1
00:00:05,510 --> 00:00:03,350
our first panel this morning is going to

2
00:00:08,960 --> 00:00:05,520
be on the importance of technology and

3
00:00:11,180 --> 00:00:08,970
innovation for our economic future the

4
00:00:12,709 --> 00:00:11,190
panel moderator is a fellow named Joe

5
00:00:16,039 --> 00:00:12,719
parish I've had the privilege of working

6
00:00:19,310 --> 00:00:16,049
with Joe for a while now Joe is the NASA

7
00:00:20,599 --> 00:00:19,320
deputy chief technologist he comes to

8
00:00:22,700 --> 00:00:20,609
NASA headquarters from the Jet

9
00:00:26,570 --> 00:00:22,710
Propulsion lab in Pasadena California

10
00:00:30,080 --> 00:00:26,580
and he also before coming to NASA worked

11
00:00:31,849 --> 00:00:30,090
in the private sector and has a at least

12
00:00:34,790 --> 00:00:31,859
one payload aboard the International

13
00:00:36,080 --> 00:00:34,800

Space Station I also know it's a

14
00:00:38,750 --> 00:00:36,090
privilege for Joe to be here today

15
00:00:42,500 --> 00:00:38,760
because I like airplanes Joe loves

16
00:00:45,110 --> 00:00:42,510
airplanes Joe is an accomplished private

17
00:00:46,729 --> 00:00:45,120
pilot he flies an airplane that's very

18
00:00:50,270 --> 00:00:46,739
odd looking at has a propeller in the

19
00:00:52,639 --> 00:00:50,280
back of it and i've been to airports

20
00:00:54,500 --> 00:00:52,649
with Joe he's a kid in the candy shop

21
00:00:57,139 --> 00:00:54,510
and I know that the Museum of Flight is

22
00:00:59,330 --> 00:00:57,149
an awesome place to visit again the

23
00:01:00,709 --> 00:00:59,340
exhibits here are amazing they've got

24
00:01:03,920 --> 00:01:00,719
the history of light from the beginning

25
00:01:06,080 --> 00:01:03,930
to the present to the future and it's

26
00:01:08,179 --> 00:01:06,090
just a great place to be having our

27
00:01:11,359 --> 00:01:08,189
future form and with that I'll turn it

28
00:01:15,090 --> 00:01:11,369
over to Joe parish great thanks very

29
00:01:21,010 --> 00:01:18,280
well it is a it is wonderful to be here

30
00:01:23,440 --> 00:01:21,020
this morning with with you all just as

31
00:01:26,170 --> 00:01:23,450
Laurie gave her her shout out to Bill

32
00:01:28,360 --> 00:01:26,180
Nye I'd like to give a shout-out to my

33
00:01:31,360 --> 00:01:28,370
twin brother Jerry who was sitting in

34
00:01:32,710 --> 00:01:31,370
the front row there Jerry actually is a

35
00:01:35,650 --> 00:01:32,720
person who built that funny-looking

36
00:01:37,780 --> 00:01:35,660
plane that David mentioned and he built

37
00:01:39,640 --> 00:01:37,790
that plane here here in Seattle right

38
00:01:41,590 --> 00:01:39,650

across the runway from where we are now

39
00:01:44,530 --> 00:01:41,600
and a little hanger over on the other

40
00:01:46,540 --> 00:01:44,540
side of a Boeing Field so thrill thrill

41
00:01:48,430 --> 00:01:46,550
for me to have my brother here he built

42
00:01:50,650 --> 00:01:48,440
a very innovative airplane and then we'd

43
00:01:53,650 --> 00:01:50,660
share that plane now and it helps to

44
00:01:56,350 --> 00:01:53,660
fuel my enthusiasm for flight and and

45
00:01:58,570 --> 00:01:56,360
moving on into all of aerospace and the

46
00:02:01,180 --> 00:01:58,580
space program so thanks for thanks for

47
00:02:02,950 --> 00:02:01,190
Jerry for being here also wanted to

48
00:02:05,020 --> 00:02:02,960
thank Doug King and the rest of the

49
00:02:08,440 --> 00:02:05,030
staff at the Museum of Flight for their

50
00:02:10,870 --> 00:02:08,450
incredibly warm welcome to us and to

51
00:02:12,699 --> 00:02:10,880
allow us to talk today about innovation

52
00:02:16,810 --> 00:02:12,709
and technology and we have a terrific

53
00:02:19,090 --> 00:02:16,820
panel here my colleagues bob pierce from

54
00:02:21,040 --> 00:02:19,100
NASA Christy morganson from the

55
00:02:23,710 --> 00:02:21,050
University of Washington Roger Myers

56
00:02:25,840 --> 00:02:23,720
from Aerojet and Ed lozada from

57
00:02:29,500 --> 00:02:25,850
University of Washington have a

58
00:02:31,120 --> 00:02:29,510
fantastic plethora of experiences and

59
00:02:33,479 --> 00:02:31,130
ideas about innovation that they're

60
00:02:35,680 --> 00:02:33,489
going to be sharing with us this morning

61
00:02:37,390 --> 00:02:35,690
the way we thought we would construct

62
00:02:39,160 --> 00:02:37,400
this Nick's a little bit more than an

63
00:02:41,800 --> 00:02:39,170

hour that will be spending talking about

64
00:02:43,330 --> 00:02:41,810
innovation is a each of us we're going

65
00:02:46,060 --> 00:02:43,340
to talk a little bit about innovation

66
00:02:48,220 --> 00:02:46,070
from our own perspectives and then we

67
00:02:50,860 --> 00:02:48,230
were we had a sort of overarching

68
00:02:52,540 --> 00:02:50,870
question that we posed to each other to

69
00:02:54,520 --> 00:02:52,550
talk about and those are what what are

70
00:02:58,140 --> 00:02:54,530
the major technology challenges that

71
00:03:00,880 --> 00:02:58,150
we're facing now how do we see our our

72
00:03:02,259 --> 00:03:00,890
technological future evolving and where

73
00:03:04,990 --> 00:03:02,269
do we think we're going to be in 20

74
00:03:06,610 --> 00:03:05,000
years in in addressing those technology

75
00:03:08,560 --> 00:03:06,620
challenges and what role might

76
00:03:09,699 --> 00:03:08,570
innovation play in that so you'll hear

77
00:03:12,100 --> 00:03:09,709
us talk a little bit about our own

78
00:03:13,479 --> 00:03:12,110
perspectives on on innovation and then

79
00:03:15,460 --> 00:03:13,489
we'll talk and address that particular

80
00:03:17,590 --> 00:03:15,470
question the other thing that I was

81
00:03:19,900 --> 00:03:17,600
going to do is rather than hit you with

82
00:03:21,550 --> 00:03:19,910
a barrage of introductions of my very

83
00:03:23,590 --> 00:03:21,560
accomplished colleagues I was going to

84
00:03:24,080 --> 00:03:23,600
do them sort of one at a time so I was

85
00:03:26,330 --> 00:03:24,090
going to make

86
00:03:28,160 --> 00:03:26,340
a couple of short remarks first and then

87
00:03:31,369 --> 00:03:28,170
introduce Bob and then we'll move move

88
00:03:33,290 --> 00:03:31,379

ourselves across the row so thanks very

89
00:03:34,910 --> 00:03:33,300
much again and really looking forward to

90
00:03:37,309 --> 00:03:34,920
to this discussion and looking forward

91
00:03:39,500 --> 00:03:37,319
to having a dialogue with you so I hope

92
00:03:41,330 --> 00:03:39,510
that as we talk you'll be thinking about

93
00:03:44,660 --> 00:03:41,340
questions that you'd like to ask us and

94
00:03:47,539 --> 00:03:44,670
we'll take them and and really start to

95
00:03:51,110 --> 00:03:47,549
engage and think about innovation and

96
00:03:52,160 --> 00:03:51,120
technology so a couple of thoughts and

97
00:03:53,839 --> 00:03:52,170
I've been thinking a little bit about

98
00:03:56,539 --> 00:03:53,849
you know what is the meaning and what is

99
00:03:58,789 --> 00:03:56,549
the significance of technology and

100
00:04:01,100 --> 00:03:58,799
innovation and I have a I have a

101
00:04:04,940 --> 00:04:01,110
somewhat unconventional definition of

102
00:04:07,880 --> 00:04:04,950
what innovation actually is I think that

103
00:04:10,640 --> 00:04:07,890
innovation is the constructive rejection

104
00:04:12,470 --> 00:04:10,650
of the status quo and what I mean when I

105
00:04:14,690 --> 00:04:12,480
say comes the constructive rejection of

106
00:04:16,400 --> 00:04:14,700
the status quo is if your saddest and

107
00:04:18,110 --> 00:04:16,410
Laurie Laurie started to talk about this

108
00:04:20,000 --> 00:04:18,120
a little bit in her remarks if you're

109
00:04:22,850 --> 00:04:20,010
satisfied with the status quo you're not

110
00:04:26,150 --> 00:04:22,860
an innovator right you're okay with your

111
00:04:29,840 --> 00:04:26,160
television set being almost two feet

112
00:04:32,150 --> 00:04:29,850
deep and weighing 200 pounds and carving

113
00:04:34,790 --> 00:04:32,160

big holes in your in your shag carpeting

114
00:04:37,430 --> 00:04:34,800
in your living room if you're satisfied

115
00:04:40,310 --> 00:04:37,440
with when a question comes up in your

116
00:04:42,680 --> 00:04:40,320
conversation to walk over to the

117
00:04:45,469 --> 00:04:42,690
Encyclopedia Britannica and try to find

118
00:04:48,650 --> 00:04:45,479
which of those thirty volumes has the

119
00:04:50,990 --> 00:04:48,660
answer for you and bring bring that back

120
00:04:53,150 --> 00:04:51,000
to the discussion then you're not an

121
00:04:56,450 --> 00:04:53,160
innovator you're okay with the status

122
00:04:58,159 --> 00:04:56,460
quo and thankfully we as a nation we're

123
00:05:00,770 --> 00:04:58,169
not satisfied with the status quo we

124
00:05:04,550 --> 00:05:00,780
never are and we always want more we

125
00:05:06,800 --> 00:05:04,560
want to have the ability to pull from

126
00:05:09,260 --> 00:05:06,810
our pockets this little gadget that not

127
00:05:12,260 --> 00:05:09,270
only allows us to talk to anyone on the

128
00:05:14,120 --> 00:05:12,270
planet practically to answer practically

129
00:05:15,860 --> 00:05:14,130
any question that one might pose now we

130
00:05:18,080 --> 00:05:15,870
don't even have to type in that question

131
00:05:20,839 --> 00:05:18,090
we can we can talk to that little gadget

132
00:05:24,650 --> 00:05:20,849
imagine imagine what that means imagine

133
00:05:28,129 --> 00:05:24,660
how incomprehensible that is to somebody

134
00:05:31,279 --> 00:05:28,139
a hundred years ago 50 years ago even 25

135
00:05:34,250 --> 00:05:31,289
years ago to be able to do that it's

136
00:05:35,890 --> 00:05:34,260
wonderful to be here in Seattle one of

137
00:05:38,409 --> 00:05:35,900
really the hotbeds of

138
00:05:41,290 --> 00:05:38,419

vation in our nation and that is not a

139
00:05:44,170 --> 00:05:41,300
new thing starting you know with with

140
00:05:46,120 --> 00:05:44,180
the innovations that boeing has made to

141
00:05:50,170 --> 00:05:46,130
make the United States the world leader

142
00:05:52,180 --> 00:05:50,180
in aviation with Microsoft and even with

143
00:05:54,670 --> 00:05:52,190
Starbucks I I personally think that the

144
00:05:57,760 --> 00:05:54,680
drive-thru starbucks is the pinnacle of

145
00:06:00,279 --> 00:05:57,770
human achievement and I'm not sure that

146
00:06:03,850 --> 00:06:00,289
we can really go much much further than

147
00:06:05,650 --> 00:06:03,860
that so thank thanks to Seattle for

148
00:06:07,650 --> 00:06:05,660
fostering innovation for the rest of us

149
00:06:09,580 --> 00:06:07,660
in the in the country and in the world I

150
00:06:11,800 --> 00:06:09,590
wanted to talk a little bit about the

151
00:06:14,290 --> 00:06:11,810
fact that investments you all are

152
00:06:17,020 --> 00:06:14,300
taxpayers and you are investing in our

153
00:06:18,520 --> 00:06:17,030
future with your tax dollars and it's

154
00:06:19,840 --> 00:06:18,530
easy for some to ask the question

155
00:06:21,159 --> 00:06:19,850
unfortunately they're none of none of

156
00:06:22,120 --> 00:06:21,169
the people who asked this question are

157
00:06:24,010 --> 00:06:22,130
sitting in this audience because you

158
00:06:25,930 --> 00:06:24,020
guys already get the answer but some

159
00:06:27,040 --> 00:06:25,940
people ask why why are we taking these

160
00:06:29,920 --> 00:06:27,050
dollars why are you taking these

161
00:06:32,980 --> 00:06:29,930
precious tax dollars and firing them off

162
00:06:34,810 --> 00:06:32,990
into space and to that I respond you

163
00:06:36,580 --> 00:06:34,820

know what we're not actually packaging

164
00:06:38,950 --> 00:06:36,590
up a bunch of dollar bills into the nose

165
00:06:41,740 --> 00:06:38,960
cone of a rocket and firing on to Mars

166
00:06:43,450 --> 00:06:41,750
to be spent by Martians on on that

167
00:06:45,010 --> 00:06:43,460
planet we're not doing that actually

168
00:06:47,290 --> 00:06:45,020
we're actually spending that money on

169
00:06:49,330 --> 00:06:47,300
planet earth and in the process of

170
00:06:52,149 --> 00:06:49,340
developing the systems that we do send

171
00:06:55,480 --> 00:06:52,159
to Mars and to Jupiter and to Saturn and

172
00:06:57,189 --> 00:06:55,490
beyond we're enabling things here on

173
00:06:59,350 --> 00:06:57,199
planet Earth we're spending that money

174
00:07:02,830 --> 00:06:59,360
on earth we're creating high technology

175
00:07:05,830 --> 00:07:02,840
jobs that in turn inspire new ideas and

176
00:07:07,000 --> 00:07:05,840
create new ecosystems of supporting come

177
00:07:10,510 --> 00:07:07,010
you think of all the companies that

178
00:07:11,589 --> 00:07:10,520
support Boeing as as Tyr providers think

179
00:07:13,750 --> 00:07:11,599
of all the companies that are going to

180
00:07:16,240 --> 00:07:13,760
support this burgeoning commercial

181
00:07:20,080 --> 00:07:16,250
launch industry that NASA is helping to

182
00:07:22,719 --> 00:07:20,090
kick off so what is it about NASA and

183
00:07:25,870 --> 00:07:22,729
what what how does innovation actually

184
00:07:27,399 --> 00:07:25,880
happen at NASA as Laura mentioned in our

185
00:07:30,010 --> 00:07:27,409
opening remarks this is kind of a

186
00:07:32,170 --> 00:07:30,020
transformational period in NASA we're

187
00:07:35,230 --> 00:07:32,180
ending the space shuttle program and

188
00:07:38,409 --> 00:07:35,240

we're embarking on an ambitious new plan

189
00:07:41,050 --> 00:07:38,419
to send humans to explore beyond Earth

190
00:07:44,350 --> 00:07:41,060
orbit to the moon to asteroids and

191
00:07:47,050 --> 00:07:44,360
ultimately on to Mars in order to do

192
00:07:50,050 --> 00:07:47,060
that we're asking our our people

193
00:07:51,850 --> 00:07:50,060
at NASA to create incredible things and

194
00:07:53,500 --> 00:07:51,860
in order to create these incredible

195
00:07:55,990 --> 00:07:53,510
innovations we believe that we need to

196
00:08:00,400 --> 00:07:56,000
create an environment of innovation

197
00:08:03,820 --> 00:08:00,410
within NASA to inspire those innovative

198
00:08:06,879 --> 00:08:03,830
products so we do that in a variety of

199
00:08:08,920 --> 00:08:06,889
ways number one we are really keeping

200
00:08:10,600 --> 00:08:08,930
our eyes open for broader societal

201
00:08:12,460 --> 00:08:10,610
benefits to the things that we develop

202
00:08:14,050 --> 00:08:12,470
now you all have heard of things that we

203
00:08:16,690 --> 00:08:14,060
call spin-offs where we develop a

204
00:08:18,820 --> 00:08:16,700
technology at NASA will recognize that

205
00:08:22,090 --> 00:08:18,830
that technology has applications beyond

206
00:08:24,370 --> 00:08:22,100
just the NASA ecosystem and we look for

207
00:08:27,070 --> 00:08:24,380
ways to to apply those technologies in

208
00:08:29,980 --> 00:08:27,080
the commercial sector or two to help

209
00:08:32,110 --> 00:08:29,990
people all over the planet and we're

210
00:08:34,149 --> 00:08:32,120
actually increasing our emphasis on our

211
00:08:38,050 --> 00:08:34,159
view toward broader societal benefits

212
00:08:41,050 --> 00:08:38,060
we've also chosen to take you unique new

213
00:08:43,600 --> 00:08:41,060

approaches to engaging with the most

214
00:08:46,120 --> 00:08:43,610
innovative thinkers in in the country

215
00:08:47,650 --> 00:08:46,130
and around the world by engaging them in

216
00:08:49,150 --> 00:08:47,660
ways that are not traditional in the

217
00:08:51,910 --> 00:08:49,160
traditional ways that i'm referring to

218
00:08:53,710 --> 00:08:51,920
or like contracts at nasa with issue to

219
00:08:55,870 --> 00:08:53,720
an aerospace firm or a grant that they

220
00:08:58,060 --> 00:08:55,880
would make we're looking at new ways of

221
00:09:00,130 --> 00:08:58,070
doing business and one of the ways that

222
00:09:02,340 --> 00:09:00,140
we have chosen to do this is through

223
00:09:04,450 --> 00:09:02,350
prizes and challenges and one of the

224
00:09:07,090 --> 00:09:04,460
wonderful things that we've just done

225
00:09:08,470 --> 00:09:07,100
this last year is we NASA created a

226
00:09:11,829 --> 00:09:08,480
challenge called a green flight

227
00:09:15,520 --> 00:09:11,839
challenge that was a prize for the

228
00:09:17,170 --> 00:09:15,530
highest performing small aircraft and we

229
00:09:18,940 --> 00:09:17,180
were asking for this to basically be a

230
00:09:22,600 --> 00:09:18,950
Prius in the sky to get the equivalent

231
00:09:25,270 --> 00:09:22,610
fuel economy to what if a Prius car gets

232
00:09:27,550 --> 00:09:25,280
on on the ground we wanted 200 passenger

233
00:09:29,650 --> 00:09:27,560
miles per gallon from this aircraft and

234
00:09:32,410 --> 00:09:29,660
this year and in California we actually

235
00:09:35,500 --> 00:09:32,420
had two aircraft the the one that

236
00:09:37,120 --> 00:09:35,510
finished in second place got 385

237
00:09:40,840 --> 00:09:37,130
passenger miles per gallon and the

238
00:09:44,140 --> 00:09:40,850

winner got 413 passenger miles per

239
00:09:45,820 --> 00:09:44,150
gallon from an airplane that is

240
00:09:47,500 --> 00:09:45,830
astonishing and it's nothing that we

241
00:09:49,690 --> 00:09:47,510
could have ever imagined in the past and

242
00:09:51,760 --> 00:09:49,700
it was through competition we issued a

243
00:09:54,100 --> 00:09:51,770
prize to the winner and the competitors

244
00:09:56,710 --> 00:09:54,110
sunk much much more than NASA gave out

245
00:09:59,400 --> 00:09:56,720
in that prize to develop the aircraft

246
00:10:00,580 --> 00:09:59,410
that competed in the competition so we

247
00:10:02,500 --> 00:10:00,590
inspire

248
00:10:04,540 --> 00:10:02,510
new things new technologies new

249
00:10:06,160 --> 00:10:04,550
innovations and we went about it in a

250
00:10:07,630 --> 00:10:06,170
way that was vastly different than the

251
00:10:09,490 --> 00:10:07,640
way that nASA has done things in the

252
00:10:12,030 --> 00:10:09,500
past and we see more and more that

253
00:10:15,220 --> 00:10:12,040
coming in the future let me close my

254
00:10:17,920 --> 00:10:15,230
comments a little bit in discussion

255
00:10:21,330 --> 00:10:17,930
discussing today's technology challenges

256
00:10:24,490 --> 00:10:21,340
one thing that strikes me is that

257
00:10:26,650 --> 00:10:24,500
technology goes at a pace that we can't

258
00:10:28,060 --> 00:10:26,660
predict unfortunately will be wonderful

259
00:10:30,310 --> 00:10:28,070
if we could predict these things but we

260
00:10:32,560 --> 00:10:30,320
can't and I'm struck by things that have

261
00:10:34,210 --> 00:10:32,570
gone at a much faster pace than we could

262
00:10:36,880 --> 00:10:34,220
have ever imagined think think of

263
00:10:38,800 --> 00:10:36,890

cellphones and computers as things that

264
00:10:42,850 --> 00:10:38,810
we could have never imagined how quickly

265
00:10:44,680 --> 00:10:42,860
they evolved technologies associated

266
00:10:47,950 --> 00:10:44,690
with transportation and and the

267
00:10:51,160 --> 00:10:47,960
environment are evolving quickly we're

268
00:10:54,430 --> 00:10:51,170
looking to having wind power solar power

269
00:10:57,190 --> 00:10:54,440
other methods of non-polluting power and

270
00:10:59,560 --> 00:10:57,200
the technology that's necessary to make

271
00:11:02,140 --> 00:10:59,570
those cost effective with the higher

272
00:11:06,010 --> 00:11:02,150
polluting approaches those are evolving

273
00:11:08,950 --> 00:11:06,020
on on a very rapid and increasing pace

274
00:11:12,910 --> 00:11:08,960
and then you know let's let's be honest

275
00:11:15,430 --> 00:11:12,920
I think that the evolution the pace of

276
00:11:17,740 --> 00:11:15,440
technology development in some segments

277
00:11:19,480 --> 00:11:17,750
of the aerospace sector have actually

278
00:11:22,240 --> 00:11:19,490
gone slower than we imagined right who

279
00:11:25,450 --> 00:11:22,250
who would have thought in july of 1969

280
00:11:27,550 --> 00:11:25,460
that we would be 42 years later and not

281
00:11:29,740 --> 00:11:27,560
have gone any farther than the moon i

282
00:11:31,720 --> 00:11:29,750
think people who were watching the the

283
00:11:34,420 --> 00:11:31,730
moon landing and that date would be very

284
00:11:35,950 --> 00:11:34,430
disappointed that fast-forward 40 years

285
00:11:38,080 --> 00:11:35,960
and that's really as far as we've gone

286
00:11:40,840 --> 00:11:38,090
so we have more work to do and we think

287
00:11:42,880 --> 00:11:40,850
at NASA very hard about this problem and

288
00:11:44,800 --> 00:11:42,890

think about how we can accelerate the

289
00:11:47,440 --> 00:11:44,810
pace so that the pace that we make

290
00:11:49,750 --> 00:11:47,450
progress in aerospace applications for

291
00:11:51,730 --> 00:11:49,760
both aeronautics and space how do we

292
00:11:53,650 --> 00:11:51,740
bring that pace up to the pace that

293
00:11:55,840 --> 00:11:53,660
we've seen in the computer consumer

294
00:11:57,880 --> 00:11:55,850
products industry energy and

295
00:12:00,070 --> 00:11:57,890
transportation industries so there's

296
00:12:02,110 --> 00:12:00,080
there's a variety of things in play

297
00:12:05,310 --> 00:12:02,120
right now and it's a very very exciting

298
00:12:07,720 --> 00:12:05,320
time to be alive and be participating so

299
00:12:09,910 --> 00:12:07,730
those are just some thoughts that I

300
00:12:12,370 --> 00:12:09,920
wanted to kick open the discussion with

301
00:12:13,540 --> 00:12:12,380
and so with with that thought I'd like

302
00:12:17,380 --> 00:12:13,550
to introduce my colleague

303
00:12:20,620 --> 00:12:17,390
mr. robert pearce bob is he is our

304
00:12:22,269 --> 00:12:20,630
vision guy in aeronautics he is he is

305
00:12:24,460 --> 00:12:22,279
the director for for strategy

306
00:12:26,410 --> 00:12:24,470
architecture and analysis in the

307
00:12:27,910 --> 00:12:26,420
aeronautics research mission directorate

308
00:12:29,920 --> 00:12:27,920
which is one of three directorates that

309
00:12:31,569 --> 00:12:29,930
we have at NASA the other two being

310
00:12:34,180 --> 00:12:31,579
science and human exploration and

311
00:12:36,310 --> 00:12:34,190
operations Bob plans the strategy that

312
00:12:38,980 --> 00:12:36,320
look forward for what we're doing in

313
00:12:43,930 --> 00:12:38,990

aeronautics trying to make aviation more

314
00:12:47,650 --> 00:12:43,940
fuel efficient more noise sense more

315
00:12:51,340 --> 00:12:47,660
lower noise capabilities increasing our

316
00:12:53,319 --> 00:12:51,350
ability to manage traffic as we get more

317
00:12:55,600 --> 00:12:53,329
populated in the United States and air

318
00:12:57,460 --> 00:12:55,610
traffic starts to increase and how to do

319
00:13:01,329 --> 00:12:57,470
that in a safe and effective manner

320
00:13:03,310 --> 00:13:01,339
that's Bob's job and he's a fascinating

321
00:13:04,810 --> 00:13:03,320
guy I asked actually all of our

322
00:13:07,000 --> 00:13:04,820
panelists to give me a little sort of

323
00:13:08,710 --> 00:13:07,010
personal tidbit about themselves to to

324
00:13:11,490 --> 00:13:08,720
make this a little bit more or human

325
00:13:14,769 --> 00:13:11,500
because the resumes are all incredible

326
00:13:17,410 --> 00:13:14,779
bob is a runner and actually just just

327
00:13:20,260 --> 00:13:17,420
did his first half marathon this year

328
00:13:23,530 --> 00:13:20,270
and so congratulations to Bob on 13

329
00:13:25,120 --> 00:13:23,540
tough miles and he's going to talk with

330
00:13:26,710 --> 00:13:25,130
us a little bit about innovation in

331
00:13:29,050 --> 00:13:26,720
aeronautics and talk a little bit more

332
00:13:33,300 --> 00:13:29,060
about how he views the future as we move

333
00:13:38,510 --> 00:13:35,860
thank

334
00:13:40,430 --> 00:13:38,520
Thank You Jonas it's a it's a real

335
00:13:42,590 --> 00:13:40,440
pleasure and a real honor to be here at

336
00:13:44,210 --> 00:13:42,600
the Museum of Flight and I certainly

337
00:13:45,829 --> 00:13:44,220
plan on taking and taking a walking

338
00:13:47,480 --> 00:13:45,839

around really enjoying the exhibits

339
00:13:49,699 --> 00:13:47,490
after after this is completed and

340
00:13:52,670 --> 00:13:49,709
actually want to ask you guys to do

341
00:13:53,990 --> 00:13:52,680
something as well on a walk that we

342
00:13:55,639 --> 00:13:54,000
often take I want you to do something

343
00:13:59,329 --> 00:13:55,649
very specific so the next time you walk

344
00:14:00,170 --> 00:13:59,339
onto an airplane on the next trip you're

345
00:14:01,820 --> 00:14:00,180
going to take and want you to look

346
00:14:03,110 --> 00:14:01,830
around a little bit and so first when

347
00:14:04,820 --> 00:14:03,120
you go in and take a look to the left

348
00:14:07,070 --> 00:14:04,830
and you and you look into the cockpit

349
00:14:09,230 --> 00:14:07,080
and you see those glass displays those a

350
00:14:10,550 --> 00:14:09,240
lot of those originally that the

351
00:14:12,620 --> 00:14:10,560
functionality in those displays

352
00:14:13,910 --> 00:14:12,630
originally pioneered by NASA if you look

353
00:14:15,800 --> 00:14:13,920
if you were able to look behind those

354
00:14:17,440 --> 00:14:15,810
glass displays that the digital flight

355
00:14:19,880 --> 00:14:17,450
controls that many airplanes have the

356
00:14:21,500 --> 00:14:19,890
the nervous system in an airplane that

357
00:14:23,510 --> 00:14:21,510
was originally pioneered by NASA if you

358
00:14:25,940 --> 00:14:23,520
actually look at the the pilots

359
00:14:28,340 --> 00:14:25,950
interacting together that crew resource

360
00:14:30,650 --> 00:14:28,350
management as we call it again something

361
00:14:32,389 --> 00:14:30,660
that that NASA pioneer those human

362
00:14:34,250 --> 00:14:32,399
factors in order to improve safety and

363
00:14:35,630 --> 00:14:34,260

then when you turn and you go down into

364
00:14:38,019 --> 00:14:35,640
the airplane and you see all those

365
00:14:44,030 --> 00:14:38,029
really tight cramped uncomfortable seats

366
00:14:45,920 --> 00:14:44,040
yeah yeah that's not NASA but but if you

367
00:14:47,360 --> 00:14:45,930
kind of look peered over those seats out

368
00:14:48,829 --> 00:14:47,370
the window and onto the wing and if you

369
00:14:50,780 --> 00:14:48,839
looked at the cross section of that wing

370
00:14:53,269 --> 00:14:50,790
most most of modern wings are

371
00:14:55,460 --> 00:14:53,279
supercritical airfoils again pioneered

372
00:14:56,840 --> 00:14:55,470
by NASA you look at the winglets that

373
00:14:59,420 --> 00:14:56,850
many you know the little wings that

374
00:15:01,100 --> 00:14:59,430
stick up at the end of the wing that

375
00:15:04,220 --> 00:15:01,110
many airplanes have again pioneered by

376
00:15:06,860 --> 00:15:04,230
NASA if you the the overall shape of the

377
00:15:08,360 --> 00:15:06,870
airplane called the area rule if you if

378
00:15:11,449 --> 00:15:08,370
you're able to look into the engine the

379
00:15:17,290 --> 00:15:11,459
low emission combustors that efficiently

380
00:15:20,170 --> 00:15:17,300
burn the fuel but but omit as few

381
00:15:23,019 --> 00:15:20,180
the bad the bad emissions as possible if

382
00:15:24,850 --> 00:15:23,029
you look at the lightweight high

383
00:15:27,040 --> 00:15:24,860
temperature alloys are in that engine

384
00:15:28,960 --> 00:15:27,050
and allow that core the core the injured

385
00:15:32,290 --> 00:15:28,970
to be as small as possible so we get the

386
00:15:34,000 --> 00:15:32,300
largest bypass so the fan can be pushed

387
00:15:35,079 --> 00:15:34,010
as much air as possible make the make

388
00:15:38,110 --> 00:15:35,089

the engine is efficient as possible

389
00:15:40,660 --> 00:15:38,120
again NASA the shape of many of the

390
00:15:42,639 --> 00:15:40,670
components inside the engine to allow a

391
00:15:45,009 --> 00:15:42,649
really optimal balance between the

392
00:15:48,639 --> 00:15:45,019
efficiency of that engine and the noise

393
00:15:50,500 --> 00:15:48,649
characteristics again NASA you know the

394
00:15:51,970 --> 00:15:50,510
the if you look at the latest designs if

395
00:15:54,190 --> 00:15:51,980
you know when you when you when I drove

396
00:15:56,560 --> 00:15:54,200
in you see the 787 parked out there just

397
00:15:58,300 --> 00:15:56,570
a magnificent Boeing Airplane and you

398
00:15:59,920 --> 00:15:58,310
know half of that airplane fifty percent

399
00:16:02,680 --> 00:15:59,930
of that airplane is composite materials

400
00:16:04,690 --> 00:16:02,690
NASA spent 30 years working through the

401
00:16:05,889 --> 00:16:04,700
all the issues associated with composite

402
00:16:08,740 --> 00:16:05,899
materials that we could safely apply

403
00:16:10,660 --> 00:16:08,750
them in a very efficient way if you look

404
00:16:12,759 --> 00:16:10,670
at the engine at the back of that engine

405
00:16:15,400 --> 00:16:12,769
you see you know this kind of scalloped

406
00:16:17,620 --> 00:16:15,410
shape it's the the Chevron's the chevron

407
00:16:19,720 --> 00:16:17,630
nozzle it helps in the mixing of the jet

408
00:16:22,240 --> 00:16:19,730
flow to reduce the overall jet noise

409
00:16:24,850 --> 00:16:22,250
that comes off the airplane so and all

410
00:16:27,069 --> 00:16:24,860
of that all of that innovation we build

411
00:16:28,810 --> 00:16:27,079
that into tools into CFD tools and the

412
00:16:30,040 --> 00:16:28,820
structural design tools and so forth and

413
00:16:31,750 --> 00:16:30,050

all of those are available to the

414
00:16:33,600 --> 00:16:31,760
industry and those tools get used to

415
00:16:36,880 --> 00:16:33,610
build those those modern airplanes so

416
00:16:38,740 --> 00:16:36,890
when you walk in fact this is an a-bomb

417
00:16:40,600 --> 00:16:38,750
term but when Boeing talks about they

418
00:16:42,010 --> 00:16:40,610
say it's the NASA DNA that's in every

419
00:16:43,540 --> 00:16:42,020
airplane is so I worked walk through a

420
00:16:44,920 --> 00:16:43,550
commercial airplane but you could I can

421
00:16:46,120 --> 00:16:44,930
do the same thing for a military or

422
00:16:48,430 --> 00:16:46,130
plane you do the same thing for a

423
00:16:51,550 --> 00:16:48,440
general aviation airplane for

424
00:16:53,769 --> 00:16:51,560
helicopters and so forth the DNA of all

425
00:16:55,720 --> 00:16:53,779
of those everything that flies started

426
00:16:56,920 --> 00:16:55,730
at NASA and so we're very proud of that

427
00:16:59,800 --> 00:16:56,930
and we're really proud of that tradition

428
00:17:01,600 --> 00:16:59,810
we talked just a minute about you know

429
00:17:03,639 --> 00:17:01,610
why do we care why is that so important

430
00:17:05,610 --> 00:17:03,649
why is this an economic engine and if

431
00:17:08,710 --> 00:17:05,620
you look at aviation that is it is

432
00:17:10,809 --> 00:17:08,720
absolutely the safest high speed global

433
00:17:13,540 --> 00:17:10,819
mobility provided it is what we use and

434
00:17:15,370 --> 00:17:13,550
there's no substitute today domestically

435
00:17:18,520 --> 00:17:15,380
if you look at an annual basis we have

436
00:17:20,679 --> 00:17:18,530
600 million passengers that fly on 200

437
00:17:22,750 --> 00:17:20,689
million two hundred million I'm sorry 20

438
00:17:25,260 --> 00:17:22,760

million flights totally about 600

439
00:17:28,770 --> 00:17:25,270
billion revenue passenger miles

440
00:17:32,400 --> 00:17:28,780
we do all of that all that flying for

441
00:17:35,310 --> 00:17:32,410
one half of one percent of GDP it is an

442
00:17:36,420 --> 00:17:35,320
efficient efficient industry but if you

443
00:17:38,940 --> 00:17:36,430
look at that and if you look at what's

444
00:17:40,080 --> 00:17:38,950
the impact on our economy all of them

445
00:17:41,280 --> 00:17:40,090
you know getting the people where they

446
00:17:44,820 --> 00:17:41,290
need to go the goods where they need to

447
00:17:47,220 --> 00:17:44,830
go the industries that absolutely

448
00:17:49,890 --> 00:17:47,230
require that capability and now the

449
00:17:52,320 --> 00:17:49,900
impact the benefit is is over five

450
00:17:55,200 --> 00:17:52,330
percent of GDP so it's a big multiplier

451
00:17:57,300 --> 00:17:55,210
it's a big impact and and I think if you

452
00:18:01,710 --> 00:17:57,310
if you look at aviation if you look at

453
00:18:03,090 --> 00:18:01,720
those industries it especially if you

454
00:18:05,490 --> 00:18:03,100
look at the manufacturing let's just

455
00:18:08,190 --> 00:18:05,500
look at manufacturing for a second it's

456
00:18:10,200 --> 00:18:08,200
incredible that now just commercial

457
00:18:12,000 --> 00:18:10,210
transport I'm not not all of aviation

458
00:18:14,670 --> 00:18:12,010
commercial transport 20 if you look at

459
00:18:16,530 --> 00:18:14,680
take a 20 year view of the commercial

460
00:18:19,520 --> 00:18:16,540
industry four trillion dollar market

461
00:18:21,710 --> 00:18:19,530
it's a global market huge growth in

462
00:18:24,690 --> 00:18:21,720
asia-pacific region and so forth and so

463
00:18:28,650 --> 00:18:24,700

we enjoy because of Boeing and because

464
00:18:30,810 --> 00:18:28,660
of the thousands of companies that

465
00:18:33,060 --> 00:18:30,820
contribute to those airplanes we enjoy a

466
00:18:36,090 --> 00:18:33,070
40 billion dollar annual balance of

467
00:18:37,440 --> 00:18:36,100
trade in airplanes and of course boeing

468
00:18:38,910 --> 00:18:37,450
is having record sales need probably

469
00:18:41,310 --> 00:18:38,920
everybody around here I'm sure knows

470
00:18:43,920 --> 00:18:41,320
that you look at the newspapers the 777

471
00:18:45,270 --> 00:18:43,930
the 737 max and so forth you look at

472
00:18:46,890 --> 00:18:45,280
seven thirty seven silver max why is

473
00:18:49,230 --> 00:18:46,900
that so important why why is that

474
00:18:51,690 --> 00:18:49,240
because if you look even though if the

475
00:18:54,000 --> 00:18:51,700
airline's provide so much benefit not

476
00:18:56,490 --> 00:18:54,010
everything is good news right there the

477
00:18:58,320 --> 00:18:56,500
cost of fuel has risen by a factor of

478
00:19:02,550 --> 00:18:58,330
six in the last twenty years as a

479
00:19:05,190 --> 00:19:02,560
function of the cost that the airline's

480
00:19:06,570 --> 00:19:05,200
pay it's gone from about a quarter used

481
00:19:10,350 --> 00:19:06,580
to pay about a quarter of their total

482
00:19:11,640 --> 00:19:10,360
cost for a fuel another a half now that

483
00:19:13,260 --> 00:19:11,650
that's really tough to manage an

484
00:19:15,360 --> 00:19:13,270
increase like that but you can also see

485
00:19:18,420 --> 00:19:15,370
if you'll went up by a factor of six but

486
00:19:19,980 --> 00:19:18,430
that only went up by a factor of two and

487
00:19:21,780 --> 00:19:19,990
the reason is those airplanes have

488
00:19:25,890 --> 00:19:21,790

gotten a lot more efficient and so that

489
00:19:27,990 --> 00:19:25,900
the the need for new airplanes the need

490
00:19:30,540 --> 00:19:28,000
to continue to push that envelope is is

491
00:19:31,950 --> 00:19:30,550
as there is going to continue but four

492
00:19:33,900 --> 00:19:31,960
trillion dollar fortunately dollar

493
00:19:35,690 --> 00:19:33,910
market attracts attention so now you

494
00:19:38,720 --> 00:19:35,700
have Embraer from from

495
00:19:41,039 --> 00:19:38,730
barbarity from Canada that are that I've

496
00:19:42,629 --> 00:19:41,049
pioneered in the regional jet market now

497
00:19:44,639 --> 00:19:42,639
they want to get into the the larger

498
00:19:45,810 --> 00:19:44,649
larger scale jets because they see that

499
00:19:47,789 --> 00:19:45,820
market and they see that there's an

500
00:19:50,369 --> 00:19:47,799
opportunity there obviously China and

501
00:19:54,539 --> 00:19:50,379
and the commack is coming along as well

502
00:19:56,489 --> 00:19:54,549
so there's a lot of competition coming

503
00:19:57,629 --> 00:19:56,499
but this is exactly the type of industry

504
00:20:00,810 --> 00:19:57,639
that the Uni at us needs to be

505
00:20:02,779 --> 00:20:00,820
successful in the scale the market as I

506
00:20:05,310 --> 00:20:02,789
just talked about but this this drives

507
00:20:08,310 --> 00:20:05,320
manufacturing and drives employment this

508
00:20:10,139 --> 00:20:08,320
is these are not you know there's some

509
00:20:12,060 --> 00:20:10,149
industries and in nineteen other places

510
00:20:13,320 --> 00:20:12,070
where you get a lot of market but it

511
00:20:15,180 --> 00:20:13,330
doesn't employ a lot of people this

512
00:20:18,060 --> 00:20:15,190
employs a lot of people you look at the

513
00:20:19,710 --> 00:20:18,070

scope of Technology it needs every bit

514
00:20:21,299 --> 00:20:19,720
of technology from every corner that you

515
00:20:22,350 --> 00:20:21,309
that you can imagine but most

516
00:20:24,600 --> 00:20:22,360
importantly I'll get to one of Joe's

517
00:20:26,220 --> 00:20:24,610
points what are the tech challenges one

518
00:20:28,109 --> 00:20:26,230
of the really critical things one of the

519
00:20:30,450 --> 00:20:28,119
things boeing does well but we as a

520
00:20:33,119 --> 00:20:30,460
nation need to do better is integration

521
00:20:35,909 --> 00:20:33,129
it takes incredible software incredible

522
00:20:37,680 --> 00:20:35,919
hardware and the people sometimes we

523
00:20:39,060 --> 00:20:37,690
forget that the person the person

524
00:20:40,499 --> 00:20:39,070
operates the airplane the person

525
00:20:42,570 --> 00:20:40,509
operates their transportation system is

526
00:20:44,249 --> 00:20:42,580
part of that system and all three need

527
00:20:46,529 --> 00:20:44,259
to work together flawlessly to make sure

528
00:20:48,450 --> 00:20:46,539
its robust to make sure it's resilient

529
00:20:51,180 --> 00:20:48,460
to make sure it's perfectly safe this

530
00:20:53,009 --> 00:20:51,190
industry has to be safe so puts

531
00:20:55,470 --> 00:20:53,019
requirements that perhaps other

532
00:20:58,200 --> 00:20:55,480
industries don't always put on it so

533
00:21:01,200 --> 00:20:58,210
these these so-called human cyber

534
00:21:04,470 --> 00:21:01,210
physical systems the integration around

535
00:21:06,720 --> 00:21:04,480
that that is I think one of the premier

536
00:21:09,930 --> 00:21:06,730
technical challenges of the 21st century

537
00:21:12,090 --> 00:21:09,940
it is what we as a nation have to be the

538
00:21:15,359 --> 00:21:12,100

best at we've got to make these things

539
00:21:16,799 --> 00:21:15,369
work from the beginning work right make

540
00:21:18,659 --> 00:21:16,809
sure the robust make sure they're safe

541
00:21:20,669 --> 00:21:18,669
and that is going to be the high ground

542
00:21:23,789 --> 00:21:20,679
for I think for the next for the next

543
00:21:27,359 --> 00:21:23,799
several decades okay let's take a look

544
00:21:28,859 --> 00:21:27,369
at a quick look at the future so when we

545
00:21:30,269 --> 00:21:28,869
went when NASA looks at this of course

546
00:21:31,289 --> 00:21:30,279
we don't we're not looking at current

547
00:21:32,549 --> 00:21:31,299
vehicles we're trying to look at a

548
00:21:34,379 --> 00:21:32,559
generation or two we're trying to look

549
00:21:36,869 --> 00:21:34,389
at where things going so we put things

550
00:21:38,489 --> 00:21:36,879
in sort of generational terms when we

551
00:21:41,249 --> 00:21:38,499
look out a couple generations we're

552
00:21:44,549 --> 00:21:41,259
looking at at let orders of magnitude

553
00:21:47,340 --> 00:21:44,559
improvement of annoys and efficiencies

554
00:21:49,620 --> 00:21:47,350
and so forth we want to make big straw

555
00:21:50,909 --> 00:21:49,630
it's okay and the questions and so

556
00:21:52,169 --> 00:21:50,919
there's a lot of technologies that go

557
00:21:54,210 --> 00:21:52,179
into trying to make those things happen

558
00:21:56,220 --> 00:21:54,220
I have numbers out in the interest of

559
00:21:57,779 --> 00:21:56,230
time I won't go through the kind of

560
00:21:59,220 --> 00:21:57,789
numbers we're looking at but we but we

561
00:22:01,560 --> 00:21:59,230
look at noise we look at emissions we

562
00:22:03,960 --> 00:22:01,570
look at efficiencies and so forth trying

563
00:22:05,820 --> 00:22:03,970

to make those Moe's much better some of

564
00:22:07,710 --> 00:22:05,830
the things we're looking at is when does

565
00:22:09,270 --> 00:22:07,720
the current configurations the tube and

566
00:22:10,860 --> 00:22:09,280
wings that we're so used to looking at

567
00:22:12,840 --> 00:22:10,870
on the runway and you so used to getting

568
00:22:15,360 --> 00:22:12,850
on to when does that have to change

569
00:22:17,370 --> 00:22:15,370
because we can't eat any more efficiency

570
00:22:20,250 --> 00:22:17,380
out of that kind of configuration so

571
00:22:21,870 --> 00:22:20,260
we're looking today at hybrid wing

572
00:22:24,299 --> 00:22:21,880
bodies that you know come these batwing

573
00:22:25,919 --> 00:22:24,309
type type airplanes airplanes whether

574
00:22:27,630 --> 00:22:25,929
the wings sort of wrap back on it on

575
00:22:31,289 --> 00:22:27,640
themselves in order to get very high

576
00:22:33,600 --> 00:22:31,299
aspect ratios struck race wings that are

577
00:22:35,279 --> 00:22:33,610
they're very long and we and we we kind

578
00:22:37,440 --> 00:22:35,289
of use braces to make sure that those

579
00:22:40,039 --> 00:22:37,450
very long wings can can operate at the

580
00:22:42,149 --> 00:22:40,049
kinds of Mach numbers and and and

581
00:22:44,130 --> 00:22:42,159
operating conditions we're looking at so

582
00:22:46,230 --> 00:22:44,140
so that's one of the that's another

583
00:22:49,320 --> 00:22:46,240
technical challenge is how do how do you

584
00:22:52,560 --> 00:22:49,330
make that transition from today's very

585
00:22:54,029 --> 00:22:52,570
mature and and understood configuration

586
00:22:56,310 --> 00:22:54,039
to a configuration that's very different

587
00:22:57,539 --> 00:22:56,320
but that you have to go to if you're

588
00:22:58,680 --> 00:22:57,549

going to continue to make the kind of

589
00:23:00,630 --> 00:22:58,690
strides we want to make so that's

590
00:23:02,549 --> 00:23:00,640
another big technical challenge and

591
00:23:04,409 --> 00:23:02,559
propulsion is the same at some point

592
00:23:06,149 --> 00:23:04,419
we're looking at hybrid electric

593
00:23:08,250 --> 00:23:06,159
propulsion distribute electric

594
00:23:09,899 --> 00:23:08,260
propulsion and so forth so another big

595
00:23:12,240 --> 00:23:09,909
big technical challenge for the future

596
00:23:15,570 --> 00:23:12,250
let's just broaden the aperture a little

597
00:23:19,200 --> 00:23:15,580
bit and look beyond just commercial air

598
00:23:20,970 --> 00:23:19,210
transportation let's look at UAS so

599
00:23:23,460 --> 00:23:20,980
unmanned aircraft systems the military

600
00:23:27,799 --> 00:23:23,470
is pioneer these systems and they and

601
00:23:30,480 --> 00:23:27,809
they provide the kinds of the kinds of

602
00:23:33,060 --> 00:23:30,490
surveillance and other other missions

603
00:23:34,799 --> 00:23:33,070
that the military needs but today they

604
00:23:37,440 --> 00:23:34,809
can't they can't fly in the airspace

605
00:23:42,090 --> 00:23:37,450
system they can't fly where except on a

606
00:23:44,610 --> 00:23:42,100
on a special exception basis they can't

607
00:23:48,060 --> 00:23:44,620
fly when in the same airspace that

608
00:23:50,100 --> 00:23:48,070
piloted aircraft fly NASA is taking that

609
00:23:52,320 --> 00:23:50,110
challenge on looking at the the issues

610
00:23:54,600 --> 00:23:52,330
with respect to the the pilot you know

611
00:23:56,820 --> 00:23:54,610
the pilot sits on the ground for for the

612
00:23:58,290 --> 00:23:56,830
UAS at least it currently at some point

613
00:24:48,070 --> 00:23:58,300

maybe they won't be a pilot

614
00:24:58,070 --> 00:24:56,900
yeah something please please bear with

615
00:25:03,770 --> 00:24:58,080
nothing can you go wrong with these

616
00:25:06,590 --> 00:25:03,780
drone aircraft is your work right okay

617
00:25:08,300 --> 00:25:06,600
yeah sounds like we're back online we

618
00:25:11,060 --> 00:25:08,310
just we just lost control the UAS for

619
00:25:39,010 --> 00:25:11,070
just a moment we now we now have it back

620
00:25:49,910 --> 00:25:47,690
we do jerra turki way back okay so we're

621
00:25:52,010 --> 00:25:49,920
so NASA is working on the problems of

622
00:25:53,810 --> 00:25:52,020
actually integrating the UAS into the

623
00:25:55,040 --> 00:25:53,820
national airspace so the separation

624
00:25:56,300 --> 00:25:55,050
insurance requirements we have to make

625
00:25:58,070 --> 00:25:56,310
sure they don't run into the airplanes

626
00:25:59,360 --> 00:25:58,080
we have to make sure the pilots actually

627
00:26:01,670 --> 00:25:59,370
situational awareness we have to know

628
00:26:03,230 --> 00:26:01,680
how to certify these things so so NASA

629
00:26:06,530 --> 00:26:03,240
is working on that but you can imagine

630
00:26:08,570 --> 00:26:06,540
the kinds that we some ways it's hard to

631
00:26:10,370 --> 00:26:08,580
imagine really what all the applications

632
00:26:12,500 --> 00:26:10,380
are some of the initial applications for

633
00:26:15,110 --> 00:26:12,510
for search and rescue for fire fighting

634
00:26:17,120 --> 00:26:15,120
for for one part smooth and so forth but

635
00:26:19,100 --> 00:26:17,130
but but if you think long term think

636
00:26:20,420 --> 00:26:19,110
about what's coming you know talked

637
00:26:23,210 --> 00:26:20,430
about you know innovation on the economy

638
00:26:27,170 --> 00:26:23,220

you know imagine you know imagine when

639
00:26:29,600 --> 00:26:27,180
when you know already the if you look at

640
00:26:32,900 --> 00:26:29,610
the way packages are distributed you

641
00:26:35,120 --> 00:26:32,910
know that the whole cargo industry you

642
00:26:38,810 --> 00:26:35,130
know UPS and FedEx operate a very

643
00:26:41,000 --> 00:26:38,820
distributed small aircraft network those

644
00:26:42,740 --> 00:26:41,010
all require pilots those all those all

645
00:26:44,240 --> 00:26:42,750
have significant costs if you could take

646
00:26:45,440 --> 00:26:44,250
the pilot station out if you could put

647
00:26:46,370 --> 00:26:45,450
more packages into one of those small

648
00:26:48,710 --> 00:26:46,380
airplanes you can get better

649
00:26:50,990 --> 00:26:48,720
distribution and then you know look at

650
00:26:52,880 --> 00:26:51,000
innovations outside of aviation look at

651
00:26:55,970 --> 00:26:52,890
3d printing right so 3d printing you

652
00:26:58,670 --> 00:26:55,980
start to build up parts and and and

653
00:27:00,140 --> 00:26:58,680
products you need print them on this on

654
00:27:02,960 --> 00:27:00,150
these 3d printers it's you know that

655
00:27:04,790 --> 00:27:02,970
just lays the the materials out just as

656
00:27:07,250 --> 00:27:04,800
in a normal printer except now you get a

657
00:27:09,320 --> 00:27:07,260
3d object this could lead to a

658
00:27:11,930 --> 00:27:09,330
revolution in the distribution of

659
00:27:13,880 --> 00:27:11,940
manufacturing capabilities on a

660
00:27:15,500 --> 00:27:13,890
geographic basis and wouldn't it be

661
00:27:18,620 --> 00:27:15,510
great to have you a s is that could

662
00:27:22,070 --> 00:27:18,630
support that kind of a distributed

663
00:27:23,870 --> 00:27:22,080

manufacturing base look at the future of

664
00:27:25,600 --> 00:27:23,880
energy when energy becomes much more

665
00:27:28,510 --> 00:27:25,610
distributed part of the infrastructure

666
00:27:32,990 --> 00:27:28,520
millions of wind turbines and and

667
00:27:35,030 --> 00:27:33,000
millions of rooftop solar panels what if

668
00:27:36,500 --> 00:27:35,040
you had UAS is that could robotically do

669
00:27:38,090 --> 00:27:36,510
the maintenance on on these these

670
00:27:39,950 --> 00:27:38,100
millions of distributed systems that

671
00:27:41,660 --> 00:27:39,960
provide energy for us so you can think

672
00:27:43,680 --> 00:27:41,670
of all those possibilities and I'll just

673
00:27:45,990 --> 00:27:43,690
add one one last piece at

674
00:27:47,759 --> 00:27:46,000
mention but one of the one of the issues

675
00:27:49,529 --> 00:27:47,769
we've got in there there's air

676
00:27:52,649 --> 00:27:49,539
transportation system is we're losing

677
00:27:54,690 --> 00:27:52,659
the short haul part of it because of the

678
00:27:56,580 --> 00:27:54,700
you know if you look at more or less

679
00:27:58,230 --> 00:27:56,590
less than 500 miles is dropping off

680
00:27:59,879 --> 00:27:58,240
precipitously people don't use our

681
00:28:01,590 --> 00:27:59,889
transportation as much in that domain

682
00:28:02,820 --> 00:28:01,600
partly because of that the hassle

683
00:28:05,789 --> 00:28:02,830
getting through the airport and so forth

684
00:28:07,680 --> 00:28:05,799
but imagine now think of the the

685
00:28:09,299 --> 00:28:07,690
airplanes that Joe just talked about

686
00:28:10,499 --> 00:28:09,309
these that that were that were flown in

687
00:28:13,169 --> 00:28:10,509
the green aviation challenge here's a

688
00:28:14,549 --> 00:28:13,179

small airplane can do twice what a Prius

689
00:28:17,519 --> 00:28:14,559
can do four times the energy efficiency

690
00:28:19,139 --> 00:28:17,529
of a 787 as a matter of fact now if you

691
00:28:21,869 --> 00:28:19,149
could get these if you could get these

692
00:28:23,570 --> 00:28:21,879
the small aircraft to operate into into

693
00:28:26,070 --> 00:28:23,580
and out of small airports and provide

694
00:28:27,990 --> 00:28:26,080
there was that short vol capability to

695
00:28:29,490 --> 00:28:28,000
be a real step forward what's one of the

696
00:28:31,649 --> 00:28:29,500
big impediments one of the big

697
00:28:33,330 --> 00:28:31,659
impediments is ue that would have to

698
00:28:34,799 --> 00:28:33,340
today you'd have to either pyro pilot

699
00:28:36,119 --> 00:28:34,809
really expensive where you have to be a

700
00:28:38,310 --> 00:28:36,129
pilot and you know so people like Joe

701
00:28:40,110 --> 00:28:38,320
would love that but others lots of folks

702
00:28:42,480 --> 00:28:40,120
don't want to go through the expense of

703
00:28:45,720 --> 00:28:42,490
and the learning curve of being a pilot

704
00:28:48,299 --> 00:28:45,730
well once we get the learning on the UAS

705
00:28:50,060 --> 00:28:48,309
once we get more autonomy and automation

706
00:28:52,289 --> 00:28:50,070
maybe these things don't have to be

707
00:28:54,090 --> 00:28:52,299
piloted maybe we can have the automation

708
00:28:56,190 --> 00:28:54,100
pilot so I know I know what you're all

709
00:28:57,779 --> 00:28:56,200
thinking that when you land you're not

710
00:28:59,850 --> 00:28:57,789
going to get the pity joke from the

711
00:29:01,470 --> 00:28:59,860
pilot but we're going to we're going to

712
00:29:03,389 --> 00:29:01,480
get there we are going to get there it's

713
00:29:05,159 --> 00:29:03,399

going to be an acceptable part of how we

714
00:29:07,889 --> 00:29:05,169
do transportation both on the ground and

715
00:29:09,960 --> 00:29:07,899
in the air autonomy is coming so I think

716
00:29:12,269 --> 00:29:09,970
there's a bright future for aviation a

717
00:29:14,340 --> 00:29:12,279
lot of innovation left to be done and

718
00:29:16,289 --> 00:29:14,350
NASA plans to be out in the forefront of

719
00:29:21,500 --> 00:29:16,299
that so thank you very much and and i

720
00:29:26,519 --> 00:29:24,120
great thank thanks very much Bobby you

721
00:29:29,549 --> 00:29:26,529
raised so many fascinating points in

722
00:29:31,350 --> 00:29:29,559
your talk and I think that one of the

723
00:29:33,120 --> 00:29:31,360
one of the most intriguing ones has to

724
00:29:35,549 --> 00:29:33,130
do with the the way that humans and

725
00:29:38,880 --> 00:29:35,559
machines work with each other and how do

726
00:29:41,490 --> 00:29:38,890
we best effect control over these

727
00:29:44,340 --> 00:29:41,500
devices and that's why it's so wonderful

728
00:29:47,370 --> 00:29:44,350
to have dr. kristi morgenson following

729
00:29:49,560 --> 00:29:47,380
Bob's comments with her own Kristi her

730
00:29:53,789 --> 00:29:49,570
specialty is in fact guidance navigation

731
00:29:56,909 --> 00:29:53,799
and control control of vehicles human

732
00:29:59,220 --> 00:29:56,919
and autonomous systems and this is her

733
00:30:01,139 --> 00:29:59,230
expertise area and she is particularly

734
00:30:03,060 --> 00:30:01,149
well versed in the area of underwater

735
00:30:05,760 --> 00:30:03,070
vehicles and it's going to talk probably

736
00:30:07,730 --> 00:30:05,770
about underwater vehicles and make a

737
00:30:10,289 --> 00:30:07,740
transition into aeronautical and space

738
00:30:12,840 --> 00:30:10,299

systems also in the in the course of

739
00:30:15,750 --> 00:30:12,850
that discussion so if you need need help

740
00:30:18,659 --> 00:30:15,760
making your robot swim straight then

741
00:30:20,940 --> 00:30:18,669
Christie is the person for for you so

742
00:30:22,350 --> 00:30:20,950
thanks very much for Christie to be for

743
00:30:24,600 --> 00:30:22,360
being here and look forward to your

744
00:30:27,870 --> 00:30:24,610
comments alright well thank you and for

745
00:30:29,310 --> 00:30:27,880
inviting me to be here actually wasn't

746
00:30:30,870 --> 00:30:29,320
going to target my comment specifically

747
00:30:32,519 --> 00:30:30,880
underwater vehicles but I'm happy to

748
00:30:35,310 --> 00:30:32,529
answer any questions along those lines

749
00:30:36,840 --> 00:30:35,320
if people have them and just as a point

750
00:30:38,549 --> 00:30:36,850
of fact Bob and I did not compare notes

751
00:30:40,399 --> 00:30:38,559
ahead of time that a number of my points

752
00:30:43,649 --> 00:30:40,409
are actually directly in line with his

753
00:30:44,760 --> 00:30:43,659
so what I wanted to do first was just

754
00:30:48,090 --> 00:30:44,770
say a few things about autonomous

755
00:30:49,409 --> 00:30:48,100
systems I think that a lot of the future

756
00:30:50,850 --> 00:30:49,419
of technology is going to lie directly

757
00:30:53,130 --> 00:30:50,860
in line with autonomous systems and

758
00:30:55,380 --> 00:30:53,140
already does probably in ways that are

759
00:30:57,960 --> 00:30:55,390
somewhat obvious in some senses to most

760
00:30:58,980 --> 00:30:57,970
people but in other cases you actually

761
00:31:00,029 --> 00:30:58,990
work with them every day probably don't

762
00:31:04,080 --> 00:31:00,039
really think of them as autonomous

763
00:31:05,639 --> 00:31:04,090

systems so some of just the big impact

764
00:31:07,409 --> 00:31:05,649
with them they're meant to be

765
00:31:09,060 --> 00:31:07,419
transformational in human perception and

766
00:31:11,700 --> 00:31:09,070
access what can we can see and what we

767
00:31:13,919 --> 00:31:11,710
can do so some of the the big areas

768
00:31:14,970 --> 00:31:13,929
where they come into play emergency

769
00:31:16,560 --> 00:31:14,980
response and some of these have already

770
00:31:19,410 --> 00:31:16,570
been mentioned so emergency response is

771
00:31:22,040 --> 00:31:19,420
something like the nuclear reactor

772
00:31:25,880 --> 00:31:22,050
disaster over to Japan the oil rig

773
00:31:28,170 --> 00:31:25,890
failure in the Gulf medical robotics

774
00:31:29,790 --> 00:31:28,180
environmental monitoring so tracking

775
00:31:32,970 --> 00:31:29,800
fires and things like that weather

776
00:31:34,680 --> 00:31:32,980
prediction monitoring the ocean that's

777
00:31:36,540 --> 00:31:34,690
actually where a bunch of my and many

778
00:31:38,910 --> 00:31:36,550
peoples underwater vehicle applications

779
00:31:41,610 --> 00:31:38,920
come into play explorations of space

780
00:31:43,620 --> 00:31:41,620
exploration exploration around the

781
00:31:47,970 --> 00:31:43,630
planet exploration inside of the human

782
00:31:50,820 --> 00:31:47,980
beings and of course military action so

783
00:31:53,190 --> 00:31:50,830
different kinds of autonomous systems

784
00:31:55,710 --> 00:31:53,200
that come up so there's the vehicle side

785
00:31:57,930 --> 00:31:55,720
of things and on on that scale we have

786
00:31:59,220 --> 00:31:57,940
vehicles that range from tethered so

787
00:32:02,160 --> 00:31:59,230
things that went down and explored the

788
00:32:05,160 --> 00:32:02,170

Titanic and go down and explore many

789
00:32:06,360 --> 00:32:05,170
other things underwater in space that

790
00:32:08,430 --> 00:32:06,370
allows you to have access to power

791
00:32:10,110 --> 00:32:08,440
unlimited communication data transfer

792
00:32:12,660 --> 00:32:10,120
things like that and access to an

793
00:32:14,730 --> 00:32:12,670
operator directly all the way two things

794
00:32:16,500 --> 00:32:14,740
are completely untethered so that would

795
00:32:18,540 --> 00:32:16,510
be something like your Rover on Mars or

796
00:32:20,490 --> 00:32:18,550
these aerial vehicles although sometimes

797
00:32:21,630 --> 00:32:20,500
you can tether some of them if you want

798
00:32:24,840 --> 00:32:21,640
to be a hobbyist and operate them

799
00:32:27,290 --> 00:32:24,850
without a khoa we can't do that at the

800
00:32:29,190 --> 00:32:27,300
university unless they're tethered

801
00:32:30,540 --> 00:32:29,200
there's differences between whether

802
00:32:32,580 --> 00:32:30,550
they're fully autonomous so they don't

803
00:32:35,340 --> 00:32:32,590
have anybody directly operating them to

804
00:32:36,930 --> 00:32:35,350
whether there's a remote control device

805
00:32:38,880 --> 00:32:36,940
directly connected in the there's a

806
00:32:40,620 --> 00:32:38,890
pilot running the vehicle and often the

807
00:32:41,790 --> 00:32:40,630
pilot particularly in like emergency

808
00:32:43,020 --> 00:32:41,800
response situations they're actually

809
00:32:44,790 --> 00:32:43,030
backed up by two or three other people

810
00:32:46,770 --> 00:32:44,800
so one of our big challenges right now

811
00:32:49,080 --> 00:32:46,780
is it a single autonomous vehicle may

812
00:32:52,950 --> 00:32:49,090
require anywhere from two to five or

813
00:32:55,430 --> 00:32:52,960

more people to make it fully operational

814
00:32:57,510 --> 00:32:55,440
and safe according to current standards

815
00:32:59,160 --> 00:32:57,520
we're looking at situations where we

816
00:33:00,960 --> 00:32:59,170
have either single autonomous vehicles

817
00:33:04,740 --> 00:33:00,970
single autonomous systems all the way up

818
00:33:06,930 --> 00:33:04,750
to groups of them we're trying to expand

819
00:33:09,930 --> 00:33:06,940
the capabilities and again all kinds of

820
00:33:11,520 --> 00:33:09,940
different regimes with them so some of

821
00:33:13,890 --> 00:33:11,530
our key technological challenges with

822
00:33:15,150 --> 00:33:13,900
these systems the limited power so again

823
00:33:17,850 --> 00:33:15,160
if you don't have a tether to the

824
00:33:19,470 --> 00:33:17,860
vehicle you have to work with whatever's

825
00:33:22,830 --> 00:33:19,480
on board the vehicle so you have to have

826
00:33:23,880 --> 00:33:22,840
effective battery capabilities some of

827
00:33:25,500 --> 00:33:23,890
the appeal of the underwater gliders

828
00:33:27,120 --> 00:33:25,510
that I work with is they have a battery

829
00:33:29,330 --> 00:33:27,130
pack on board that allows them to

830
00:33:31,280 --> 00:33:29,340
operate for six to nine months with no

831
00:33:34,160 --> 00:33:31,290
servicing depending on the particular

832
00:33:36,860 --> 00:33:34,170
battery how do you deal with this human

833
00:33:38,060 --> 00:33:36,870
and autonomy integration so depending on

834
00:33:39,290 --> 00:33:38,070
what kind of regime you're working in

835
00:33:43,300 --> 00:33:39,300
you might be able to drive a vehicle

836
00:33:45,320 --> 00:33:43,310
directly and have a remote operated

837
00:33:47,090 --> 00:33:45,330
situation or if you have the rover out

838
00:33:49,160 --> 00:33:47,100

on Mars it takes you know minutes just

839
00:33:50,900 --> 00:33:49,170
to even send a signal out to them much

840
00:33:52,130 --> 00:33:50,910
less get data back and you you know over

841
00:33:54,740 --> 00:33:52,140
that kind of a channel you're not

842
00:33:57,080 --> 00:33:54,750
sending a lot of information very

843
00:33:59,030 --> 00:33:57,090
quickly dealing with the the actual

844
00:34:01,940 --> 00:33:59,040
interface between the human and a

845
00:34:03,590 --> 00:34:01,950
autonomous system where you know i'ma

846
00:34:04,790 --> 00:34:03,600
generically say that Thomas system might

847
00:34:05,960 --> 00:34:04,800
be something like a prosthetic device

848
00:34:09,980 --> 00:34:05,970
there's a lot of work being done right

849
00:34:11,960 --> 00:34:09,990
now trying to further human augmentation

850
00:34:14,120 --> 00:34:11,970
in the sense of you know not trying to

851
00:34:17,270 --> 00:34:14,130
necessarily make like you know the board

852
00:34:18,830 --> 00:34:17,280
from Star Trek but you know trying to

853
00:34:23,060 --> 00:34:18,840
come up with better prosthetic devices

854
00:34:25,310 --> 00:34:23,070
for say people who've lost limbs or have

855
00:34:27,830 --> 00:34:25,320
medical conditions that prevent them

856
00:34:28,940 --> 00:34:27,840
from using their limbs so there's all

857
00:34:32,030 --> 00:34:28,950
kinds of things that come up their trust

858
00:34:36,050 --> 00:34:32,040
between the devices security of wireless

859
00:34:39,640 --> 00:34:36,060
transmission of information you know how

860
00:34:42,140 --> 00:34:39,650
are the device is perceived by by people

861
00:34:44,570 --> 00:34:42,150
safety number of things along the lines

862
00:34:46,430 --> 00:34:44,580
there and dealing with the data transfer

863
00:34:47,570 --> 00:34:46,440

so some of the key enablers I actually

864
00:34:49,480 --> 00:34:47,580
wanted to mention some of these because

865
00:34:51,950 --> 00:34:49,490
I think these are key things um I think

866
00:34:54,920 --> 00:34:51,960
getting the general population involved

867
00:34:57,890 --> 00:34:54,930
is like historically a huge impact on

868
00:35:01,160 --> 00:34:57,900
making progress one point I really

869
00:35:04,880 --> 00:35:01,170
wanted to make is what we often see or

870
00:35:07,280 --> 00:35:04,890
market as games and toys are in fact the

871
00:35:09,560 --> 00:35:07,290
steps to technological advances and this

872
00:35:11,090 --> 00:35:09,570
goes all the way down to you know babies

873
00:35:12,170 --> 00:35:11,100
I have a one-year-old and you can watch

874
00:35:13,430 --> 00:35:12,180
him playing with blocks and he's

875
00:35:15,440 --> 00:35:13,440
figuring out how to manipulate the world

876
00:35:18,050 --> 00:35:15,450
around him so what for him as a game is

877
00:35:20,150 --> 00:35:18,060
actually how he's gonna I have no idea

878
00:35:22,790 --> 00:35:20,160
what he's going to build it well scared

879
00:35:24,560 --> 00:35:22,800
about that actually but things like 3d

880
00:35:26,450 --> 00:35:24,570
printing which may not be a phrase

881
00:35:27,890 --> 00:35:26,460
that's familiar to everyone but the

882
00:35:30,950 --> 00:35:27,900
maker technology so there are these

883
00:35:34,430 --> 00:35:30,960
devices where you can print as Bob

884
00:35:36,170 --> 00:35:34,440
mentioned a mechanism you can also print

885
00:35:37,440 --> 00:35:36,180
cookie dough with them and you know bake

886
00:35:41,910 --> 00:35:37,450
cookies with your initials on the end

887
00:35:43,170 --> 00:35:41,920
I'd for very low cost so devices like

888
00:35:44,670 --> 00:35:43,180

that getting them out to the general

889
00:35:46,290 --> 00:35:44,680
population letting the population sort

890
00:35:48,300 --> 00:35:46,300
of drive where they go and how they're

891
00:35:52,040 --> 00:35:48,310
developed that generally leads to low

892
00:35:55,260 --> 00:35:52,050
cost high efficiency kinds of situations

893
00:35:57,750 --> 00:35:55,270
crowd sourcing the movie industry I

894
00:35:59,190 --> 00:35:57,760
would say that you know in 20 years this

895
00:36:00,359 --> 00:35:59,200
is something we were targeted to sort of

896
00:36:02,430 --> 00:36:00,369
look at what do we think might be

897
00:36:04,530 --> 00:36:02,440
happening I think that James Cameron's

898
00:36:07,800 --> 00:36:04,540
vision of avatar while we might not do

899
00:36:10,410 --> 00:36:07,810
that specific kind of application of you

900
00:36:13,430 --> 00:36:10,420
know an actual genetically built second

901
00:36:16,560 --> 00:36:13,440
person I think a lot of the things that

902
00:36:17,940 --> 00:36:16,570
you saw in that kind of movie are things

903
00:36:22,050 --> 00:36:17,950
that we will be seeing much more

904
00:36:31,120 --> 00:36:22,060
integrated into society in 20 years so I

905
00:36:37,520 --> 00:36:35,480
thanks so much Christy I neglected to

906
00:36:39,020 --> 00:36:37,530
fill in the the human element for

907
00:36:41,000 --> 00:36:39,030
Christy although she's alluded to some

908
00:36:44,329 --> 00:36:41,010
of them with the one-year-old which must

909
00:36:46,690 --> 00:36:44,339
dominate your life christy is also an

910
00:36:49,370 --> 00:36:46,700
outdoor enthusiast scuba diver

911
00:36:52,099 --> 00:36:49,380
bicyclists and mountain climbers climb

912
00:36:54,380 --> 00:36:52,109
Mount Kilimanjaro so very very

913
00:36:55,730 --> 00:36:54,390

impressive Benjamin I didn't make it to

914
00:36:59,240 --> 00:36:55,740
the topic Kilimanjaro like I held it to

915
00:37:01,819 --> 00:36:59,250
sickness I got to 16,000 feet that's

916
00:37:04,130 --> 00:37:01,829
pretty aggressive we have oxygen on were

917
00:37:07,490 --> 00:37:04,140
above 12,000 in the airplane so that's

918
00:37:10,400 --> 00:37:07,500
that's terrific okay so let's move on

919
00:37:12,980 --> 00:37:10,410
and I'd like to introduce dr. Roger

920
00:37:14,990 --> 00:37:12,990
Myers he is the executive director for

921
00:37:17,690 --> 00:37:15,000
electric propulsion and integrated

922
00:37:19,700 --> 00:37:17,700
systems at aerojet which is a company

923
00:37:22,160 --> 00:37:19,710
that develops propulsion systems and

924
00:37:25,040 --> 00:37:22,170
Roger will will likely talk about this

925
00:37:29,750 --> 00:37:25,050
for many of NASA's missions both human

926
00:37:32,059 --> 00:37:29,760
and and robotic Roger is he is also a

927
00:37:33,859 --> 00:37:32,069
forward thinker and has been responsible

928
00:37:35,930 --> 00:37:33,869
for strategic planning develop and

929
00:37:37,849 --> 00:37:35,940
production of next-generation chemical

930
00:37:39,829 --> 00:37:37,859
and electric propulsion systems electric

931
00:37:41,300 --> 00:37:39,839
propulsion for those of you who don't

932
00:37:44,240 --> 00:37:41,310
know is sort of one of the next

933
00:37:47,180 --> 00:37:44,250
breakthrough technology areas for

934
00:37:48,950 --> 00:37:47,190
planetary exploration missions and Roger

935
00:37:53,540 --> 00:37:48,960
is expert in that he has a long history

936
00:37:58,250 --> 00:37:53,550
in research with NASA and in academia at

937
00:38:00,530 --> 00:37:58,260
Princeton he and his wife live in

938
00:38:03,530 --> 00:38:00,540

woodinville which is wine country here

939
00:38:07,010 --> 00:38:03,540
in in Seattle a fascinating place where

940
00:38:09,319 --> 00:38:07,020
they enjoy bird-watching as their in

941
00:38:11,569 --> 00:38:09,329
interaction with with the outdoor so

942
00:38:13,160 --> 00:38:11,579
please welcome Roger and really look

943
00:38:14,809 --> 00:38:13,170
forward to your comments on propulsion

944
00:38:18,490 --> 00:38:14,819
technologies and innovation and where

945
00:38:21,859 --> 00:38:18,500
we're going in that area so good morning

946
00:38:23,839 --> 00:38:21,869
so it's really nice to be here it was a

947
00:38:26,059 --> 00:38:23,849
pleasure to participate yesterday and

948
00:38:30,530 --> 00:38:26,069
the opening of the Charles simoni new

949
00:38:32,930 --> 00:38:30,540
space gallery so as joe said i was asked

950
00:38:35,990 --> 00:38:32,940
to comment on some of the transportation

951
00:38:38,059 --> 00:38:36,000
technologies and I call a transportation

952
00:38:40,220 --> 00:38:38,069
as opposed to propulsion because it's

953
00:38:42,920 --> 00:38:40,230
not just about the Rockets

954
00:38:46,540 --> 00:38:42,930
also about the vehicles that are

955
00:38:49,970 --> 00:38:46,550
required to do this to do the missions

956
00:38:51,980 --> 00:38:49,980
and so in addition to talking about the

957
00:38:53,750 --> 00:38:51,990
technologies I want to talk a little bit

958
00:38:56,450 --> 00:38:53,760
about some programmatic challenges that

959
00:38:58,820 --> 00:38:56,460
we actually face you know what are the

960
00:39:01,040 --> 00:38:58,830
issues that were really facing today but

961
00:39:04,370 --> 00:39:01,050
i'll start with technology so we heard

962
00:39:06,109 --> 00:39:04,380
today from lori garver about the

963
00:39:08,510 --> 00:39:06,119

dramatic cost reductions that are

964
00:39:10,250 --> 00:39:08,520
necessary and space transportation we

965
00:39:13,010 --> 00:39:10,260
talked to me we heard about the big

966
00:39:15,830 --> 00:39:13,020
rockets and how expensive they are and

967
00:39:19,520 --> 00:39:15,840
if we're going to explore deep space we

968
00:39:21,320 --> 00:39:19,530
have to get the cost down if we have if

969
00:39:23,330 --> 00:39:21,330
we want to go beyond low-earth orbit and

970
00:39:25,880 --> 00:39:23,340
essentially it's just saying that the

971
00:39:28,670 --> 00:39:25,890
cost of developing building operating

972
00:39:31,220 --> 00:39:28,680
and maintaining the launch vehicles and

973
00:39:33,980 --> 00:39:31,230
infrastructure required for those launch

974
00:39:37,190 --> 00:39:33,990
vehicles as well as all of the Deep

975
00:39:40,300 --> 00:39:37,200
Space Systems habitats the Landers the

976
00:39:43,430 --> 00:39:40,310
asset vehicles and all the exploration

977
00:39:46,340 --> 00:39:43,440
exploration equipment within the budgets

978
00:39:47,900 --> 00:39:46,350
that we currently have is going to

979
00:39:50,210 --> 00:39:47,910
really have to change we have to change

980
00:39:53,300 --> 00:39:50,220
our paradigm in the way that we do deep

981
00:39:56,090 --> 00:39:53,310
space exploration and that's that's not

982
00:39:58,370 --> 00:39:56,100
rocket science as much as I'd like it to

983
00:40:00,830 --> 00:39:58,380
be it's really just basic physics and

984
00:40:03,380 --> 00:40:00,840
economics we don't have the money to do

985
00:40:06,410 --> 00:40:03,390
all of the big rockets that we would

986
00:40:08,920 --> 00:40:06,420
really like to do and so we need to

987
00:40:13,070 --> 00:40:08,930
think about doing deep space exploration

988
00:40:15,640 --> 00:40:13,080

differently the key that the reason that

989
00:40:19,310 --> 00:40:15,650
it takes so many of those big rockets is

990
00:40:22,220 --> 00:40:19,320
energy going beyond low-earth orbit

991
00:40:26,090 --> 00:40:22,230
takes a lot of energy there's a quote by

992
00:40:27,620 --> 00:40:26,100
a science-fiction author that if you get

993
00:40:31,160 --> 00:40:27,630
to low Earth orbit you're halfway to any

994
00:40:33,500 --> 00:40:31,170
anywhere in the solar system that's only

995
00:40:35,640 --> 00:40:33,510
true if you don't want to land and you

996
00:40:38,070 --> 00:40:35,650
don't want to come home

997
00:40:39,510 --> 00:40:38,080
so if you want to come home if you want

998
00:40:41,910 --> 00:40:39,520
to do something there and you want to

999
00:40:44,670 --> 00:40:41,920
come home it drops it to about a quarter

1000
00:40:46,950 --> 00:40:44,680
or thereabouts-- of the energy is the

1001
00:40:49,370 --> 00:40:46,960
energy going to low-earth orbit it's

1002
00:40:52,650 --> 00:40:49,380
only about a quarter of the total energy

1003
00:40:54,870 --> 00:40:52,660
required to do those missions so so if

1004
00:40:58,440 --> 00:40:54,880
we want to go do something cool on the

1005
00:41:00,960 --> 00:40:58,450
surface of Mars you we have to invest in

1006
00:41:02,910 --> 00:41:00,970
the in space elements it's it's a

1007
00:41:05,760 --> 00:41:02,920
requirement you know much as we make

1008
00:41:08,570 --> 00:41:05,770
progress in our launch vehicles and

1009
00:41:14,000 --> 00:41:08,580
reducing the cost of the launch vehicles

1010
00:41:17,280 --> 00:41:14,010
we have to invest in in deep space so

1011
00:41:20,880 --> 00:41:17,290
the reason for that is that today's

1012
00:41:23,700 --> 00:41:20,890
propulsion systems the in space what's

1013
00:41:25,530 --> 00:41:23,710

available for in space propulsion are

1014
00:41:27,210 --> 00:41:25,540
pretty inefficient they're they're not

1015
00:41:29,220 --> 00:41:27,220
very high performance and that means

1016
00:41:31,980 --> 00:41:29,230
that you have to carry a huge amount of

1017
00:41:35,250 --> 00:41:31,990
fuel you have to launch a tremendous

1018
00:41:37,650 --> 00:41:35,260
amount of propellant to get beyond

1019
00:41:41,130 --> 00:41:37,660
low-earth orbit and that takes big

1020
00:41:45,480 --> 00:41:41,140
expensive unique rockets to do that and

1021
00:41:47,610 --> 00:41:45,490
we have to change that paradigm so if

1022
00:41:50,220 --> 00:41:47,620
we're going to explore deep space we

1023
00:41:52,890 --> 00:41:50,230
need a balanced set of investments in

1024
00:41:57,300 --> 00:41:52,900
both the launch architecture the way

1025
00:41:59,820 --> 00:41:57,310
that we launch people and cargo and also

1026
00:42:03,270 --> 00:41:59,830
we need a parallel set of investments in

1027
00:42:05,340 --> 00:42:03,280
deep space transportation system

1028
00:42:09,060 --> 00:42:05,350
technologies deep space transportation

1029
00:42:11,160 --> 00:42:09,070
architectures as we heard earlier today

1030
00:42:15,000 --> 00:42:11,170
we're making huge progress in the launch

1031
00:42:17,160 --> 00:42:15,010
arena we're making investments in crew

1032
00:42:19,440 --> 00:42:17,170
transport commercial crew transportation

1033
00:42:21,690 --> 00:42:19,450
the Sierra Nevada dreamchaser program is

1034
00:42:25,320 --> 00:42:21,700
really cool program using some green

1035
00:42:27,360 --> 00:42:25,330
technologies for instead of the toxic

1036
00:42:30,300 --> 00:42:27,370
rocket propellants so making great

1037
00:42:32,400 --> 00:42:30,310
progress in various areas a sexes is

1038
00:42:36,450 --> 00:42:32,410

here we'll hear from from them later and

1039
00:42:40,980 --> 00:42:36,460
the SLS which lori Garver talked about

1040
00:42:44,190 --> 00:42:40,990
earlier will enable the Orion capsule to

1041
00:42:47,400 --> 00:42:44,200
go beyond low-earth orbit and that's a

1042
00:42:49,350 --> 00:42:47,410
great step but we need to take more than

1043
00:42:51,300 --> 00:42:49,360
just the Orion capsule right it'd be

1044
00:42:53,610 --> 00:42:51,310
kind of boring if the only thing that

1045
00:42:55,500 --> 00:42:53,620
you had was the Orion capsule there and

1046
00:42:57,990 --> 00:42:55,510
it's it's not not all that big so we

1047
00:43:01,860 --> 00:42:58,000
also need to send food water habitats

1048
00:43:04,140 --> 00:43:01,870
Rovers asset vehicles all of that stuff

1049
00:43:05,760 --> 00:43:04,150
that is needed to do those interesting

1050
00:43:08,700 --> 00:43:05,770
missions that we want to do in an

1051
00:43:12,360 --> 00:43:08,710
affordable manner and affordability is

1052
00:43:14,100 --> 00:43:12,370
really central to it needs to be central

1053
00:43:16,890 --> 00:43:14,110
to the way that we think about deep

1054
00:43:20,460 --> 00:43:16,900
space exploration we need to think about

1055
00:43:23,250 --> 00:43:20,470
cargo not just crew much as the human

1056
00:43:26,700 --> 00:43:23,260
part of a mission is what excites us all

1057
00:43:29,160 --> 00:43:26,710
if we don't have useful tools for them

1058
00:43:31,830 --> 00:43:29,170
to use and food to eat and oxygen to

1059
00:43:36,630 --> 00:43:31,840
breathe and the Rockets to bring them

1060
00:43:42,600 --> 00:43:36,640
back it's it's not going to be an

1061
00:43:46,920 --> 00:43:42,610
interesting mission so it if we separate

1062
00:43:48,930 --> 00:43:46,930
cargo and crew in that manner our

1063
00:43:51,990 --> 00:43:48,940

studies show that you can really

1064
00:43:54,390 --> 00:43:52,000
dramatically reduce the cost of deep

1065
00:43:58,650 --> 00:43:54,400
space exploration because you can

1066
00:44:03,000 --> 00:43:58,660
optimize the two transportation systems

1067
00:44:05,370 --> 00:44:03,010
you can do crew fast the way crews will

1068
00:44:07,770 --> 00:44:05,380
want to go to Mars or the back to the

1069
00:44:10,140 --> 00:44:07,780
moon or the asteroids or wherever

1070
00:44:12,480 --> 00:44:10,150
they're at the end up going and cargo

1071
00:44:14,520 --> 00:44:12,490
can be pre-positioned and it's really

1072
00:44:16,440 --> 00:44:14,530
the same analogy though the way we do it

1073
00:44:17,880 --> 00:44:16,450
on earth right now we don't have one

1074
00:44:20,460 --> 00:44:17,890
transportation system we heard about

1075
00:44:23,220 --> 00:44:20,470
aircraft earlier but we also have big

1076
00:44:26,490 --> 00:44:23,230
cargo ships and we have trains and the

1077
00:44:30,270 --> 00:44:26,500
way that we think about transportation

1078
00:44:32,460 --> 00:44:30,280
architectures really needs to move from

1079
00:44:35,370 --> 00:44:32,470
the way we're currently thinking about

1080
00:44:37,710 --> 00:44:35,380
deep exploration to a new paradigm if we

1081
00:44:40,980 --> 00:44:37,720
are going to truly get the cost of deep

1082
00:44:44,240 --> 00:44:40,990
space explorations down the cool thing

1083
00:44:46,530 --> 00:44:44,250
is that the basic technologies are

1084
00:44:50,610 --> 00:44:46,540
pretty much there we've been doing this

1085
00:44:52,190 --> 00:44:50,620
for decades now and we have a lot of the

1086
00:44:54,800 --> 00:44:52,200
basic technologies so

1087
00:44:56,720 --> 00:44:54,810
if we started a program today using

1088
00:44:58,339 --> 00:44:56,730

technologies that are very near to

1089
00:45:00,710 --> 00:44:58,349
application they're not ready yet but

1090
00:45:02,210 --> 00:45:00,720
they're very near to application I think

1091
00:45:04,609 --> 00:45:02,220
we can go to the moon the asteroids

1092
00:45:09,109 --> 00:45:04,619
Martian moons and the surface of Mars

1093
00:45:11,870 --> 00:45:09,119
and do it affordably specifically if we

1094
00:45:16,520 --> 00:45:11,880
use a combination of Commercial Crew the

1095
00:45:18,589 --> 00:45:16,530
SLS the MPCV modular cryogenic stages

1096
00:45:20,839 --> 00:45:18,599
for crew transport so those are the

1097
00:45:23,569 --> 00:45:20,849
elements of the crew transport and we

1098
00:45:26,599 --> 00:45:23,579
use realistic high power solar electric

1099
00:45:28,849 --> 00:45:26,609
propulsion for pre positioning cargo at

1100
00:45:30,829 --> 00:45:28,859
our destinations I think we can

1101
00:45:32,720 --> 00:45:30,839
implement an affordable robust

1102
00:45:35,870 --> 00:45:32,730
transportation system for Space

1103
00:45:37,609 --> 00:45:35,880
Exploration when I say transportation

1104
00:45:39,650 --> 00:45:37,619
system this isn't just to go to Mars

1105
00:45:42,380 --> 00:45:39,660
this is a system that would that would

1106
00:45:44,210 --> 00:45:42,390
be multifunctional go to all the

1107
00:45:45,859 --> 00:45:44,220
destinations it's another way that you

1108
00:45:48,140 --> 00:45:45,869
get the cost down is that you have

1109
00:45:51,829 --> 00:45:48,150
systems which are used for multiple

1110
00:45:54,890 --> 00:45:51,839
purposes by multiple markets it's a very

1111
00:45:57,859 --> 00:45:54,900
important way to distribute fixed costs

1112
00:46:00,140 --> 00:45:57,869
for example so technologically this

1113
00:46:03,890 --> 00:46:00,150

seems doable and it seems affordable to

1114
00:46:05,660 --> 00:46:03,900
us if we do it right but we have

1115
00:46:08,390 --> 00:46:05,670
programmatic challenges this is the

1116
00:46:10,849 --> 00:46:08,400
second part so our biggest programmatic

1117
00:46:13,940 --> 00:46:10,859
challenge is sustaining a technology

1118
00:46:16,849 --> 00:46:13,950
program that sees new developments

1119
00:46:19,339 --> 00:46:16,859
through to application we have a lot of

1120
00:46:20,809 --> 00:46:19,349
basic technologies the electric

1121
00:46:24,170 --> 00:46:20,819
propulsion systems have been around for

1122
00:46:25,970 --> 00:46:24,180
a long time cryogenic Rockets have been

1123
00:46:27,530 --> 00:46:25,980
around for a long time there are some

1124
00:46:29,900 --> 00:46:27,540
new innovations that we need in

1125
00:46:32,630 --> 00:46:29,910
long-term cryo storage high power solar

1126
00:46:34,370 --> 00:46:32,640
arrays a very high power solar arrays

1127
00:46:37,190 --> 00:46:34,380
there are some new technologies like

1128
00:46:39,980 --> 00:46:37,200
that that we do do need but pretty much

1129
00:46:42,140 --> 00:46:39,990
we're we're pretty much there from a

1130
00:46:44,870 --> 00:46:42,150
basic technology perspective solar

1131
00:46:46,579 --> 00:46:44,880
arrays exist today cryogenic rockets

1132
00:46:50,270 --> 00:46:46,589
exist today they need to be engineered

1133
00:46:52,190 --> 00:46:50,280
but it's not new technology so to speak

1134
00:46:54,500 --> 00:46:52,200
but what we don't what we have not done

1135
00:46:57,260 --> 00:46:54,510
is validated them we have not

1136
00:46:59,059 --> 00:46:57,270
transitioned them and lori Garver talked

1137
00:47:02,240 --> 00:46:59,069
earlier today about transitioning

1138
00:47:04,510 --> 00:47:02,250

technology and that is it's an expensive

1139
00:47:07,670 --> 00:47:04,520
process but

1140
00:47:09,350 --> 00:47:07,680
making sure that we can actually use the

1141
00:47:12,230 --> 00:47:09,360
technologies and the with the

1142
00:47:13,790 --> 00:47:12,240
appropriate risk profile is really

1143
00:47:15,950 --> 00:47:13,800
what's what I'm talking about when I say

1144
00:47:18,800 --> 00:47:15,960
transition technologies to application

1145
00:47:21,620 --> 00:47:18,810
and we don't have a robust program now

1146
00:47:24,440 --> 00:47:21,630
for technology transition I personally

1147
00:47:28,780 --> 00:47:24,450
transitioned a lot of technologies in

1148
00:47:31,970 --> 00:47:28,790
the commercial sector to to spaceflight

1149
00:47:33,410 --> 00:47:31,980
several different propulsion systems

1150
00:47:38,150 --> 00:47:33,420
including some electric propulsion

1151
00:47:40,280 --> 00:47:38,160
systems but we need to take that next

1152
00:47:42,320 --> 00:47:40,290
step with the larger missions that are

1153
00:47:45,710 --> 00:47:42,330
larger systems that are required for

1154
00:47:48,170 --> 00:47:45,720
human space exploration so in summary a

1155
00:47:50,210 --> 00:47:48,180
lot of the technologies are there we do

1156
00:47:53,630 --> 00:47:50,220
need some key innovations as I as I

1157
00:47:57,370 --> 00:47:53,640
mentioned but what we're lacking more

1158
00:48:00,580 --> 00:47:57,380
than anything is a robust transition to

1159
00:48:03,200 --> 00:48:00,590
application program a sustained effort

1160
00:48:05,930 --> 00:48:03,210
to take the technologies that we have

1161
00:48:07,850 --> 00:48:05,940
and make them useful show that we can

1162
00:48:15,430 --> 00:48:07,860
use them and I'll leave it at that for

1163
00:48:21,500 --> 00:48:17,559

thanks very much for your thoughts Roger

1164
00:48:25,000 --> 00:48:21,510
I'd like to now introduce last but

1165
00:48:28,430 --> 00:48:25,010
definitely not least dr. ed lisowski ed

1166
00:48:31,099 --> 00:48:28,440
has the fantastic title of Bill and

1167
00:48:32,660 --> 00:48:31,109
Melinda Gates chair in computer science

1168
00:48:34,970 --> 00:48:32,670
and engineering at the University of

1169
00:48:38,120 --> 00:48:34,980
Washington and when I hear that title I

1170
00:48:39,920 --> 00:48:38,130
can't help but think that this this this

1171
00:48:43,069 --> 00:48:39,930
person has the opportunity to really

1172
00:48:45,200 --> 00:48:43,079
think big thoughts and think about the

1173
00:48:48,380 --> 00:48:45,210
role of computers and information

1174
00:48:51,140 --> 00:48:48,390
technologies at society as a whole and

1175
00:48:56,120 --> 00:48:51,150
that in fact is what ed has dedicated

1176
00:48:58,700 --> 00:48:56,130
himself to doing he does he does a both

1177
00:49:00,680 --> 00:48:58,710
locally here and across the country

1178
00:49:02,089 --> 00:49:00,690
including directing the University of

1179
00:49:04,190 --> 00:49:02,099
Washington's East Science Institute

1180
00:49:06,289 --> 00:49:04,200
which is the organization that tries to

1181
00:49:09,200 --> 00:49:06,299
spread computing technologies across the

1182
00:49:12,039 --> 00:49:09,210
UW campus he chairs the computing

1183
00:49:14,420 --> 00:49:12,049
community consortium which is looking at

1184
00:49:16,940 --> 00:49:14,430
addressing challenges and information

1185
00:49:19,309 --> 00:49:16,950
technology across the 21st century and

1186
00:49:21,079 --> 00:49:19,319
he also has been involved in the

1187
00:49:23,599 --> 00:49:21,089
President's Council of Advisors on

1188
00:49:25,609 --> 00:49:23,609

science and technology addressing a

1189
00:49:27,770 --> 00:49:25,619
working group there helping helping the

1190
00:49:29,230 --> 00:49:27,780
chair a working group there on reviewing

1191
00:49:32,319 --> 00:49:29,240
federal networking and information

1192
00:49:35,660 --> 00:49:32,329
technology research and development so

1193
00:49:37,849 --> 00:49:35,670
ed is your your person number one if

1194
00:49:39,770 --> 00:49:37,859
your if your iphone is crashed I think

1195
00:49:42,440 --> 00:49:39,780
Ed's the guy to to talk to you to help

1196
00:49:44,420 --> 00:49:42,450
get get that resolved but really at is

1197
00:49:46,609 --> 00:49:44,430
EDD is the guy who's forecasting where

1198
00:49:48,349 --> 00:49:46,619
we were going to be in the middle of the

1199
00:49:50,870 --> 00:49:48,359
21st century at the end of the 21st

1200
00:49:53,660 --> 00:49:50,880
century for information technology and

1201
00:49:55,849 --> 00:49:53,670
that is that is a wonderful space to be

1202
00:49:57,920 --> 00:49:55,859
in so welcome ed and we look forward to

1203
00:49:59,359 --> 00:49:57,930
your comments well thanks it's great to

1204
00:50:00,859 --> 00:49:59,369
be here that's of course an introduction

1205
00:50:03,650 --> 00:50:00,869
that one cannot possibly fulfill that

1206
00:50:05,539 --> 00:50:03,660
side I i will say that almost everything

1207
00:50:08,839 --> 00:50:05,549
has been said so I'll at least attempt

1208
00:50:10,039 --> 00:50:08,849
to repeat it quickly here it's important

1209
00:50:11,900 --> 00:50:10,049
that computer science information

1210
00:50:14,329 --> 00:50:11,910
technology is represented here today

1211
00:50:16,130 --> 00:50:14,339
because really the two pillars of the

1212
00:50:18,829 --> 00:50:16,140
technology economy in the Puget Sound

1213
00:50:21,170 --> 00:50:18,839

region our aerospace and computing

1214
00:50:23,720 --> 00:50:21,180
information technology and this is a

1215
00:50:25,070 --> 00:50:23,730
region that's really contributed to

1216
00:50:28,580 --> 00:50:25,080
making our nation

1217
00:50:30,380 --> 00:50:28,590
in both of those areas let me tie the

1218
00:50:32,570 --> 00:50:30,390
two together by going back to nineteen

1219
00:50:35,570 --> 00:50:32,580
sixty-nine you've heard about Neil

1220
00:50:37,460 --> 00:50:35,580
Armstrong and walking on the moon in

1221
00:50:39,110 --> 00:50:37,470
1969 there a set of other important

1222
00:50:41,890 --> 00:50:39,120
things that happened about 40 years ago

1223
00:50:46,160 --> 00:50:41,900
in 1969 the mets won the world series

1224
00:50:47,990 --> 00:50:46,170
there was a Woodstock and more germane

1225
00:50:49,250 --> 00:50:48,000
than either of those and no one

1226
00:50:51,860 --> 00:50:49,260
remembers what happened at Woodstock

1227
00:50:54,350 --> 00:50:51,870
anyway is that the first packet of data

1228
00:50:55,850 --> 00:50:54,360
flowed over ARPANET the precursor to

1229
00:50:57,800 --> 00:50:55,860
today's Internet all right so that

1230
00:51:00,740 --> 00:50:57,810
happened in October just a couple of

1231
00:51:03,230 --> 00:51:00,750
months after an American walked on the

1232
00:51:04,640 --> 00:51:03,240
surface of the Moon I'll give you a bit

1233
00:51:06,950 --> 00:51:04,650
of detail on this because it'll I'll

1234
00:51:08,990 --> 00:51:06,960
come back to it later the goal of

1235
00:51:10,940 --> 00:51:09,000
ARPANET at that point was making it

1236
00:51:13,940 --> 00:51:10,950
possible to remotely use expensive

1237
00:51:16,490 --> 00:51:13,950
mainframe computers right and the first

1238
00:51:18,920 --> 00:51:16,500

packet that flowed over ARPANET was the

1239
00:51:21,500 --> 00:51:18,930
characters L & O which were the first

1240
00:51:23,990 --> 00:51:21,510
two letters of the word login alright so

1241
00:51:26,330 --> 00:51:24,000
a gentleman at UCLA was trying to log in

1242
00:51:28,970 --> 00:51:26,340
remotely to a computer at essar I and

1243
00:51:31,370 --> 00:51:28,980
after he got to L&O the network crashed

1244
00:51:34,300 --> 00:51:31,380
so there are a set of things that that

1245
00:51:36,920 --> 00:51:34,310
never change right but these were both

1246
00:51:38,780 --> 00:51:36,930
monumental engineering accomplishments

1247
00:51:41,930 --> 00:51:38,790
that over time have changed our world

1248
00:51:44,270 --> 00:51:41,940
and most importantly and NASA is really

1249
00:51:48,050 --> 00:51:44,280
the poster child for this they led to a

1250
00:51:49,820 --> 00:51:48,060
set of aspirations that that kids have

1251
00:51:53,630 --> 00:51:49,830
and people have for what we can achieve

1252
00:51:55,070 --> 00:51:53,640
and and mechanisms for fulfilling those

1253
00:51:56,630 --> 00:51:55,080
aspirations and that's what's so

1254
00:51:58,490 --> 00:51:56,640
important about the space program and I

1255
00:52:01,100 --> 00:51:58,500
think so important about information

1256
00:52:03,460 --> 00:52:01,110
technology as well that is it causes us

1257
00:52:06,920 --> 00:52:03,470
to aspire to do things to dream about

1258
00:52:10,820 --> 00:52:06,930
about what's possible now computing has

1259
00:52:13,370 --> 00:52:10,830
an advantage over over aerospace and

1260
00:52:15,170 --> 00:52:13,380
space travel and that is that we benefit

1261
00:52:17,750 --> 00:52:15,180
from Exponential's so you're familiar

1262
00:52:21,530 --> 00:52:17,760
with Moore's law if you go back just 20

1263
00:52:23,600 --> 00:52:21,540

years right to 1991 the Intel 486

1264
00:52:26,060 --> 00:52:23,610
processor had a million transistors and

1265
00:52:28,160 --> 00:52:26,070
today's high-end Intel processors have

1266
00:52:31,040 --> 00:52:28,170
two billion transistors so a factor of a

1267
00:52:32,480 --> 00:52:31,050
thousand greater in 20 years and the

1268
00:52:34,700 --> 00:52:32,490
number doesn't wet matter what matters

1269
00:52:37,700 --> 00:52:34,710
is that it transforms what you can

1270
00:52:38,550 --> 00:52:37,710
actually do right similarly 20 years ago

1271
00:52:42,540 --> 00:52:38,560
in nineteen

1272
00:52:44,460 --> 00:52:42,550
91 there were about half a million users

1273
00:52:47,610 --> 00:52:44,470
on the internet that's a lot but today

1274
00:52:49,890 --> 00:52:47,620
there are about a billion so again a

1275
00:52:51,810 --> 00:52:49,900
factor of 20 increase and you get what

1276
00:52:53,190 --> 00:52:51,820
we call Network effects right Network

1277
00:52:54,840 --> 00:52:53,200
the facts are that the value of

1278
00:52:57,980 --> 00:52:54,850
something increases exponentially with

1279
00:53:00,720 --> 00:52:57,990
the number of people participating in it

1280
00:53:02,220 --> 00:53:00,730
so examples of these Exponential's in

1281
00:53:04,950 --> 00:53:02,230
addition to transistor count and the

1282
00:53:08,010 --> 00:53:04,960
internet use it is that I'm told that

1283
00:53:15,930 --> 00:53:08,020
the computational power that was used to

1284
00:53:18,300 --> 00:53:15,940
get a hollow spacecraft 20 years ago to

1285
00:53:22,350 --> 00:53:18,310
make them successful is now embodied in

1286
00:53:24,630 --> 00:53:22,360
a Furby right so so it's not clear that

1287
00:53:25,920 --> 00:53:24,640
this is the the greatest social use for

1288
00:53:27,540 --> 00:53:25,930

that technology but it's still a

1289
00:53:30,000 --> 00:53:27,550
remarkable comment on what we've been

1290
00:53:31,560 --> 00:53:30,010
able to do so let me talk about what's

1291
00:53:33,120 --> 00:53:31,570
happened in the past 10 years what's

1292
00:53:35,640 --> 00:53:33,130
going to happen in the next 10 years and

1293
00:53:37,350 --> 00:53:35,650
then how it happens so you know if you

1294
00:53:38,790 --> 00:53:37,360
think about things that are totally

1295
00:53:41,130 --> 00:53:38,800
different aday than they were 10 years

1296
00:53:43,620 --> 00:53:41,140
ago you've heard already about digital

1297
00:53:45,060 --> 00:53:43,630
media you've heard about mobility the

1298
00:53:46,740 --> 00:53:45,070
fact that you're connected to the world

1299
00:53:48,750 --> 00:53:46,750
no matter where you are by little device

1300
00:53:51,480 --> 00:53:48,760
in your pocket you've heard about social

1301
00:53:53,810 --> 00:53:51,490
networking we are using it today by a

1302
00:53:56,790 --> 00:53:53,820
Twitter and other means in this meeting

1303
00:53:59,850 --> 00:53:56,800
but their search you know 10 years ago

1304
00:54:01,350 --> 00:53:59,860
you you filed things away so that you

1305
00:54:02,490 --> 00:54:01,360
could maybe or maybe not find them and

1306
00:54:05,610 --> 00:54:02,500
today you just search for them

1307
00:54:07,590 --> 00:54:05,620
scalability ecommerce the cloud all of

1308
00:54:11,160 --> 00:54:07,600
these are total revolutions in the past

1309
00:54:13,260 --> 00:54:11,170
10 years looking forward I think the

1310
00:54:16,680 --> 00:54:13,270
real contribution that we're going to

1311
00:54:19,800 --> 00:54:16,690
help make in partnership with with NASA

1312
00:54:22,140 --> 00:54:19,810
and folks like christy is putting the

1313
00:54:24,060 --> 00:54:22,150

smarts in everything all right so that's

1314
00:54:26,580 --> 00:54:24,070
that's the business computing is in so

1315
00:54:30,330 --> 00:54:26,590
when you hear about smart homes or smart

1316
00:54:32,310 --> 00:54:30,340
cars or smart bodies I always wonder why

1317
00:54:35,040 --> 00:54:32,320
my body is so much worse instrumented

1318
00:54:37,860 --> 00:54:35,050
than my car right when I go to the

1319
00:54:40,110 --> 00:54:37,870
automobile dealership they jack a little

1320
00:54:41,760 --> 00:54:40,120
computer in under the dashboard readout

1321
00:54:43,410 --> 00:54:41,770
the parameters from the past six months

1322
00:54:45,240 --> 00:54:43,420
figure out what the problem was and fix

1323
00:54:46,860 --> 00:54:45,250
it and when I go into the doctor she

1324
00:54:48,840 --> 00:54:46,870
taps me on the knee and sees if it

1325
00:54:50,750 --> 00:54:48,850
bounces up and asks where it hurts right

1326
00:54:53,300 --> 00:54:50,760
and you got to believe there's

1327
00:54:55,250 --> 00:54:53,310
something that will happen there you

1328
00:54:59,930 --> 00:54:55,260
heard a lot about robotics nASA has been

1329
00:55:01,970 --> 00:54:59,940
a leader in robotics and robots in some

1330
00:55:04,550 --> 00:55:01,980
sense with the exception of NASA over

1331
00:55:06,620 --> 00:55:04,560
the past 40 years have been in what we

1332
00:55:09,020 --> 00:55:06,630
call structured environments bolted to

1333
00:55:11,150 --> 00:55:09,030
factory floors and NASA has been a

1334
00:55:12,740 --> 00:55:11,160
pioneer in robots in unstructured

1335
00:55:14,570 --> 00:55:12,750
environments where they have to be

1336
00:55:17,240 --> 00:55:14,580
autonomous and they have to respond to

1337
00:55:19,040 --> 00:55:17,250
unanticipated situations you see these

1338
00:55:21,770 --> 00:55:19,050

in your home today and in the person of

1339
00:55:23,480 --> 00:55:21,780
the Roomba vacuum cleaner you see

1340
00:55:26,180 --> 00:55:23,490
google's robot cars on the roads of

1341
00:55:28,910 --> 00:55:26,190
California right and so so this notion

1342
00:55:30,230 --> 00:55:28,920
of robots in unstructured environments

1343
00:55:32,230 --> 00:55:30,240
working with us is going to be

1344
00:55:35,390 --> 00:55:32,240
transforming over the next ten years

1345
00:55:37,250 --> 00:55:35,400
you're going to see smart crowds citizen

1346
00:55:39,800 --> 00:55:37,260
science work done here at the University

1347
00:55:41,690 --> 00:55:39,810
of Washington and this program called

1348
00:55:43,700 --> 00:55:41,700
folded has hundreds of thousands of

1349
00:55:46,550 --> 00:55:43,710
people doing protein folding and protein

1350
00:55:48,890 --> 00:55:46,560
structure calculation as a game they

1351
00:55:50,960 --> 00:55:48,900
were in the news a couple of weeks ago

1352
00:55:52,280 --> 00:55:50,970
for solving an aids-related protein

1353
00:55:55,550 --> 00:55:52,290
structure problem that had eluded

1354
00:55:56,930 --> 00:55:55,560
scientists for a decade and the beauty

1355
00:55:58,280 --> 00:55:56,940
there is not that just that you're

1356
00:56:00,080 --> 00:55:58,290
bringing many people to bear on a

1357
00:56:02,720 --> 00:56:00,090
problem it's that each of us has unique

1358
00:56:04,400 --> 00:56:02,730
capabilities unique strengths unique

1359
00:56:06,080 --> 00:56:04,410
things that we can do and if you can

1360
00:56:08,420 --> 00:56:06,090
design systems that let people work

1361
00:56:10,400 --> 00:56:08,430
together then you can really do

1362
00:56:12,320 --> 00:56:10,410
something that no collection of

1363
00:56:14,600 --> 00:56:12,330

identical individuals much less a single

1364
00:56:16,370 --> 00:56:14,610
individual can do so let me say just a

1365
00:56:17,570 --> 00:56:16,380
word about how this happens and again I

1366
00:56:20,450 --> 00:56:17,580
think there's a lot of commonality

1367
00:56:22,220 --> 00:56:20,460
between computing and and aerospace

1368
00:56:23,840 --> 00:56:22,230
they've been a lot of studies about how

1369
00:56:27,290 --> 00:56:23,850
innovation takes place in computer

1370
00:56:29,660 --> 00:56:27,300
science and most importantly essentially

1371
00:56:32,240 --> 00:56:29,670
all of the billion-dollar sub sectors of

1372
00:56:34,460 --> 00:56:32,250
today's computing industry trace their

1373
00:56:35,570 --> 00:56:34,470
roots to federally sponsored research so

1374
00:56:37,670 --> 00:56:35,580
the federal government has a really

1375
00:56:40,370 --> 00:56:37,680
essential role in doing this and it's a

1376
00:56:42,680 --> 00:56:40,380
complex ecosystem that involves federal

1377
00:56:44,300 --> 00:56:42,690
agencies doing research federal agencies

1378
00:56:47,840 --> 00:56:44,310
funding research the university

1379
00:56:50,420 --> 00:56:47,850
community and Industry R&D and there's

1380
00:56:52,190 --> 00:56:50,430
no simple pipeline people and ideas are

1381
00:56:55,070 --> 00:56:52,200
constantly moving back and forth it

1382
00:56:56,660 --> 00:56:55,080
really is an ecology that allows us to

1383
00:56:59,810 --> 00:56:56,670
be a leader and we have to maintain that

1384
00:57:01,760 --> 00:56:59,820
ecology going forward the interaction of

1385
00:57:02,500 --> 00:57:01,770
research ideas multiplies the effect

1386
00:57:04,540 --> 00:57:02,510
there

1387
00:57:06,700 --> 00:57:04,550
an unpredictable period from sort of

1388
00:57:10,000 --> 00:57:06,710

first idea to billion dollar market and

1389
00:57:11,740 --> 00:57:10,010
most interestingly it's often not clear

1390
00:57:14,590 --> 00:57:11,750
at the outset what the real benefit of

1391
00:57:16,690 --> 00:57:14,600
an innovation is going to be when people

1392
00:57:18,850 --> 00:57:16,700
were working on the internet ARPANET

1393
00:57:22,900 --> 00:57:18,860
nobody was thinking about email or the

1394
00:57:25,150 --> 00:57:22,910
web or e-commerce or digital media it

1395
00:57:28,270 --> 00:57:25,160
was for remotely using expensive

1396
00:57:30,670 --> 00:57:28,280
mainframe computers so you know you see

1397
00:57:32,230 --> 00:57:30,680
this pattern again and again the final

1398
00:57:34,240 --> 00:57:32,240
thing i want to touch on is the role of

1399
00:57:35,860 --> 00:57:34,250
universities in tech transfer this is

1400
00:57:38,230 --> 00:57:35,870
something that's commonly misunderstood

1401
00:57:42,160 --> 00:57:38,240
and I think it gets back to this

1402
00:57:44,740 --> 00:57:42,170
ecosystem notion the goal of university

1403
00:57:47,050 --> 00:57:44,750
technology transfer is to put publicly

1404
00:57:49,900 --> 00:57:47,060
funded innovation to work for the public

1405
00:57:51,340 --> 00:57:49,910
good all right and people have to get

1406
00:57:53,080 --> 00:57:51,350
over the notion that somehow you're

1407
00:57:55,960 --> 00:57:53,090
going to float the institutional boat on

1408
00:57:58,450 --> 00:57:55,970
licensing revenues and realize that the

1409
00:58:03,600 --> 00:57:58,460
goal is to make our nation the world

1410
00:58:07,390 --> 00:58:03,610
leader and make our region's regions of

1411
00:58:09,130 --> 00:58:07,400
innovation so there are very many ways

1412
00:58:13,150 --> 00:58:09,140
in which universities contribute to

1413
00:58:15,760 --> 00:58:13,160

innovation explicit Technology Transfer

1414
00:58:17,530 --> 00:58:15,770
Vehicle Licensing is just one of them by

1415
00:58:19,960 --> 00:58:17,540
no means the most important it just gets

1416
00:58:22,960 --> 00:58:19,970
the most attention so the bottom line

1417
00:58:24,460 --> 00:58:22,970
message here is it's an ecosystem we

1418
00:58:26,110 --> 00:58:24,470
have a wonderful one in this region we

1419
00:58:28,450 --> 00:58:26,120
have a wonderful one in this nation it's

1420
00:58:30,510 --> 00:58:28,460
up to all of us to preserve it and to

1421
00:58:33,310 --> 00:58:30,520
make sure that the next generation

1422
00:58:34,180 --> 00:58:33,320
appreciates the wonder of discovery that

1423
00:58:42,350 --> 00:58:34,190
we've been fortunate enough to

1424
00:58:48,200 --> 00:58:44,840
wonderful thank you so much those are

1425
00:58:50,690 --> 00:58:48,210
really insightful remarks so what I'd

1426
00:58:52,550 --> 00:58:50,700
like to do now is is open open the floor

1427
00:58:55,250 --> 00:58:52,560
to questions and while folks are coming

1428
00:58:57,380 --> 00:58:55,260
to the microphone we were receiving

1429
00:59:00,500 --> 00:58:57,390
questions from from Twitter as as we go

1430
00:59:03,860 --> 00:59:00,510
along and we received one from Matt Matt

1431
00:59:06,860 --> 00:59:03,870
Moffitt on Twitter who asked about space

1432
00:59:08,780 --> 00:59:06,870
applications for robotic nanotechnology

1433
00:59:11,270 --> 00:59:08,790
so he's interested he's interested in

1434
00:59:13,310 --> 00:59:11,280
the in the in the tiny robots and I was

1435
00:59:15,200 --> 00:59:13,320
wondering if perhaps Christy might want

1436
00:59:16,700 --> 00:59:15,210
to take a crack at that or someone else

1437
00:59:18,910 --> 00:59:16,710
on the panel to talk a little bit about

1438
00:59:21,620 --> 00:59:18,920

space applications for robotic

1439
00:59:23,390 --> 00:59:21,630
nanotechnology I'm happy to start

1440
00:59:25,610 --> 00:59:23,400
although i will say i'm not an expert in

1441
00:59:29,570 --> 00:59:25,620
nanotechnology i tend to work on a

1442
00:59:31,340 --> 00:59:29,580
slightly larger scale than that so what

1443
00:59:33,740 --> 00:59:31,350
I can say about it there's a number of

1444
00:59:35,330 --> 00:59:33,750
things going on so there are projects

1445
00:59:37,550 --> 00:59:35,340
called cube SATs that are being worked

1446
00:59:41,120 --> 00:59:37,560
on by a number of people so those are

1447
00:59:42,380 --> 00:59:41,130
not nanotechnology they're actually not

1448
00:59:44,960 --> 00:59:42,390
sure the exact dimensions but they're

1449
00:59:49,280 --> 00:59:44,970
usually you know bread box size or B

1450
00:59:50,840 --> 00:59:49,290
kilogram 10 centimeters ok so that's one

1451
00:59:52,850 --> 00:59:50,850
area I think some of the limits with

1452
00:59:54,650 --> 00:59:52,860
going smaller that than that in space

1453
00:59:58,310 --> 00:59:54,660
applications are what are you trying to

1454
01:00:00,670 --> 00:59:58,320
do so if you have actuation limit so you

1455
01:00:02,960 --> 01:00:00,680
need to have enough power to move or

1456
01:00:04,100 --> 01:00:02,970
actually accomplish something in terms

1457
01:00:08,480 --> 01:00:04,110
of manipulating the environment they

1458
01:00:09,740 --> 01:00:08,490
tend to need to be a larger scale so

1459
01:00:11,030 --> 01:00:09,750
achievements in that area like I said

1460
01:00:12,710 --> 01:00:11,040
there's a cube SATs are also number of

1461
01:00:15,370 --> 01:00:12,720
things going on in air environments in

1462
01:00:17,540 --> 01:00:15,380
the earth so small flying things and

1463
01:00:19,340 --> 01:00:17,550

people are also looking at getting

1464
01:00:22,580 --> 01:00:19,350
medical robotics inside of people on

1465
01:00:25,670 --> 01:00:22,590
that scale as well I could comment on

1466
01:00:28,000 --> 01:00:25,680
the applications of robotics and the

1467
01:00:31,910 --> 01:00:28,010
kinds of things that I was talking about

1468
01:00:34,220 --> 01:00:31,920
pre positioning cargo and putting

1469
01:00:37,730 --> 01:00:34,230
habitats in place and maybe starting

1470
01:00:40,070 --> 01:00:37,740
in-situ propellant production those

1471
01:00:44,150 --> 01:00:40,080
kinds of things will require highly

1472
01:00:47,000 --> 01:00:44,160
autonomous systems robots to go do those

1473
01:00:51,140 --> 01:00:47,010
things and so I think it's it's an

1474
01:00:51,950 --> 01:00:51,150
essential piece of an affordable space

1475
01:00:54,710 --> 01:00:51,960
exploration

1476
01:00:56,870 --> 01:00:54,720
program I think dad was saying computer

1477
01:00:59,589 --> 01:00:56,880
sciences absolutely integral to

1478
01:01:03,740 --> 01:00:59,599
everything that we're going to try to do

1479
01:01:05,900 --> 01:01:03,750
great thanks very much I i must say that

1480
01:01:08,060 --> 01:01:05,910
I've envisioned many questions that I'd

1481
01:01:10,730 --> 01:01:08,070
like to ask of bill nye the science guy

1482
01:01:12,620 --> 01:01:10,740
that I never I never imagined that we

1483
01:01:16,490 --> 01:01:12,630
might be taking a question from Bill Nye

1484
01:01:19,609 --> 01:01:16,500
the Science Guy so in a bit of a role

1485
01:01:21,620 --> 01:01:19,619
reversal please bill how much are you

1486
01:01:24,980 --> 01:01:21,630
all working on what I'm going to call

1487
01:01:28,370 --> 01:01:24,990
biofuels these would be renewable fuels

1488
01:01:30,710 --> 01:01:28,380

and it seems to me and not just I'd like

1489
01:01:32,750 --> 01:01:30,720
to know what NASA is doing I'd like to

1490
01:01:36,140 --> 01:01:32,760
know what distributed computers doing

1491
01:01:38,210 --> 01:01:36,150
and I'm very into here with the Museum

1492
01:01:41,660 --> 01:01:38,220
of Flight if there's any plans to have a

1493
01:01:44,780 --> 01:01:41,670
renewable fuel display here i'm

1494
01:01:49,430 --> 01:01:44,790
imagining algae algae that's been

1495
01:01:53,839 --> 01:01:49,440
genetically modified to produce kerosene

1496
01:01:55,970 --> 01:01:53,849
or something akin to that versus swamp

1497
01:01:58,820 --> 01:01:55,980
gas and then enclosing have another

1498
01:02:00,589 --> 01:01:58,830
question about efficiency is there is

1499
01:02:04,880 --> 01:02:00,599
there really a good reason that that

1500
01:02:07,430 --> 01:02:04,890
door is open I'm not kidding it seems I

1501
01:02:10,180 --> 01:02:07,440
feel cold air coming in I see natural

1502
01:02:14,300 --> 01:02:10,190
light which of course is unsettling and

1503
01:02:17,839 --> 01:02:14,310
and I hear a lot of noise that you guys

1504
01:02:20,599 --> 01:02:17,849
have to overcome so this to me i think

1505
01:02:23,030 --> 01:02:20,609
if i understand it biofuels would be

1506
01:02:25,609 --> 01:02:23,040
part of the future for national security

1507
01:02:28,220 --> 01:02:25,619
reasons but also for this fundamental

1508
01:02:31,060 --> 01:02:28,230
bigger idea especially in space

1509
01:02:33,589 --> 01:02:31,070
exploration we have to do more with less

1510
01:02:36,140 --> 01:02:33,599
so I'm looking forward to hear your

1511
01:02:38,180 --> 01:02:36,150
answers thanks Bill Bob please take take

1512
01:02:40,220 --> 01:02:38,190
a crack at the discussion on biofuels

1513
01:02:45,109 --> 01:02:40,230

yeah I think I'm not sure I can answer

1514
01:02:47,750 --> 01:02:45,119
the door issue but on the at least on

1515
01:02:51,829 --> 01:02:47,760
the Aviators side so NASA is working in

1516
01:02:55,880 --> 01:02:51,839
partnership with DoD FAA and industry on

1517
01:02:58,310 --> 01:02:55,890
the the overall life cycle issues

1518
01:03:00,059 --> 01:02:58,320
associated with biofuels so that the

1519
01:03:02,519 --> 01:03:00,069
piece that we're working on that now

1520
01:03:06,180 --> 01:03:02,529
working on is the characterization of

1521
01:03:09,390 --> 01:03:06,190
those fuels in the engines in the

1522
01:03:11,789 --> 01:03:09,400
systems and so forth so others are are

1523
01:03:14,459 --> 01:03:11,799
working more of the the development of

1524
01:03:17,459 --> 01:03:14,469
the the fuels themselves and and and the

1525
01:03:19,799 --> 01:03:17,469
especially the de and so forth and the

1526
01:03:23,430 --> 01:03:19,809
scaling of those and the production but

1527
01:03:25,499 --> 01:03:23,440
but one of the key issues in aviation is

1528
01:03:26,789 --> 01:03:25,509
the you got to be able to drop basically

1529
01:03:28,259 --> 01:03:26,799
we call it drop-in fuels gotta build

1530
01:03:29,789 --> 01:03:28,269
Raupp the fuel and you got able to use

1531
01:03:32,039 --> 01:03:29,799
current systems so we have to

1532
01:03:34,979 --> 01:03:32,049
characterize make sure that the that all

1533
01:03:36,599 --> 01:03:34,989
the seals you know are going to be are

1534
01:03:39,029 --> 01:03:36,609
going to keep their integrity that that

1535
01:03:41,880 --> 01:03:39,039
the mission the other aspects of

1536
01:03:43,229 --> 01:03:41,890
emissions are well characterized that we

1537
01:03:46,229 --> 01:03:43,239
get the same level performance and so

1538
01:03:47,430 --> 01:03:46,239

forth so we are in a in a really tight

1539
01:03:49,229 --> 01:03:47,440
partnership with the other government

1540
01:03:51,689 --> 01:03:49,239
agencies in industry and doing that and

1541
01:03:55,529 --> 01:03:51,699
you know a lot of progress is being made

1542
01:03:57,719 --> 01:03:55,539
we've we've had a couple of of campaigns

1543
01:03:59,400 --> 01:03:57,729
already ground campaigns where we put it

1544
01:04:01,140 --> 01:03:59,410
onto a couple vehicles that we have

1545
01:04:04,799 --> 01:04:01,150
would done this out the Dryden Flight

1546
01:04:06,479 --> 01:04:04,809
Research Center and and basically looked

1547
01:04:10,349 --> 01:04:06,489
at the what's coming out the tailpipe

1548
01:04:11,880 --> 01:04:10,359
we're where we haven't done it yet but

1549
01:04:13,499 --> 01:04:11,890
we are looking at doing a flight

1550
01:04:15,359 --> 01:04:13,509
campaign as well so actually taking up

1551
01:04:18,599 --> 01:04:15,369
flying these and then and then having

1552
01:04:21,569 --> 01:04:18,609
other aircraft in trail absorb

1553
01:04:23,759 --> 01:04:21,579
collecting the the exhaust that we can

1554
01:04:26,880 --> 01:04:23,769
measure it in flight as well so we are

1555
01:04:28,859 --> 01:04:26,890
we're quite active in that from a space

1556
01:04:32,099 --> 01:04:28,869
exploration perspective it's fascinating

1557
01:04:34,589 --> 01:04:32,109
question I'm not aware of any any

1558
01:04:37,380 --> 01:04:34,599
particular work that's directly asking

1559
01:04:40,620 --> 01:04:37,390
that question other than some

1560
01:04:42,660 --> 01:04:40,630
interesting work on aggregate the

1561
01:04:44,579 --> 01:04:42,670
potential for growing plants and algae

1562
01:04:47,449 --> 01:04:44,589
for example that would be used to make

1563
01:04:51,359 --> 01:04:47,459

fuels on Mars and there are some very

1564
01:04:55,859 --> 01:04:51,369
early preliminary studies being done to

1565
01:04:58,259 --> 01:04:55,869
ask how would you set up a greenhouse on

1566
01:05:01,590 --> 01:04:58,269
Mars that might enable for example the

1567
01:05:03,240 --> 01:05:01,600
in-situ production of some of those

1568
01:05:04,740 --> 01:05:03,250
some of those fuels for example that

1569
01:05:07,830 --> 01:05:04,750
certainly it hasn't been the focus it's

1570
01:05:09,330 --> 01:05:07,840
been food food and oxygen or has been

1571
01:05:12,000 --> 01:05:09,340
the focus so far from an exploration

1572
01:05:13,380 --> 01:05:12,010
perspective but well I would imagine

1573
01:05:15,900 --> 01:05:13,390
that will be leveraging what the

1574
01:05:19,800 --> 01:05:15,910
aircraft industry does in that in that

1575
01:05:26,100 --> 01:05:19,810
case thanks for six more friendships

1576
01:05:27,720 --> 01:05:26,110
okay Reese lumps in space enthusiasts my

1577
01:05:29,610 --> 01:05:27,730
question Connor is predicated on you

1578
01:05:31,560 --> 01:05:29,620
earlier comments John actually it's for

1579
01:05:33,480 --> 01:05:31,570
the whole panel however I kind of find

1580
01:05:35,370 --> 01:05:33,490
it a little bit ironic that what we when

1581
01:05:37,530 --> 01:05:35,380
we talk about NASA and what's held up is

1582
01:05:39,630 --> 01:05:37,540
the kind of strategic element of NASA

1583
01:05:40,860 --> 01:05:39,640
being the space shuttle as I'm sure most

1584
01:05:43,190 --> 01:05:40,870
of you on the panel know but probably

1585
01:05:46,140 --> 01:05:43,200
most people don't know is predicated on

1586
01:05:48,330 --> 01:05:46,150
1960s and 70s design at ease technology

1587
01:05:49,920 --> 01:05:48,340
so it's kind of ironic obviously that

1588
01:05:51,900 --> 01:05:49,930

we're talking about innovation and

1589
01:05:54,240 --> 01:05:51,910
technological advancement yet that that

1590
01:05:55,860 --> 01:05:54,250
the centerpiece of NASA was the space

1591
01:05:58,050 --> 01:05:55,870
shuttle which is obviously very old

1592
01:05:59,900 --> 01:05:58,060
technology but I think it gets into what

1593
01:06:03,930 --> 01:05:59,910
you're talking about dr. Myers about how

1594
01:06:06,630 --> 01:06:03,940
incredibly long it takes to to have

1595
01:06:08,130 --> 01:06:06,640
Hardware in space and I think that kind

1596
01:06:10,500 --> 01:06:08,140
of hints at where we perhaps need to

1597
01:06:12,900 --> 01:06:10,510
broaden our definition of innovation not

1598
01:06:14,700 --> 01:06:12,910
just to focus on technology but all

1599
01:06:16,710 --> 01:06:14,710
those also those things that enable

1600
01:06:18,900 --> 01:06:16,720
technology i would suggest and i'm sure

1601
01:06:20,220 --> 01:06:18,910
most of the panelists here have probably

1602
01:06:22,890 --> 01:06:20,230
heard this argument time and time again

1603
01:06:25,110 --> 01:06:22,900
that if we were to see innovation in our

1604
01:06:28,980 --> 01:06:25,120
Export Control and regulatory regime

1605
01:06:30,780 --> 01:06:28,990
that would immensely expand and forward

1606
01:06:32,580 --> 01:06:30,790
our space economy in inverted commas

1607
01:06:35,910 --> 01:06:32,590
because we don't really have a space

1608
01:06:37,980 --> 01:06:35,920
economy but it kind of also hints on

1609
01:06:40,230 --> 01:06:37,990
something that also other panelists I'm

1610
01:06:43,590 --> 01:06:40,240
sure aware of this idea of tech push

1611
01:06:45,480 --> 01:06:43,600
versus need pool jump across to the

1612
01:06:47,280 --> 01:06:45,490
pharmaceuticals industry and you see

1613
01:06:49,080 --> 01:06:47,290

that there's certainly a lot of money

1614
01:06:51,600 --> 01:06:49,090
the pharmaceuticals are pushing into

1615
01:06:53,940 --> 01:06:51,610
drugs for diabetes drugs for heart

1616
01:06:55,920 --> 01:06:53,950
disease and there are say it drugs from

1617
01:06:57,630 --> 01:06:55,930
our impotence why do they do that it's

1618
01:06:59,190 --> 01:06:57,640
because there's increasingly never

1619
01:07:02,520 --> 01:06:59,200
present need for it from the market

1620
01:07:05,100 --> 01:07:02,530
basis and so I guess my question after

1621
01:07:08,610 --> 01:07:05,110
all that is how are we going to balance

1622
01:07:10,980 --> 01:07:08,620
tech push versus a market pull when for

1623
01:07:12,780 --> 01:07:10,990
space we don't really have a market oh

1624
01:07:14,210 --> 01:07:12,790
it's just if we suddenly found a colony

1625
01:07:17,540 --> 01:07:14,220
on Mars we were

1626
01:07:20,150 --> 01:07:17,550
Sea Launch System development increase

1627
01:07:22,750 --> 01:07:20,160
or certainly the money to go to launches

1628
01:07:26,480 --> 01:07:22,760
development increase rather rapidly

1629
01:07:30,589 --> 01:07:26,490
thanks 11 one quick remark I sometimes

1630
01:07:34,700 --> 01:07:30,599
I'm approached by people who ask me why

1631
01:07:38,570 --> 01:07:34,710
why NASA is covering up evidence of life

1632
01:07:41,270 --> 01:07:38,580
on Mars and I'm fascinated by that

1633
01:07:42,800 --> 01:07:41,280
question because if we were to find life

1634
01:07:45,170 --> 01:07:42,810
on Mars what would that do to NASA's

1635
01:07:47,570 --> 01:07:45,180
budget it was skyrocket and so we if

1636
01:07:49,070 --> 01:07:47,580
there's if there's life there we're very

1637
01:07:51,640 --> 01:07:49,080
interested in finding it and we're very

1638
01:07:56,150 --> 01:07:51,650

interested in getting the word out so

1639
01:07:58,700 --> 01:07:56,160
innovation is a fascinating thing you

1640
01:08:00,650 --> 01:07:58,710
you mentioned this notion that the Space

1641
01:08:04,370 --> 01:08:00,660
Shuttle is actually taking advantage of

1642
01:08:06,910 --> 01:08:04,380
60s and 70s technology and yet it's held

1643
01:08:10,160 --> 01:08:06,920
up as one of the the great technological

1644
01:08:11,390 --> 01:08:10,170
achievements of recent time one of the

1645
01:08:14,720 --> 01:08:11,400
reasons why we're not in a position

1646
01:08:17,780 --> 01:08:14,730
today to send humans beyond the moon and

1647
01:08:19,490 --> 01:08:17,790
onto asteroids and Mars is we don't

1648
01:08:21,680 --> 01:08:19,500
actually have the technologies in hand

1649
01:08:23,360 --> 01:08:21,690
to accomplish that and so that what

1650
01:08:25,970 --> 01:08:23,370
we're doing at NASA now is trying to

1651
01:08:27,530 --> 01:08:25,980
develop the technologies to enable these

1652
01:08:29,599 --> 01:08:27,540
incredible missions so today's

1653
01:08:31,610 --> 01:08:29,609
technology has become tomorrow's

1654
01:08:33,709 --> 01:08:31,620
missions and the real question is how do

1655
01:08:36,050 --> 01:08:33,719
you shorten that life cycle so that

1656
01:08:38,300 --> 01:08:36,060
you're not having to wait 20 years from

1657
01:08:40,309 --> 01:08:38,310
the advent of a technology to when it

1658
01:08:43,070 --> 01:08:40,319
can actually be be implemented that that

1659
01:08:46,220 --> 01:08:43,080
is a huge huge challenge that were that

1660
01:08:47,809 --> 01:08:46,230
we're trying to face I wonder if any of

1661
01:08:50,420 --> 01:08:47,819
my my colleagues would like to talk

1662
01:08:53,150 --> 01:08:50,430
about this interplay between push and

1663
01:08:55,130 --> 01:08:53,160

pull in technology and once we do that

1664
01:08:56,539 --> 01:08:55,140
we'll go to our next question we have

1665
01:08:58,430 --> 01:08:56,549
about another 10 minutes and I see

1666
01:08:59,870 --> 01:08:58,440
several people waiting in line so I'd

1667
01:09:03,260 --> 01:08:59,880
really love to be able to get to all of

1668
01:09:04,970 --> 01:09:03,270
your questions if we can so I can say

1669
01:09:06,890 --> 01:09:04,980
something about the technology push and

1670
01:09:09,380 --> 01:09:06,900
pull I mean I think it's something I

1671
01:09:10,849 --> 01:09:09,390
don't think that there's a ger if that

1672
01:09:13,610 --> 01:09:10,859
we have for optimizing that right now

1673
01:09:15,079 --> 01:09:13,620
but I think it's something that you

1674
01:09:16,820 --> 01:09:15,089
don't want to suppress either side of it

1675
01:09:20,610 --> 01:09:16,830
I think that there needs to be the

1676
01:09:22,020 --> 01:09:20,620
driving you know questions from the

1677
01:09:23,910 --> 01:09:22,030
agencies that say you know we definitely

1678
01:09:25,560 --> 01:09:23,920
want people looking at these particular

1679
01:09:28,440 --> 01:09:25,570
problems to solve but you also need to

1680
01:09:31,170 --> 01:09:28,450
be engaging the general population in

1681
01:09:32,790 --> 01:09:31,180
terms of what do they want and you know

1682
01:09:34,170 --> 01:09:32,800
given make sure that they're aware of

1683
01:09:35,550 --> 01:09:34,180
the latest innovations and then just see

1684
01:09:36,840 --> 01:09:35,560
where they take them because I think you

1685
01:09:39,210 --> 01:09:36,850
just don't have any way of necessarily

1686
01:09:41,250 --> 01:09:39,220
predicting and you shouldn't so I don't

1687
01:09:43,500 --> 01:09:41,260
know that there's a fixed answer to that

1688
01:09:49,010 --> 01:09:43,510

other than we need to have activity on

1689
01:09:51,480 --> 01:09:49,020
both sides and actively engage it thanks

1690
01:09:54,390 --> 01:09:51,490
Dave Anderson retired blowing product

1691
01:09:56,610 --> 01:09:54,400
development mine is an easy question I

1692
01:09:58,320 --> 01:09:56,620
believe there are still discoveries to

1693
01:10:00,840 --> 01:09:58,330
be developed that benefit commercial air

1694
01:10:03,030 --> 01:10:00,850
transportation my interest primarily is

1695
01:10:05,310 --> 01:10:03,040
in aeronautics but I know that can be

1696
01:10:08,010 --> 01:10:05,320
linked to space exploration and even

1697
01:10:09,540 --> 01:10:08,020
underwater exploration nASA has had an

1698
01:10:11,850 --> 01:10:09,550
interest in understanding the physics of

1699
01:10:15,060 --> 01:10:11,860
flying through atmospheres other than

1700
01:10:17,640 --> 01:10:15,070
Earth's so that when we get there we can

1701
01:10:22,140 --> 01:10:17,650
move fast can you tell us about that

1702
01:10:23,790 --> 01:10:22,150
interest in progress let me let me take

1703
01:10:26,280 --> 01:10:23,800
a crack at that first of all let me

1704
01:10:28,290 --> 01:10:26,290
confess to my greatest life dream is to

1705
01:10:30,630 --> 01:10:28,300
pilot an aircraft in the in the

1706
01:10:32,640 --> 01:10:30,640
atmosphere of Mars that would for me be

1707
01:10:34,860 --> 01:10:32,650
completely fulfilling so I've been

1708
01:10:37,110 --> 01:10:34,870
looking at at this technical challenge

1709
01:10:39,210 --> 01:10:37,120
we've approached it from a couple of

1710
01:10:42,060 --> 01:10:39,220
different perspectives at NASA with with

1711
01:10:43,950 --> 01:10:42,070
mission with mission concepts some of

1712
01:10:45,810 --> 01:10:43,960
which are looking at lying in very

1713
01:10:48,570 --> 01:10:45,820

rarefied atmospheres like the one we

1714
01:10:51,090 --> 01:10:48,580
have in in Mars the Mars atmosphere at

1715
01:10:53,430 --> 01:10:51,100
at the surface of Mars is roughly

1716
01:10:55,740 --> 01:10:53,440
equivalent to a hundred thousand feet at

1717
01:10:57,690 --> 01:10:55,750
Earth so you can imagine aircraft flying

1718
01:11:00,270 --> 01:10:57,700
and Mars it look like our very high

1719
01:11:02,850 --> 01:11:00,280
altitude aircraft like the like the u2

1720
01:11:04,890 --> 01:11:02,860
or might perhaps look more like rockets

1721
01:11:07,590 --> 01:11:04,900
that are not depending on lifting

1722
01:11:10,740 --> 01:11:07,600
surfaces to to achieve their their

1723
01:11:12,390 --> 01:11:10,750
flight we're also looking at operations

1724
01:11:15,650 --> 01:11:12,400
and atmospheres in other places like in

1725
01:11:18,240 --> 01:11:15,660
Titan the moon of Saturn and it has a

1726
01:11:20,340 --> 01:11:18,250
fascinating atmosphere that's much more

1727
01:11:22,730 --> 01:11:20,350
dense than the one I just mentioned at

1728
01:11:25,320 --> 01:11:22,740
Mars and it turns out that balloons are

1729
01:11:28,050 --> 01:11:25,330
one of the more optimal systems for

1730
01:11:31,350 --> 01:11:28,060
exploring around Titan to find some

1731
01:11:32,730 --> 01:11:31,360
perhaps biological precursors for life

1732
01:11:35,400 --> 01:11:32,740
that we've only found as

1733
01:11:37,200 --> 01:11:35,410
as organic compounds are evidence of

1734
01:11:39,330 --> 01:11:37,210
organic compounds now and we're

1735
01:11:44,310 --> 01:11:39,340
wondering what what might be there next

1736
01:11:47,700 --> 01:11:44,320
so Ariel atmospheric flight in planetary

1737
01:11:49,980 --> 01:11:47,710
exploration is a very rich research area

1738
01:11:52,200 --> 01:11:49,990

at NASA and we're looking to take the

1739
01:11:54,300 --> 01:11:52,210
next steps in actual mission concepts

1740
01:11:56,600 --> 01:11:54,310
for how we might execute some of those

1741
01:12:00,810 --> 01:11:56,610
some of those missions in the future

1742
01:12:06,000 --> 01:12:00,820
Thank You Ryan lobster justice

1743
01:12:08,640 --> 01:12:06,010
technologies I Roger Myers outlined all

1744
01:12:10,830 --> 01:12:08,650
the technologies that are available for

1745
01:12:12,330 --> 01:12:10,840
in space propulsion but what about the

1746
01:12:14,250 --> 01:12:12,340
hard part which is from the surface of

1747
01:12:15,570 --> 01:12:14,260
the earth to low-earth orbit so my

1748
01:12:17,840 --> 01:12:15,580
question of the panel is what do you

1749
01:12:19,920 --> 01:12:17,850
think the next new paradigm for

1750
01:12:22,340 --> 01:12:19,930
propulsion from the surface of the earth

1751
01:12:25,440 --> 01:12:22,350
to low-earth orbit is going to be

1752
01:12:27,660 --> 01:12:25,450
broader would you take that sure when

1753
01:12:30,540 --> 01:12:27,670
you say new paradigm I mean that we've

1754
01:12:34,740 --> 01:12:30,550
done studies of being power launches

1755
01:12:36,270 --> 01:12:34,750
we've done air launches air launched in

1756
01:12:37,920 --> 01:12:36,280
fact Virgin Galactic's going to do air

1757
01:12:45,870 --> 01:12:37,930
launched their various different

1758
01:12:47,340 --> 01:12:45,880
architectures I I hesitate to say you

1759
01:12:49,410 --> 01:12:47,350
know it's the next new paradigm you know

1760
01:12:51,570 --> 01:12:49,420
one of the messages I tried to convey is

1761
01:12:55,620 --> 01:12:51,580
that it's it takes a long time to

1762
01:12:58,140 --> 01:12:55,630
transition technologies and you know if

1763
01:12:59,900 --> 01:12:58,150

we look at what space X for example of

1764
01:13:02,130 --> 01:12:59,910
don't have has done they have

1765
01:13:08,390 --> 01:13:02,140
dramatically reduced the cost of launch

1766
01:13:12,030 --> 01:13:08,400
by focusing on how to build less complex

1767
01:13:14,190 --> 01:13:12,040
vehicles and so they didn't really you

1768
01:13:16,800 --> 01:13:14,200
could say oh they they went to old

1769
01:13:18,540 --> 01:13:16,810
technology but look at the cost

1770
01:13:21,030 --> 01:13:18,550
reduction that they have enabled by

1771
01:13:23,550 --> 01:13:21,040
actually in some sense using older

1772
01:13:26,010 --> 01:13:23,560
technology and focusing instead on the

1773
01:13:28,410 --> 01:13:26,020
manufacturing flow and the way that they

1774
01:13:31,980 --> 01:13:28,420
the way that they build their their

1775
01:13:34,140 --> 01:13:31,990
systems so it's hard to predict what the

1776
01:13:35,790 --> 01:13:34,150
next new paradigm is going to be I know

1777
01:13:37,650 --> 01:13:35,800
there's a there's a program that the

1778
01:13:40,140 --> 01:13:37,660
office of the chief technologist is

1779
01:13:41,959 --> 01:13:40,150
funding now on be tried to light it's a

1780
01:13:44,490 --> 01:13:41,969
beamed power

1781
01:13:47,280 --> 01:13:44,500
system and actually we're doing one of

1782
01:13:49,200 --> 01:13:47,290
those studies you know frankly the state

1783
01:13:52,200 --> 01:13:49,210
of the art of laser technology even

1784
01:13:55,740 --> 01:13:52,210
looking out 10 or 20 years makes me

1785
01:13:59,040 --> 01:13:55,750
personally concerned about the real

1786
01:14:02,820 --> 01:13:59,050
feasibility of that architecture so I'm

1787
01:14:05,940 --> 01:14:02,830
not sure that that we're going to see

1788
01:14:08,370 --> 01:14:05,950

huge differences in terms of a paradigm

1789
01:14:11,670 --> 01:14:08,380
shift and launch technology just given

1790
01:14:14,880 --> 01:14:11,680
the reality of how much energy it does

1791
01:14:16,170 --> 01:14:14,890
take i will say that i take i do take

1792
01:14:18,479 --> 01:14:16,180
some exception to your characterization

1793
01:14:20,760 --> 01:14:18,489
of launch as the hard part look at the

1794
01:14:22,890 --> 01:14:20,770
total mission and the energy balance of

1795
01:14:24,630 --> 01:14:22,900
the whole mission and you will find that

1796
01:14:26,520 --> 01:14:24,640
actually you need to do both you can't

1797
01:14:28,530 --> 01:14:26,530
say that one is necessarily harder than

1798
01:14:30,540 --> 01:14:28,540
the other we're focused on launch now

1799
01:14:32,370 --> 01:14:30,550
with the Commercial Crew and the cots

1800
01:14:35,790 --> 01:14:32,380
programs that we heard about before and

1801
01:14:38,760 --> 01:14:35,800
the SLS because that's where we are but

1802
01:14:40,709 --> 01:14:38,770
if we want to go beyond the oh look at

1803
01:14:44,940 --> 01:14:40,719
the total energy and you will see you

1804
01:14:49,459 --> 01:14:44,950
need to do both a very effective job at

1805
01:14:51,810 --> 01:14:49,469
getting affordable systems in both areas

1806
01:14:53,610 --> 01:14:51,820
thanks Roger we have about five minutes

1807
01:14:57,090 --> 01:14:53,620
left and I'd like to sort of go to the

1808
01:14:58,470 --> 01:14:57,100
lightning round questianus questions and

1809
01:14:59,729 --> 01:14:58,480
answers so if you could be as succinct

1810
01:15:02,430 --> 01:14:59,739
as possible and we'll try to do the same

1811
01:15:06,840 --> 01:15:02,440
do my best Meredith Anderson flight

1812
01:15:08,910 --> 01:15:06,850
tests at Boeing the panel mentioned two

1813
01:15:12,150 --> 01:15:08,920

technologies blended wing body and pilot

1814
01:15:15,150 --> 01:15:12,160
on the ground technologies that the the

1815
01:15:17,880 --> 01:15:15,160
technological side exists but there's a

1816
01:15:19,500 --> 01:15:17,890
human factor challenge and that's really

1817
01:15:21,560 --> 01:15:19,510
hard for industry to break through is

1818
01:15:25,110 --> 01:15:21,570
there any sort of national international

1819
01:15:27,780 --> 01:15:25,120
social networking campaign to help with

1820
01:15:30,479 --> 01:15:27,790
the human perception side of things yes

1821
01:15:32,970 --> 01:15:30,489
so let's see lightning round so I'm

1822
01:15:36,750 --> 01:15:32,980
getting you're absolutely right big

1823
01:15:39,479 --> 01:15:36,760
issue that the history has been for new

1824
01:15:41,130 --> 01:15:39,489
configuration like that we we look to

1825
01:15:43,020 --> 01:15:41,140
try to partner with the military with

1826
01:15:45,900 --> 01:15:43,030
DoD to see if they've got a mission that

1827
01:15:48,540 --> 01:15:45,910
that works mature it there and then

1828
01:15:50,459 --> 01:15:48,550
transition it to to the civil sector and

1829
01:15:52,030 --> 01:15:50,469
honestly for things like hyper booing

1830
01:15:54,070 --> 01:15:52,040
body and things like that I see the

1831
01:15:55,330 --> 01:15:54,080
same I think we got look there we got to

1832
01:15:56,830 --> 01:15:55,340
see if we can make that work with the

1833
01:15:58,600 --> 01:15:56,840
military because that's the best way to

1834
01:16:00,100 --> 01:15:58,610
get these things in full scale and get

1835
01:16:02,460 --> 01:16:00,110
them out and then get some experience

1836
01:16:05,770 --> 01:16:02,470
then transition to the civil sector

1837
01:16:07,750 --> 01:16:05,780
Thanks get my name is Bruce kidman from

1838
01:16:10,270 --> 01:16:07,760

NASA Ames I guess a question I'd like to

1839
01:16:12,370 --> 01:16:10,280
ask is following up on lori garver

1840
01:16:15,460 --> 01:16:12,380
comments about that the difficulty of

1841
01:16:17,230 --> 01:16:15,470
bringing new technology in the battle

1842
01:16:19,480 --> 01:16:17,240
between the past and the future in

1843
01:16:22,030 --> 01:16:19,490
aerospace and I guess my question for

1844
01:16:23,320 --> 01:16:22,040
the panel is why has it been easier to

1845
01:16:26,170 --> 01:16:23,330
do that in other industries like

1846
01:16:28,570 --> 01:16:26,180
personal computers and and and software

1847
01:16:31,600 --> 01:16:28,580
and so much more difficult in in

1848
01:16:34,810 --> 01:16:31,610
aerospace to to make these technological

1849
01:16:36,250 --> 01:16:34,820
advancements and and and evolve the the

1850
01:16:39,730 --> 01:16:36,260
technology and is there anything that we

1851
01:16:48,940 --> 01:16:39,740
can do about it to enhance that 22 words

1852
01:16:53,620 --> 01:16:48,950
Bruce risk tolerance money I would also

1853
01:16:55,930 --> 01:16:53,630
say profit motive right on point for me

1854
01:16:57,970 --> 01:16:55,940
my name is Chen McBrayer I'm a trustee

1855
01:17:00,100 --> 01:16:57,980
of the museum a museum of flight a

1856
01:17:02,290 --> 01:17:00,110
private pilot on an experimental

1857
01:17:04,800 --> 01:17:02,300
aircraft builder so I can identify with

1858
01:17:08,500 --> 01:17:04,810
with Joseph about that and his brother

1859
01:17:11,370 --> 01:17:08,510
I'm also interested have been my entire

1860
01:17:14,170 --> 01:17:11,380
career in economic energy solutions

1861
01:17:17,320 --> 01:17:14,180
underscore economic and I'm impressed

1862
01:17:19,420 --> 01:17:17,330
with how uh na macmini of our forwards

1863
01:17:22,000 --> 01:17:19,430

loop forward-looking solutions are today

1864
01:17:24,760 --> 01:17:22,010
I'd like to ask you about some

1865
01:17:27,280 --> 01:17:24,770
technology that I know NASA developed at

1866
01:17:31,750 --> 01:17:27,290
least a decade ago the concept of

1867
01:17:34,210 --> 01:17:31,760
putting in geo stationary orbit around

1868
01:17:38,470 --> 01:17:34,220
the equator a raise of photovoltaic

1869
01:17:40,750 --> 01:17:38,480
cells where it maximizes the efficiency

1870
01:17:44,410 --> 01:17:40,760
of the photovoltaics we have today and

1871
01:17:48,670 --> 01:17:44,420
beams it back to earth with demonstrated

1872
01:17:51,730 --> 01:17:48,680
microwave technology the study I saw the

1873
01:17:54,520 --> 01:17:51,740
studies I saw said that the physics is

1874
01:17:57,010 --> 01:17:54,530
clearly there the efficiencies of there

1875
01:17:59,410 --> 01:17:57,020
except for one thing the economies are

1876
01:18:02,410 --> 01:17:59,420
putting that much material in space to

1877
01:18:03,430 --> 01:18:02,420
create those arrays when are we going to

1878
01:18:05,890 --> 01:18:03,440
get Moore's

1879
01:18:08,350 --> 01:18:05,900
ought to work on that if we could solve

1880
01:18:11,200 --> 01:18:08,360
that problem I honestly believe we have

1881
01:18:12,939 --> 01:18:11,210
a long-range energy energy solution that

1882
01:18:16,000 --> 01:18:12,949
would produce enough electricity to

1883
01:18:18,040 --> 01:18:16,010
replace all of the other options by the

1884
01:18:21,070 --> 01:18:18,050
21st century what are your comments on

1885
01:18:22,780 --> 01:18:21,080
that well one of the things that I would

1886
01:18:25,740 --> 01:18:22,790
say is that putting things in

1887
01:18:28,270 --> 01:18:25,750
geosynchronous orbit takes twice the

1888
01:18:30,580 --> 01:18:28,280

typical spacecraft that is launched a

1889
01:18:32,410 --> 01:18:30,590
geosynchronous orbit is half propellant

1890
01:18:34,660 --> 01:18:32,420
and that's if you launch into

1891
01:18:36,400 --> 01:18:34,670
geosynchronous transfer orbit if you

1892
01:18:40,120 --> 01:18:36,410
launched a low-earth orbit which is the

1893
01:18:42,370 --> 01:18:40,130
lowest cost place to launch to its it's

1894
01:18:46,180 --> 01:18:42,380
a lot it's even more so you're launching

1895
01:18:49,630 --> 01:18:46,190
mostly fuel which does not make power

1896
01:18:51,189 --> 01:18:49,640
right doesn't create revenue and so one

1897
01:18:54,189 --> 01:18:51,199
of the things that we really have to do

1898
01:18:58,090 --> 01:18:54,199
is invest in systems I'm sorry but in

1899
01:19:01,720 --> 01:18:58,100
space propulsion systems to get the clot

1900
01:19:04,930 --> 01:19:01,730
the total mass that you have to get to

1901
01:19:07,030 --> 01:19:04,940
low Earth orbit down to the point where

1902
01:19:09,970 --> 01:19:07,040
you're not paying for these enormous

1903
01:19:13,720 --> 01:19:09,980
unique rockets in order to get those

1904
01:19:16,030 --> 01:19:13,730
space power systems to geo if you can

1905
01:19:18,459 --> 01:19:16,040
shrink the architecture make it more

1906
01:19:20,410 --> 01:19:18,469
affordable use rockets that aren't

1907
01:19:22,450 --> 01:19:20,420
unique to that one application but

1908
01:19:25,660 --> 01:19:22,460
instead the DoD might use commercial

1909
01:19:28,030 --> 01:19:25,670
industry and then they launch comsats if

1910
01:19:30,010 --> 01:19:28,040
you can distribute those fixed costs now

1911
01:19:31,630 --> 01:19:30,020
we're stock we're talking about really

1912
01:19:33,610 --> 01:19:31,640
changing the economics of space travel

1913
01:19:36,970 --> 01:19:33,620

and that's kind of exciting to me

1914
01:19:39,550 --> 01:19:36,980
personally sorry that was not a

1915
01:19:40,930 --> 01:19:39,560
lightning round I think well I think we

1916
01:19:44,860 --> 01:19:40,940
have time for just one more question

1917
01:19:48,360 --> 01:19:44,870
Lloyd McCracken and a question on man

1918
01:19:52,420 --> 01:19:48,370
spit Space Flight we've been in

1919
01:19:54,490 --> 01:19:52,430
low-earth orbit and we've experienced

1920
01:19:56,920 --> 01:19:54,500
long periods of time up there but big

1921
01:19:59,439 --> 01:19:56,930
challenge to go to the moon Mars

1922
01:20:02,260 --> 01:19:59,449
anything is getting outside of the

1923
01:20:05,910 --> 01:20:02,270
protective envelope of the earth once we

1924
01:20:09,790 --> 01:20:05,920
get outside that we're exposed to

1925
01:20:12,459 --> 01:20:09,800
radiation and the human factor we can

1926
01:20:15,040 --> 01:20:12,469
send robots all day long it's the human

1927
01:20:16,870 --> 01:20:15,050
factor how are we working on shielding

1928
01:20:18,669 --> 01:20:16,880
to really protect

1929
01:20:21,729 --> 01:20:18,679
to be able to actually venture outside

1930
01:20:24,550 --> 01:20:21,739
low-earth orbit thank you for raising

1931
01:20:26,290 --> 01:20:24,560
that because it is it is actually ironic

1932
01:20:27,820 --> 01:20:26,300
that when I talk with my colleagues at

1933
01:20:29,470 --> 01:20:27,830
the Johnson Space Center in Houston and

1934
01:20:31,360 --> 01:20:29,480
ask them what do they think are the

1935
01:20:34,270 --> 01:20:31,370
biggest technological challenges to

1936
01:20:36,629 --> 01:20:34,280
going beyond the moon they talk about

1937
01:20:39,640 --> 01:20:36,639
radiation and they talk about psychology

1938
01:20:41,919 --> 01:20:39,650

group psychology on these extremely long

1939
01:20:43,510 --> 01:20:41,929
missions could be one of the the biggest

1940
01:20:45,520 --> 01:20:43,520
challenges that we face but let me come

1941
01:20:47,320 --> 01:20:45,530
back to the point of radiation and talk

1942
01:20:49,300 --> 01:20:47,330
about some fascinating new technologies

1943
01:20:52,479 --> 01:20:49,310
that we're looking at one method of

1944
01:20:54,340 --> 01:20:52,489
shielding for radiation is to put large

1945
01:20:56,530 --> 01:20:54,350
heavy things in between you and what

1946
01:20:58,419 --> 01:20:56,540
you're afraid of that might be water

1947
01:21:00,939 --> 01:20:58,429
that might be led it depends on the on

1948
01:21:02,760 --> 01:21:00,949
the style of the threat one thing that

1949
01:21:07,209 --> 01:21:02,770
we're looking at at NASA is making

1950
01:21:10,090 --> 01:21:07,219
magnetospheric spheres shields if you

1951
01:21:12,820 --> 01:21:10,100
will that way nothing and require only

1952
01:21:15,189 --> 01:21:12,830
power to achieve that help to block

1953
01:21:18,129 --> 01:21:15,199
radiation coming in that would be a risk

1954
01:21:20,500 --> 01:21:18,139
to the crew and and to the avionics on

1955
01:21:21,910 --> 01:21:20,510
on a spacecraft and this is one of one

1956
01:21:24,970 --> 01:21:21,920
of the ideas that has come through our

1957
01:21:28,120 --> 01:21:24,980
nayak program NASA institute for

1958
01:21:30,520 --> 01:21:28,130
advanced concepts and NASA innovative

1959
01:21:31,990 --> 01:21:30,530
advanced concepts now is the name of the

1960
01:21:33,850 --> 01:21:32,000
program and we're looking at these

1961
01:21:36,189 --> 01:21:33,860
really advanced ideas for trying to

1962
01:21:37,090 --> 01:21:36,199
address issues like like radiation and I

1963
01:21:38,620 --> 01:21:37,100

think that we may have some

1964
01:21:40,479 --> 01:21:38,630
breakthroughs on this in the next ten

1965
01:21:42,790 --> 01:21:40,489
years or so but it's at very low

1966
01:21:44,680 --> 01:21:42,800
technology readiness right now and we've

1967
01:21:47,229 --> 01:21:44,690
only come to really appreciate the

1968
01:21:49,540 --> 01:21:47,239
challenge that we're facing not solving

1969
01:21:52,060 --> 01:21:49,550
this problem with with heavy massive

1970
01:21:56,800 --> 01:21:52,070
things but much cleverer ideas and

1971
01:21:58,899 --> 01:21:56,810
achieve the same same end so i think i

1972
01:22:00,910 --> 01:21:58,909
think that brings the our panel

1973
01:22:03,939 --> 01:22:00,920
discussion on innovation to a conclusion

1974
01:22:07,060 --> 01:22:03,949
i'd really like to thank my colleagues

1975
01:22:09,129 --> 01:22:07,070
bob christie roger ed for their very

1976
01:22:11,470 --> 01:22:09,139
insightful comments and thank you the

1977
01:22:13,930 --> 01:22:11,480
audience for your wonderful thoughts and

1978
01:22:16,959 --> 01:22:13,940
ideas and please keep the discussion

1979
01:22:27,330 --> 01:22:16,969
going and let's keep paving our way to