407
00:14:33,430 --> 00:14:27,839
you're using it for and what you're

408
00:14:39,750 --> 00:14:35,750
what are some of the biggest problems

409
00:14:42,150 --> 00:14:39,760
about colonizing mars

410
00:14:44,629 --> 00:14:42,160
see the big problems for colonizing mars

411
00:14:47,189 --> 00:14:44,639
is that you need a way to support that

412
00:14:49,030 --> 00:14:47,199
colony on mars so you need if you're

413
00:14:50,230 --> 00:14:49,040

going to have to export or if you're

414
00:14:52,069 --> 00:14:50,240
there import

415
00:14:54,150 --> 00:14:52,079
all of your food all of your water all

416
00:14:55,590 --> 00:14:54,160
of your air everything you need to live

417
00:14:58,069 --> 00:14:55,600
then you're going to need a wagon train

418
00:14:59,910 --> 00:14:58,079
of ships going out to mars

419
00:15:01,030 --> 00:14:59,920
you know burning rocket fuel you know by

420
00:15:02,230 --> 00:15:01,040
the truckload to get out there to

421
00:15:03,990 --> 00:15:02,240
support everything and if one of those

422
00:15:05,590 --> 00:15:04,000
doesn't make it for some reason

423
00:15:08,069 --> 00:15:05,600
you could be in for a very lean time

424
00:15:09,030 --> 00:15:08,079
between those resupply missions so big

425
00:15:09,910 --> 00:15:09,040
thing is you want to be able to grow

426
00:15:11,030 --> 00:15:09,920
your own

427
00:15:12,629 --> 00:15:11,040
food or

428
00:15:13,350 --> 00:15:12,639
or create your own food while you're

429
00:15:15,829 --> 00:15:13,360
there

430
00:15:17,110 --> 00:15:15,839
mars we suspect will have seen pres

431
00:15:18,790 --> 00:15:17,120
evidence that there's water beneath the

432
00:15:20,069 --> 00:15:18,800
soil so if you can create use your own

433
00:15:21,509 --> 00:15:20,079
water there you don't have to bring that

434
00:15:22,790 --> 00:15:21,519
up from earth as well and that's

435
00:15:23,750 --> 00:15:22,800
probably the key ingredient to life is

436
00:15:27,590 --> 00:15:23,760
water

437
00:15:30,470 --> 00:15:27,600
air that you can breathe so we need ways

438
00:15:32,790 --> 00:15:30,480

of harvesting that water and

439
00:15:35,430 --> 00:15:32,800
then using it to keep ourselves alive on

440
00:15:36,790 --> 00:15:35,440
mars also mars has a lot of the same raw

441
00:15:38,790 --> 00:15:36,800
materials that earth has so if you're

442
00:15:41,350 --> 00:15:38,800
going to rather than bring up some type

443
00:15:42,629 --> 00:15:41,360
of iron you know bracket or something

444
00:15:44,150 --> 00:15:42,639
like that you might be able to

445
00:15:46,230 --> 00:15:44,160
manufacture it there at mars it'd be a

446
00:15:48,069 --> 00:15:46,240
whole lot cheaper and easier and with

447
00:15:49,590 --> 00:15:48,079
things like 3d printing technology now

448
00:15:52,470 --> 00:15:49,600
we may be able to do

449
00:15:53,990 --> 00:15:52,480
create complex pieces of equipment

450
00:15:56,069 --> 00:15:54,000
without having to go through a big

451
00:15:57,509 --> 00:15:56,079
factory you can sit there and make a 3d

452
00:15:59,829 --> 00:15:57,519
cad file of it and then print it up and

453
00:16:01,749 --> 00:15:59,839
use it there so it's that ability to be

454
00:16:03,430 --> 00:16:01,759
self-reliant so you're not so dependent

455
00:16:05,189 --> 00:16:03,440
upon this wagon train of logistics from

456
00:16:11,269 --> 00:16:05,199
planet earth to keep you alive will be

457
00:16:15,749 --> 00:16:13,350
uh what type of spacecraft will be

458
00:16:17,509 --> 00:16:15,759
needed to land on mars and would rockets

459
00:16:19,509 --> 00:16:17,519
still work

460
00:16:21,189 --> 00:16:19,519
to go land on mars i think you'd almost

461
00:16:23,430 --> 00:16:21,199
have to use a rocket unless we develop

462
00:16:24,230 --> 00:16:23,440
something very new and exotic

463
00:16:25,590 --> 00:16:24,240

these

464
00:16:27,269 --> 00:16:25,600
nuclear propulsion systems and other

465
00:16:29,030 --> 00:16:27,279
ones they don't put out a whole lot of

466
00:16:31,430 --> 00:16:29,040
thrust for their weight they're very

467
00:16:32,790 --> 00:16:31,440
very efficient and so if you want

468
00:16:35,430 --> 00:16:32,800
something that puts out a lot of power

469
00:16:37,110 --> 00:16:35,440
that that dragster of a motor then you

470
00:16:38,949 --> 00:16:37,120
need a just a chemical rocket to get you

471
00:16:41,430 --> 00:16:38,959
in and out of mars atmosphere so i

472
00:16:43,829 --> 00:16:41,440
expect we'll use a combination of

473
00:16:45,829 --> 00:16:43,839
aerodynamic braking uh parachutes and

474
00:16:47,189 --> 00:16:45,839
then finally just a landing rocket to

475
00:16:48,790 --> 00:16:47,199
get us those last few feet down the

476
00:16:50,389 --> 00:16:48,800
surface of mars and you're going to need

477
00:16:52,470 --> 00:16:50,399
a rocket to get yourself off the surface

478
00:16:54,230 --> 00:16:52,480
of mars that's one thing we've yet to do

479
00:16:55,590 --> 00:16:54,240
is have something land on mars and take

480
00:16:57,590 --> 00:16:55,600
back off again

481
00:16:59,189 --> 00:16:57,600
and so that's where you're going to need

482
00:17:01,430 --> 00:16:59,199
a chemical rocket you can't just get

483
00:17:02,870 --> 00:17:01,440
there by bouncing bags or parachutes if

484
00:17:04,230 --> 00:17:02,880
you want to get off the surface mars and

485
00:17:04,949 --> 00:17:04,240
come back to earth which i would like to

486
00:17:06,309 --> 00:17:04,959
do

487
00:17:07,750 --> 00:17:06,319
then you'll need a rocket and a chemical

488
00:17:10,789 --> 00:17:07,760

rocket is about the best solution for

489
00:17:14,309 --> 00:17:12,630
so great questions and we still have

490
00:17:16,630 --> 00:17:14,319
time for a few more you got any more

491
00:17:18,470 --> 00:17:16,640
questions

492
00:17:19,429 --> 00:17:18,480
what would be the best

493
00:17:21,990 --> 00:17:19,439
plan

494
00:17:25,189 --> 00:17:22,000
to go grow on mars

495
00:17:28,390 --> 00:17:25,199
the best plants to grow on mars

496
00:17:32,390 --> 00:17:30,150
yes sir okay

497
00:17:34,070 --> 00:17:32,400
boy i really couldn't tell but i imagine

498
00:17:35,270 --> 00:17:34,080
that um

499
00:17:36,710 --> 00:17:35,280
maybe we should ask you what's your

500
00:17:38,630 --> 00:17:36,720
favorite vegetable what my favorite

501
00:17:39,430 --> 00:17:38,640
vegetable is

502
00:17:41,350 --> 00:17:39,440
oh

503
00:17:42,789 --> 00:17:41,360
i'd say like anything that makes a good

504
00:17:44,950 --> 00:17:42,799
salad give me give me lettuce and

505
00:17:46,710 --> 00:17:44,960
tomatoes and and fruits like like

506
00:17:48,150 --> 00:17:46,720
oranges and apples

507
00:17:50,230 --> 00:17:48,160
but there's probably more efficient

508
00:17:51,830 --> 00:17:50,240
things out there that like soy that you

509
00:17:52,870 --> 00:17:51,840
can turn into lots of other foods if

510
00:17:54,390 --> 00:17:52,880
you're going to grow something like that

511
00:17:56,070 --> 00:17:54,400
or things that don't take up a whole lot

512
00:18:00,310 --> 00:17:56,080
of

513
00:18:02,230 --> 00:18:00,320

you what you need but i'm not the person

514
00:18:03,909 --> 00:18:02,240
to ask about that i'm i'm a physical

515
00:18:05,510 --> 00:18:03,919
scientist not a biological scientist and

516
00:18:07,110 --> 00:18:05,520
i'm profoundly ignorant about those

517
00:18:09,190 --> 00:18:07,120
things we do grow things in our in our

518
00:18:10,870 --> 00:18:09,200
habitat demonstration units uh fresh

519
00:18:12,870 --> 00:18:10,880
vegetables like cucumbers and cherry

520
00:18:15,190 --> 00:18:12,880
tomatoes and and it's always good when

521
00:18:17,190 --> 00:18:15,200
you get to harvest your own

522
00:18:18,950 --> 00:18:17,200
garden to put on your on your meals

523
00:18:20,630 --> 00:18:18,960
though so it's more than just nutrition

524
00:18:26,870 --> 00:18:20,640
as a certain part of it that's just it

525
00:18:33,350 --> 00:18:29,990
in space what is the average miles per

526
00:18:34,150 --> 00:18:33,360
hour at top speed

527
00:18:36,549 --> 00:18:34,160
okay

528
00:18:37,909 --> 00:18:36,559
uh to just to get to orbit and stay in

529
00:18:41,350 --> 00:18:37,919
earth orbit so you don't fall back to

530
00:18:43,190 --> 00:18:41,360
earth you must go at least 17 500 miles

531
00:18:45,029 --> 00:18:43,200
an hour

532
00:18:47,110 --> 00:18:45,039
now ironically enough that's that

533
00:18:48,549 --> 00:18:47,120
out to the space station uh if you were

534
00:18:49,990 --> 00:18:48,559
to go out and measure the speed of the

535
00:18:51,190 --> 00:18:50,000
moon it would be actually much slower

536
00:18:52,230 --> 00:18:51,200
than that it doesn't fall the earth so

537
00:18:53,990 --> 00:18:52,240
the further you get away from the earth

538
00:18:55,909 --> 00:18:54,000

the slower you can go but you still need

539
00:18:57,830 --> 00:18:55,919
that much speed to get out there the

540
00:19:00,070 --> 00:18:57,840
apollo rockets that went to the moon

541
00:19:02,549 --> 00:19:00,080
left the earth's atmosphere going about

542
00:19:04,549 --> 00:19:02,559
oh let's see mach 32 which i think is

543
00:19:06,710 --> 00:19:04,559
somewhere in an uh

544
00:19:08,070 --> 00:19:06,720
around 25 000 miles an hour much faster

545
00:19:10,710 --> 00:19:08,080
than orbital velocity but they were

546
00:19:12,230 --> 00:19:10,720
going much slower when they got to this

547
00:19:13,430 --> 00:19:12,240
out to the moon imagine if you were in a

548
00:19:15,190 --> 00:19:13,440
roller coaster at the very bottom of

549
00:19:17,110 --> 00:19:15,200
that roller coaster to get to the top of

550
00:19:18,870 --> 00:19:17,120
that you need a whole lot of speed but

551
00:19:20,470 --> 00:19:18,880
once you're at the very top of that hump

552
00:19:21,750 --> 00:19:20,480
there on a roller coaster you're almost

553
00:19:23,110 --> 00:19:21,760
out of speed that's like going to the

554
00:19:25,029 --> 00:19:23,120
moon you leave the earth with a lot of

555
00:19:26,230 --> 00:19:25,039
speed but you lose a lot of that energy

556
00:19:27,750 --> 00:19:26,240
on the way up to the moon so you're not

557
00:19:28,630 --> 00:19:27,760
going very fast by the time you get

558
00:19:30,710 --> 00:19:28,640
there

559
00:19:32,789 --> 00:19:30,720
so so we always talk about the it's

560
00:19:34,950 --> 00:19:32,799
called the delta v or the velocity you

561
00:19:38,470 --> 00:19:34,960
need to escape to go other places and

562
00:19:40,789 --> 00:19:38,480
that's i'd say it's that's it's it's oh

563
00:19:42,310 --> 00:19:40,799

i wanna say 32

564
00:19:43,350 --> 00:19:42,320
000 feet per second and i haven't

565
00:19:44,710 --> 00:19:43,360
haven't quite figured how to convert

566
00:19:46,150 --> 00:19:44,720
that to miles an hour for you on the fly

567
00:19:47,830 --> 00:19:46,160
here yet but that's about what you need

568
00:19:49,669 --> 00:19:47,840
to escape from the earth

569
00:19:51,990 --> 00:19:49,679
great and thank you i think that's all

570
00:19:53,350 --> 00:19:52,000
the time that we have now um al thanks

571
00:19:55,110 --> 00:19:53,360
again for coming out and talking with