



1
00:00:07,829 --> 00:00:05,910
good afternoon everyone this is the

2
00:00:10,310 --> 00:00:07,839
mission science briefing for the

3
00:00:11,990 --> 00:00:10,320
magnetospheric multi-scale mission or

4
00:00:13,910 --> 00:00:12,000
mms

5
00:00:16,070 --> 00:00:13,920
and we'd like to show you something

6
00:00:18,630 --> 00:00:16,080
first before we go to our briefers

7
00:00:21,990 --> 00:00:18,640
earlier this morning about 5 after 10 we

8
00:00:24,550 --> 00:00:22,000
rolled out the atlas 5 rocket from the

9
00:00:26,310 --> 00:00:24,560
vertical integration facility at launch

10
00:00:28,950 --> 00:00:26,320
complex 41

11
00:00:32,870 --> 00:00:28,960
out to the launch pad

12
00:00:34,950 --> 00:00:32,880
we see the 53rd atlas v to be launched

13
00:00:38,470 --> 00:00:34,960

this is nasa's 12th

14

00:00:40,709 --> 00:00:38,480
and once the atlas v lifts off

15

00:00:42,389 --> 00:00:40,719
tomorrow night it's a fairly lengthy

16

00:00:45,190 --> 00:00:42,399
flight in comparison to some others

17

00:00:48,069 --> 00:00:45,200
it'll be an hour and 47 minutes and 12

18

00:00:50,709 --> 00:00:48,079
seconds until the last mms spacecraft

19

00:00:55,110 --> 00:00:52,630
right now i would like to

20

00:00:56,790 --> 00:00:55,120
begin talking about our mission that's

21

00:00:59,990 --> 00:00:56,800
coming up starting

22

00:01:02,709 --> 00:01:00,000
first with jeff newmark the interim

23

00:01:06,950 --> 00:01:02,719
director for the heliophysics division

24

00:01:11,910 --> 00:01:09,429
jim burch the principal investigator for

25

00:01:14,469 --> 00:01:11,920
the mms instrument suite science team

26
00:01:17,350 --> 00:01:14,479
from the southwest research institute in

27
00:01:20,230 --> 00:01:17,360
san antonio

28
00:01:21,749 --> 00:01:20,240
roy torbert the mms fields investigation

29
00:01:26,070 --> 00:01:21,759
lead from the university of new

30
00:01:28,630 --> 00:01:26,080
hampshire at durham new hampshire

31
00:01:31,670 --> 00:01:28,640
craig the lead co-investigator

32
00:01:33,590 --> 00:01:31,680
for the mms fast plasma investigation

33
00:01:36,550 --> 00:01:33,600
from nasa's goddard space flight center

34
00:01:38,630 --> 00:01:36,560
in greenbelt maryland

35
00:01:40,390 --> 00:01:38,640
and paul kasich

36
00:01:42,230 --> 00:01:40,400
the associate professor

37
00:01:45,429 --> 00:01:42,240
from west virginia university at

38
00:01:47,830 --> 00:01:45,439

morgantown west virginia

39

00:01:48,789 --> 00:01:47,840

and we'll begin first with jeff newmark

40

00:01:50,870 --> 00:01:48,799

jeff

41

00:01:53,109 --> 00:01:50,880

thank you george good afternoon everyone

42

00:01:56,389 --> 00:01:53,119

i'm really pleased to be here today to

43

00:01:58,310 --> 00:01:56,399

talk about magnetospheric multi-scale

44

00:02:00,469 --> 00:01:58,320

or mms or

45

00:02:02,230 --> 00:02:00,479

this is a lot of complex words you're

46

00:02:05,350 --> 00:02:02,240

hearing these days magnetosphere

47

00:02:08,630 --> 00:02:05,360

multi-scale magnetic reconnection

48

00:02:10,949 --> 00:02:08,640

heliophysics uh i hope that all this

49

00:02:13,430 --> 00:02:10,959

briefing next few minutes we can we can

50

00:02:15,270 --> 00:02:13,440

simplify this kind of introduce you to

51
00:02:18,070 --> 00:02:15,280
the subject and why we're really so

52
00:02:20,070 --> 00:02:18,080
excited here at nasa about this

53
00:02:21,910 --> 00:02:20,080
let's start off with heliophysics what

54
00:02:23,270 --> 00:02:21,920
is heliophysics heliophysics is the

55
00:02:25,110 --> 00:02:23,280
study of the sun

56
00:02:27,510 --> 00:02:25,120
and its interaction with the earth and

57
00:02:29,190 --> 00:02:27,520
the solar system including what we call

58
00:02:30,630 --> 00:02:29,200
space weather

59
00:02:32,550 --> 00:02:30,640
what is this going to do for us well

60
00:02:35,030 --> 00:02:32,560
we're looking to answer big questions

61
00:02:36,630 --> 00:02:35,040
like why does the sun vary

62
00:02:38,309 --> 00:02:36,640
how does the space environment around

63
00:02:39,430 --> 00:02:38,319

the planets

64

00:02:41,350 --> 00:02:39,440

react

65

00:02:43,509 --> 00:02:41,360

and what are the impacts on humanity in

66

00:02:47,030 --> 00:02:43,519

our technological society all of these

67

00:02:48,949 --> 00:02:47,040

are what we study in heliophysics

68

00:02:51,670 --> 00:02:48,959

in fact the earth and all the other

69

00:02:53,670 --> 00:02:51,680

planets are embedded in the extended

70

00:02:55,509 --> 00:02:53,680

atmosphere of the sun where actually

71

00:02:57,270 --> 00:02:55,519

these charged particles stream from the

72

00:02:59,110 --> 00:02:57,280

sun all the time and we live within this

73

00:03:03,509 --> 00:02:59,120

environment

74

00:03:05,350 --> 00:03:03,519

this we're actually a single system

75

00:03:07,750 --> 00:03:05,360

that's what heliophysics is about it's

76
00:03:08,550 --> 00:03:07,760
studying the connected system from the

77
00:03:10,790 --> 00:03:08,560
sun

78
00:03:11,990 --> 00:03:10,800
to our space environment around us to

79
00:03:13,750 --> 00:03:12,000
the edges of what we call the

80
00:03:16,790 --> 00:03:13,760
heliosphere this bubble around the

81
00:03:18,470 --> 00:03:16,800
entire solar system

82
00:03:20,470 --> 00:03:18,480
when we

83
00:03:21,990 --> 00:03:20,480
just really understand this i'd like to

84
00:03:24,390 --> 00:03:22,000
follow take you on a journey a journey

85
00:03:27,030 --> 00:03:24,400
of space weather a journey that starts

86
00:03:28,390 --> 00:03:27,040
in the interior of the sun

87
00:03:29,270 --> 00:03:28,400
and

88
00:03:32,789 --> 00:03:29,280

the

89

00:03:35,990 --> 00:03:32,799

magnetic field

90

00:03:38,390 --> 00:03:36,000

then gets

91

00:03:39,990 --> 00:03:38,400

wrapped around itself and the sun as the

92

00:03:42,309 --> 00:03:40,000

sun rotates

93

00:03:45,750 --> 00:03:42,319

and let's see what happens when that uh

94

00:03:50,070 --> 00:03:47,910

we're looking at is the sun in the outer

95

00:03:52,630 --> 00:03:50,080

atmosphere of the sun the bright areas

96

00:03:55,030 --> 00:03:52,640

are areas where the magnetic field is

97

00:03:57,990 --> 00:03:55,040

really concentrated and you'll see off

98

00:04:00,710 --> 00:03:58,000

on the left side of the sun a tremendous

99

00:04:03,750 --> 00:04:00,720

explosion a slower flare what we call

100

00:04:06,550 --> 00:04:03,760

coronal mass ejection or a solar storm

101
00:04:08,630 --> 00:04:06,560
these storms contain a billion tons of

102
00:04:11,670 --> 00:04:08,640
material traveling a million miles an

103
00:04:13,589 --> 00:04:11,680
hour throughout interplanetary space

104
00:04:15,190 --> 00:04:13,599
occasionally they come right to the

105
00:04:16,069 --> 00:04:15,200
earth

106
00:04:18,069 --> 00:04:16,079
where

107
00:04:19,670 --> 00:04:18,079
fortunately we have a the earth has its

108
00:04:21,749 --> 00:04:19,680
own magnetic field

109
00:04:24,310 --> 00:04:21,759
and we ex this magnetic field extends

110
00:04:26,230 --> 00:04:24,320
into space we call it a magnetosphere

111
00:04:29,510 --> 00:04:26,240
that's what we'll be studying the area

112
00:04:31,110 --> 00:04:29,520
the region that mms will be flying in

113
00:04:33,430 --> 00:04:31,120

it interacts though

114

00:04:35,749 --> 00:04:33,440

in each of these stages from the initial

115

00:04:38,469 --> 00:04:35,759

flare that we saw at the sun that is

116

00:04:41,189 --> 00:04:38,479

caused by magnetic reconnection

117

00:04:43,270 --> 00:04:41,199

as that giant solar storm gets driven

118

00:04:44,469 --> 00:04:43,280

from the sun that's released by magnetic

119

00:04:47,110 --> 00:04:44,479

reconnection

120

00:04:49,510 --> 00:04:47,120

as the storm interacts with the earth's

121

00:04:51,510 --> 00:04:49,520

magnetosphere that interaction again is

122

00:04:54,790 --> 00:04:51,520

magnetic reconnection so this entire

123

00:04:58,230 --> 00:04:54,800

journey is a story of space weather

124

00:05:00,790 --> 00:04:58,240

geophysics and magnetic reconnection

125

00:05:02,550 --> 00:05:00,800

a really exciting event just happened

126

00:05:04,230 --> 00:05:02,560

earlier this morning there was an x

127

00:05:07,029 --> 00:05:04,240

flare on the sun this is the largest

128

00:05:09,029 --> 00:05:07,039

class flare that we classify as stores

129

00:05:10,790 --> 00:05:09,039

and this same kind of series of events

130

00:05:13,189 --> 00:05:10,800

this was on the front facing side of the

131

00:05:14,710 --> 00:05:13,199

sun and the same series of events is

132

00:05:17,670 --> 00:05:14,720

actually going to be unfolding in front

133

00:05:19,590 --> 00:05:17,680

of our eyes over the next few days so

134

00:05:22,550 --> 00:05:19,600

we're really excited

135

00:05:25,189 --> 00:05:22,560

how does heliophysics study these events

136

00:05:28,550 --> 00:05:25,199

well if you'll see in my next slide

137

00:05:30,150 --> 00:05:28,560

healing physics we actually have a

138

00:05:32,310 --> 00:05:30,160

fleet of

139

00:05:34,150 --> 00:05:32,320

missions we call the heliophysics system

140

00:05:36,230 --> 00:05:34,160

observatory we actually have 18 missions

141

00:05:38,950 --> 00:05:36,240

with 29 spacecraft

142

00:05:41,350 --> 00:05:38,960

throughout interplanetary space some

143

00:05:43,270 --> 00:05:41,360

around earth earth orbit some going

144

00:05:45,590 --> 00:05:43,280

towards closer to the sun some going

145

00:05:47,830 --> 00:05:45,600

around to the far side of the sun

146

00:05:49,749 --> 00:05:47,840

and we study all this whole link system

147

00:05:52,469 --> 00:05:49,759

that i was just talking about

148

00:05:54,310 --> 00:05:52,479

from the interior of the sun through the

149

00:05:55,670 --> 00:05:54,320

release of the magnetic reconnection the

150

00:05:57,670 --> 00:05:55,680

flare in the sun

151
00:05:59,510 --> 00:05:57,680
watching that material stream throughout

152
00:06:02,790 --> 00:05:59,520
interplanetary space we can actually see

153
00:06:05,270 --> 00:06:02,800
it today through our stereo spacecraft

154
00:06:08,070 --> 00:06:05,280
impacting the earth's magnetosphere and

155
00:06:10,230 --> 00:06:08,080
that's where mms comes in

156
00:06:12,070 --> 00:06:10,240
the part that's been missing i've

157
00:06:14,070 --> 00:06:12,080
mentioned magnetic reconnection but we

158
00:06:16,469 --> 00:06:14,080
don't understand the physics we don't

159
00:06:19,189 --> 00:06:16,479
understand the details it's a word but

160
00:06:20,469 --> 00:06:19,199
the actual details we really don't know

161
00:06:22,870 --> 00:06:20,479
yet and that's what we're going to learn

162
00:06:24,790 --> 00:06:22,880
mms is really going to teach us that

163
00:06:26,150 --> 00:06:24,800

so my last video

164

00:06:28,950 --> 00:06:26,160

i'm going to introduce you just to the

165

00:06:31,189 --> 00:06:28,960

mission itself a little bit

166

00:06:34,550 --> 00:06:31,199

we see the solar storm like the one

167

00:06:37,510 --> 00:06:34,560

that's coming our way now from the sun

168

00:06:39,189 --> 00:06:37,520

this impacts the

169

00:06:43,029 --> 00:06:39,199

earth's magnetosphere

170

00:06:44,870 --> 00:06:43,039

mms will have four spacecraft

171

00:06:46,790 --> 00:06:44,880

because you'll hear much more about the

172

00:06:48,309 --> 00:06:46,800

spacecraft

173

00:06:50,790 --> 00:06:48,319

traveling around the earth through this

174

00:06:52,309 --> 00:06:50,800

magnetic the magnetosphere this region

175

00:06:54,870 --> 00:06:52,319

sampling the magnetic reconnection

176

00:06:57,830 --> 00:06:54,880

itself using our magnetosphere as a

177

00:06:59,189 --> 00:06:57,840

laboratory an actual laboratory in space

178

00:07:01,670 --> 00:06:59,199

that we didn't have to build nature

179

00:07:03,510 --> 00:07:01,680

built it for us and so

180

00:07:06,070 --> 00:07:03,520

to learn and how each one of these

181

00:07:08,390 --> 00:07:06,080

stages of magnetic reconnection occur so

182

00:07:10,469 --> 00:07:08,400

we're really thrilled uh to see this

183

00:07:12,950 --> 00:07:10,479

launch tomorrow and i hope you can

184

00:07:14,070 --> 00:07:12,960

follow us on this journey and to give

185

00:07:15,670 --> 00:07:14,080

you some of the details about the

186

00:07:17,830 --> 00:07:15,680

science i'd like to pass over to jim

187

00:07:20,150 --> 00:07:17,840

burch thank you jeff it's very difficult

188

00:07:22,309 --> 00:07:20,160

for me to appreciate how excited we all

189

00:07:23,909 --> 00:07:22,319

are about the launch of mms we've worked

190

00:07:25,430 --> 00:07:23,919

10 years with a large science and

191

00:07:27,029 --> 00:07:25,440

engineering team

192

00:07:29,029 --> 00:07:27,039

working with us at southwest resource

193

00:07:32,550 --> 00:07:29,039

institute at university of new hampshire

194

00:07:34,230 --> 00:07:32,560

ucla applied physics lab and a large

195

00:07:36,309 --> 00:07:34,240

science and instrument and engineering

196

00:07:38,230 --> 00:07:36,319

team at goddard space flight center and

197

00:07:40,230 --> 00:07:38,240

all of these all of these individuals

198

00:07:42,390 --> 00:07:40,240

work together very well we're all very

199

00:07:44,870 --> 00:07:42,400

happy we'd do it again in a minute

200

00:07:46,790 --> 00:07:44,880

now what's the mission about as jeff

201
00:07:48,710 --> 00:07:46,800
said it's about magnetic fields

202
00:07:51,029 --> 00:07:48,720
throughout the universe magnetic fields

203
00:07:52,390 --> 00:07:51,039
are continuously being generated and

204
00:07:54,230 --> 00:07:52,400
destroyed

205
00:07:56,869 --> 00:07:54,240
now the generation part is not

206
00:07:58,150 --> 00:07:56,879
completely understood but it's uh we

207
00:08:00,309 --> 00:07:58,160
have a better idea of what's happening

208
00:08:01,909 --> 00:08:00,319
this is caused by a dynamo effect where

209
00:08:04,869 --> 00:08:01,919
if you have a conducting fluid or a

210
00:08:07,189 --> 00:08:04,879
conducting gas that starts in motion

211
00:08:08,230 --> 00:08:07,199
with a rotating body like a star or sun

212
00:08:10,390 --> 00:08:08,240
or planet

213
00:08:12,469 --> 00:08:10,400

then you can create the magnetic fields

214

00:08:14,070 --> 00:08:12,479

the destruction part is more difficult

215

00:08:15,430 --> 00:08:14,080

we know that it's caused by magnetic

216

00:08:17,510 --> 00:08:15,440

reconnection

217

00:08:19,990 --> 00:08:17,520

with two magnetic fields in adjacent

218

00:08:21,909 --> 00:08:20,000

regions or even a magnetic field in a

219

00:08:23,270 --> 00:08:21,919

loop type configuration which i'll show

220

00:08:25,430 --> 00:08:23,280

in the same region

221

00:08:27,589 --> 00:08:25,440

at the base can reconnect and destroy

222

00:08:29,189 --> 00:08:27,599

magnetic field energy

223

00:08:31,110 --> 00:08:29,199

we know what happens we know it genera

224

00:08:33,430 --> 00:08:31,120

it converts that energy to high energy

225

00:08:35,350 --> 00:08:33,440

charged particles and heat we just don't

226

00:08:37,509 --> 00:08:35,360

know what causes it to happen because

227

00:08:39,670 --> 00:08:37,519

these processes happen at the smallest

228

00:08:42,389 --> 00:08:39,680

scale of the plasma which is the

229

00:08:44,949 --> 00:08:42,399

electron scale and any previous mission

230

00:08:47,910 --> 00:08:44,959

has fallen short by a factor of 100 of

231

00:08:50,470 --> 00:08:47,920

investigating that scale so this is why

232

00:08:52,389 --> 00:08:50,480

mms was given such a high priority for

233

00:08:54,790 --> 00:08:52,399

the nation by the national academy about

234

00:08:55,990 --> 00:08:54,800

12 years ago and this is why nasa picked

235

00:08:58,710 --> 00:08:56,000

up on that

236

00:08:59,910 --> 00:08:58,720

and implemented the mission i mentioned

237

00:09:01,430 --> 00:08:59,920

how

238

00:09:04,150 --> 00:09:01,440

you know this happens we want to know

239

00:09:05,829 --> 00:09:04,160

more but how does it affect us

240

00:09:07,430 --> 00:09:05,839

jeff mentioned that

241

00:09:09,350 --> 00:09:07,440

as well

242

00:09:10,630 --> 00:09:09,360

reconnection is the engine that drives

243

00:09:14,790 --> 00:09:10,640

space weather

244

00:09:17,509 --> 00:09:14,800

flares you have energetic particles from

245

00:09:18,630 --> 00:09:17,519

the sun you have the auroras magnetic

246

00:09:20,310 --> 00:09:18,640

storms

247

00:09:22,389 --> 00:09:20,320

all of these things every single one of

248

00:09:24,070 --> 00:09:22,399

them are driven by reconnection

249

00:09:26,710 --> 00:09:24,080

so we're not setting out here to solve

250

00:09:28,150 --> 00:09:26,720

space weather we're setting out to learn

251

00:09:29,829 --> 00:09:28,160

the fundamental

252

00:09:32,070 --> 00:09:29,839

features of magnetic reconnection

253

00:09:33,750 --> 00:09:32,080

because that's what drives space weather

254

00:09:35,509 --> 00:09:33,760

someone else can take that and use it

255

00:09:37,509 --> 00:09:35,519

for predictions if they want

256

00:09:40,070 --> 00:09:37,519

now reconnection also happens in the

257

00:09:42,389 --> 00:09:40,080

laboratory there are people for 20 years

258

00:09:44,310 --> 00:09:42,399

or more who've been trying to harness

259

00:09:45,829 --> 00:09:44,320

nuclear fusion

260

00:09:48,150 --> 00:09:45,839

by trapping

261

00:09:49,990 --> 00:09:48,160

particles in a donut shaped magnetic

262

00:09:52,150 --> 00:09:50,000

field and heating these up to something

263

00:09:54,630 --> 00:09:52,160

like 100 million degrees

264

00:09:56,230 --> 00:09:54,640

when the fusion starts happening if you

265

00:09:58,070 --> 00:09:56,240

could maintain that we will have solved

266

00:09:59,990 --> 00:09:58,080

the energy crisis

267

00:10:01,829 --> 00:10:00,000

trouble is it always crashes these

268

00:10:04,070 --> 00:10:01,839

temperatures always come down

269

00:10:05,910 --> 00:10:04,080

repeatedly and on the plot it looks like

270

00:10:07,269 --> 00:10:05,920

the blades of a saw which is called a

271

00:10:09,509 --> 00:10:07,279

sawtooth crash

272

00:10:11,269 --> 00:10:09,519

caused by magnetic reconnection so we

273

00:10:13,670 --> 00:10:11,279

looked closely with the people that got

274

00:10:15,829 --> 00:10:13,680

a nice long chat with some of the people

275

00:10:17,829 --> 00:10:15,839

from princeton plasma physics laboratory

276

00:10:19,509 --> 00:10:17,839

yesterday after our mission briefing

277

00:10:21,829 --> 00:10:19,519

that are very interested in working with

278

00:10:23,829 --> 00:10:21,839

us so there are practical applications

279

00:10:26,550 --> 00:10:23,839

once you understand how magnetic

280

00:10:28,310 --> 00:10:26,560

reconnection works now i mentioned this

281

00:10:31,430 --> 00:10:28,320

loop type reconnection where you have a

282

00:10:34,150 --> 00:10:31,440

dynamo say on the surface of a star or

283

00:10:36,550 --> 00:10:34,160

maybe in a disc that surrounds uh black

284

00:10:39,430 --> 00:10:36,560

holes and it creates a magnetic loop as

285

00:10:42,150 --> 00:10:39,440

this expands the base of that loop might

286

00:10:43,990 --> 00:10:42,160

converge so the outer magnetic field is

287

00:10:45,190 --> 00:10:44,000

pointing outward on one side and inward

288

00:10:46,630 --> 00:10:45,200

on the other side they're in opposite

289

00:10:48,870 --> 00:10:46,640

directions that's what you need for

290

00:10:51,110 --> 00:10:48,880

magnetic reconnection so now we look at

291

00:10:52,949 --> 00:10:51,120

video we're going to see this

292

00:10:54,230 --> 00:10:52,959

in the accretion disk around a black

293

00:10:55,829 --> 00:10:54,240

hole after

294

00:10:58,310 --> 00:10:55,839

a brief introduction

295

00:10:59,509 --> 00:10:58,320

about the earth etc but the next thing

296

00:11:02,150 --> 00:10:59,519

you're going to see

297

00:11:04,389 --> 00:11:02,160

is a black hole sagittarius center of

298

00:11:06,389 --> 00:11:04,399

our galaxy there's the flares a loop

299

00:11:08,630 --> 00:11:06,399

type reconnection there's a flare on the

300

00:11:10,550 --> 00:11:08,640

sun exactly the same process if you look

301
00:11:12,790 --> 00:11:10,560
closely you can see these loops that

302
00:11:15,110 --> 00:11:12,800
reconnects at their bases

303
00:11:17,350 --> 00:11:15,120
now when as jeff mentioned

304
00:11:19,910 --> 00:11:17,360
when these events become very energetic

305
00:11:22,310 --> 00:11:19,920
they cause outbursts called coronal mass

306
00:11:24,230 --> 00:11:22,320
ejections that propagate rapidly towards

307
00:11:26,069 --> 00:11:24,240
the earth you see here

308
00:11:27,750 --> 00:11:26,079
causes magnetic storms

309
00:11:28,470 --> 00:11:27,760
and the aurora and this is the thing

310
00:11:32,790 --> 00:11:28,480
that

311
00:11:35,030 --> 00:11:32,800
drives it is reconnection so there's

312
00:11:37,190 --> 00:11:35,040
reconnection on the day side when the

313
00:11:38,310 --> 00:11:37,200

cloud first hits the magnetosphere not

314

00:11:41,030 --> 00:11:38,320

that much happens when it gets

315

00:11:43,269 --> 00:11:41,040

interesting is on the night side you see

316

00:11:44,870 --> 00:11:43,279

in a moment on the right side of this

317

00:11:46,230 --> 00:11:44,880

where you have reconnection in the tail

318

00:11:47,910 --> 00:11:46,240

of the magnetosphere and this is what

319

00:11:49,430 --> 00:11:47,920

produces the aurora

320

00:11:53,030 --> 00:11:49,440

and the currents that

321

00:11:55,350 --> 00:11:53,040

uh carry the energy in magnetic storms

322

00:11:57,750 --> 00:11:55,360

now here was looking in the next

323

00:11:59,509 --> 00:11:57,760

sequence here this is a bastille day

324

00:12:01,670 --> 00:11:59,519

starting back in 2001 this is another

325

00:12:04,150 --> 00:12:01,680

spacecraft that same a lot of our same

326

00:12:05,990 --> 00:12:04,160

group did and that was a shock wave

327

00:12:07,350 --> 00:12:06,000

hitting the earth causing this brighter

328

00:12:09,670 --> 00:12:07,360

rural display

329

00:12:11,110 --> 00:12:09,680

now how does a reconnection work how do

330

00:12:13,190 --> 00:12:11,120

we think it works we're going to look at

331

00:12:15,990 --> 00:12:13,200

a still drawing here

332

00:12:18,150 --> 00:12:16,000

okay it's in one sense it's very simple

333

00:12:20,069 --> 00:12:18,160

and another sense is very complicated

334

00:12:21,829 --> 00:12:20,079

and also mysterious

335

00:12:23,350 --> 00:12:21,839

simple part is that if you have magnetic

336

00:12:25,910 --> 00:12:23,360

fields pointing in opposite directions

337

00:12:27,750 --> 00:12:25,920

let's say the top of this graph

338

00:12:29,750 --> 00:12:27,760

of this figure pointing to the left at

339

00:12:31,110 --> 00:12:29,760

the bottom pointing to the right and if

340

00:12:32,790 --> 00:12:31,120

something is squeezing these together

341

00:12:36,069 --> 00:12:32,800

and these are plasmas one side could be

342

00:12:37,829 --> 00:12:36,079

the solar wind the other side could be

343

00:12:39,190 --> 00:12:37,839

could be a stellar wind or it could be a

344

00:12:41,430 --> 00:12:39,200

magnetospheric flow but if you're

345

00:12:43,590 --> 00:12:41,440

squeezing these together then we do know

346

00:12:45,030 --> 00:12:43,600

that the magnetic fields interconnect

347

00:12:46,389 --> 00:12:45,040

and you see those jets those are high

348

00:12:47,990 --> 00:12:46,399

energy particles

349

00:12:50,310 --> 00:12:48,000

that are produced as you destroy

350

00:12:52,790 --> 00:12:50,320

magnetic energy and convert it to

351
00:12:54,870 --> 00:12:52,800
particle energy so we know what goes on

352
00:12:56,870 --> 00:12:54,880
around that blue box called diffusion

353
00:12:58,870 --> 00:12:56,880
region from previous missions

354
00:13:00,790 --> 00:12:58,880
and from theoretical work

355
00:13:03,269 --> 00:13:00,800
but previous missions and theoretical

356
00:13:05,110 --> 00:13:03,279
work have told us nothing about what

357
00:13:08,389 --> 00:13:05,120
goes on in that diffusion region and

358
00:13:10,710 --> 00:13:08,399
that's what mms is going to do

359
00:13:12,230 --> 00:13:10,720
okay now in a minute uh this is comes up

360
00:13:13,750 --> 00:13:12,240
pretty quickly so i'll just tell you

361
00:13:15,910 --> 00:13:13,760
there's one of these boxes shown on the

362
00:13:17,430 --> 00:13:15,920
day side of the magnetosphere and one on

363
00:13:19,110 --> 00:13:17,440

the nice side of the magnetosphere and

364

00:13:20,949 --> 00:13:19,120

then right away we come up with a

365

00:13:23,030 --> 00:13:20,959

computer simulation

366

00:13:24,870 --> 00:13:23,040

showing what theory says is going on

367

00:13:26,790 --> 00:13:24,880

inside those boxes so you start that

368

00:13:28,870 --> 00:13:26,800

video

369

00:13:31,110 --> 00:13:28,880

see those two boxes day side and night

370

00:13:33,110 --> 00:13:31,120

side and then you see this is what's

371

00:13:35,190 --> 00:13:33,120

going on inside the boxes you can plot

372

00:13:36,790 --> 00:13:35,200

different things this particular plot is

373

00:13:38,870 --> 00:13:36,800

electron currents

374

00:13:40,550 --> 00:13:38,880

produced by one of the top

375

00:13:42,550 --> 00:13:40,560

computer simulations of reconnection

376

00:13:44,470 --> 00:13:42,560

that we have but these are only

377

00:13:46,470 --> 00:13:44,480

approximations because

378

00:13:48,870 --> 00:13:46,480

as most of us know the protons are about

379

00:13:50,629 --> 00:13:48,880

2 000 times heavier than the electrons

380

00:13:53,509 --> 00:13:50,639

any of the computers that exist cannot

381

00:13:56,470 --> 00:13:53,519

handle that ratio these ratios are

382

00:14:00,629 --> 00:13:56,480

at 100 at best so these are guides the

383

00:14:02,710 --> 00:14:00,639

true answer is going to come from mms

384

00:14:05,750 --> 00:14:02,720

now there's another

385

00:14:07,269 --> 00:14:05,760

video that's going to show how we access

386

00:14:09,110 --> 00:14:07,279

these two regions of interest those two

387

00:14:11,189 --> 00:14:09,120

boxes we launch on the nice side with

388

00:14:12,870 --> 00:14:11,199

that red orbit it precesses around you

389

00:14:14,710 --> 00:14:12,880

see the sun off to the left

390

00:14:16,710 --> 00:14:14,720

skims a boundary between the solar wind

391

00:14:18,310 --> 00:14:16,720

and the magnetosphere all the time we're

392

00:14:19,990 --> 00:14:18,320

adjusting the separation between these

393

00:14:22,150 --> 00:14:20,000

four spacecraft they're in a pyramid

394

00:14:24,629 --> 00:14:22,160

formation but we can adjust it second

395

00:14:26,310 --> 00:14:24,639

time around we pick the optimum

396

00:14:27,829 --> 00:14:26,320

separation based on the data from the

397

00:14:30,389 --> 00:14:27,839

first time around

398

00:14:31,990 --> 00:14:30,399

then we double our apogee out to 25 re

399

00:14:34,069 --> 00:14:32,000

to access that

400

00:14:36,389 --> 00:14:34,079

box in the tail and there we can adjust

401
00:14:37,509 --> 00:14:36,399
the separation from 10 kilometers out to

402
00:14:39,030 --> 00:14:37,519
400

403
00:14:41,030 --> 00:14:39,040
kilometers the reason we pick 10

404
00:14:43,590 --> 00:14:41,040
kilometers or six miles is that's a

405
00:14:45,189 --> 00:14:43,600
characteristic skill length of the

406
00:14:46,949 --> 00:14:45,199
electrons especially on the day side

407
00:14:49,350 --> 00:14:46,959
where the densities are high

408
00:14:51,430 --> 00:14:49,360
and previous missions have only gone to

409
00:14:53,110 --> 00:14:51,440
a few hundred kilometers so you need to

410
00:14:54,230 --> 00:14:53,120
get down to that you need four

411
00:14:56,790 --> 00:14:54,240
spacecraft because it's a

412
00:14:58,389 --> 00:14:56,800
three-dimensional phenomenon as you know

413
00:15:00,629 --> 00:14:58,399

three points to find a plane

414

00:15:01,750 --> 00:15:00,639

and so you couldn't do anything uh with

415

00:15:04,710 --> 00:15:01,760

three

416

00:15:07,030 --> 00:15:04,720

and so this is uh our

417

00:15:10,470 --> 00:15:07,040

strategy now the next

418

00:15:14,310 --> 00:15:12,389

gonna show what happens while we're in

419

00:15:16,069 --> 00:15:14,320

those orbits so i mentioned these

420

00:15:17,990 --> 00:15:16,079

pyramids there are also tetrahedrons

421

00:15:19,110 --> 00:15:18,000

another word for it in a minute they'll

422

00:15:21,110 --> 00:15:19,120

zoom in a little bit and they'll

423

00:15:23,590 --> 00:15:21,120

separate and you'll see this pyramid

424

00:15:25,509 --> 00:15:23,600

formation and that pyramid

425

00:15:27,750 --> 00:15:25,519

develops and is maintained out in the

426

00:15:29,670 --> 00:15:27,760

outer reaches of the magnetosphere those

427

00:15:32,230 --> 00:15:29,680

two boxes we looked at dayside and

428

00:15:34,310 --> 00:15:32,240

nightside are at fairly large distances

429

00:15:36,230 --> 00:15:34,320

you can't really tell it that well from

430

00:15:38,310 --> 00:15:36,240

this video but there's the pyramid and

431

00:15:40,069 --> 00:15:38,320

then when it gets close to the earth

432

00:15:41,350 --> 00:15:40,079

they line up in a line and they get

433

00:15:43,430 --> 00:15:41,360

farther away

434

00:15:45,430 --> 00:15:43,440

they maintain the pyramid again and this

435

00:15:46,470 --> 00:15:45,440

is done using a very sensitive and

436

00:15:50,389 --> 00:15:46,480

accurate

437

00:15:52,550 --> 00:15:50,399

gps receiver and a lot of propulsion we

438

00:15:54,470 --> 00:15:52,560

have propulsion that can do

439

00:15:56,710 --> 00:15:54,480

we can use it once or twice in orbit to

440

00:15:59,350 --> 00:15:56,720

maintain almost perfect pyramids in the

441

00:16:02,310 --> 00:15:59,360

regions that we're uh interested in

442

00:16:03,910 --> 00:16:02,320

so now again why we're doing this is

443

00:16:05,910 --> 00:16:03,920

magnetic reconnection is what drives

444

00:16:07,670 --> 00:16:05,920

space weather see this event that jeff's

445

00:16:09,189 --> 00:16:07,680

talking about coming this way is going

446

00:16:10,790 --> 00:16:09,199

to cause space weather but it was

447

00:16:12,310 --> 00:16:10,800

produced by magnetic reconnection and

448

00:16:14,470 --> 00:16:12,320

when it hits the earth

449

00:16:16,230 --> 00:16:14,480

its effects are going to be produced by

450

00:16:18,230 --> 00:16:16,240

magnetic reconnection so that's why

451
00:16:21,189 --> 00:16:18,240
we're so excited and very excited about

452
00:16:22,389 --> 00:16:21,199
our mission now turn it over to roy

453
00:16:24,550 --> 00:16:22,399
good afternoon

454
00:16:26,710 --> 00:16:24,560
uh as jim mentioned

455
00:16:29,670 --> 00:16:26,720
magnetic reconnection is the process

456
00:16:31,990 --> 00:16:29,680
that releases magnetic field energy and

457
00:16:33,910 --> 00:16:32,000
so it's very important on mms to measure

458
00:16:36,470 --> 00:16:33,920
these electromagnetic fields very very

459
00:16:39,430 --> 00:16:36,480
accurately so starting about three days

460
00:16:42,790 --> 00:16:39,440
after launch mms will start to release a

461
00:16:44,710 --> 00:16:42,800
set of booms uh that have very sensitive

462
00:16:46,470 --> 00:16:44,720
instruments on them we get them as far

463
00:16:48,389 --> 00:16:46,480

away from the spacecraft as possible

464

00:16:50,870 --> 00:16:48,399

because the spacecraft itself produces

465

00:16:53,189 --> 00:16:50,880

electromagnetic fields if you if you saw

466

00:16:55,189 --> 00:16:53,199

the mission briefing you you know that

467

00:16:56,629 --> 00:16:55,199

the mission spent a lot of time trying

468

00:16:59,030 --> 00:16:56,639

to reduce the magnetic electric

469

00:17:01,269 --> 00:16:59,040

signature of the spacecraft so that we

470

00:17:03,430 --> 00:17:01,279

don't measure our spacecraft itself so

471

00:17:06,150 --> 00:17:03,440

in the first video we

472

00:17:08,390 --> 00:17:06,160

show the deployment of these booms this

473

00:17:10,069 --> 00:17:08,400

is the magnetic booms deployed on about

474

00:17:12,069 --> 00:17:10,079

the third day there are two

475

00:17:13,669 --> 00:17:12,079

magnetometers on the end of five meter

476
00:17:14,789 --> 00:17:13,679
booms and another magnetometer about

477
00:17:16,309 --> 00:17:14,799
halfway in

478
00:17:18,710 --> 00:17:16,319
measuring the magnetic fields very

479
00:17:20,390 --> 00:17:18,720
sensitively and then we just deploy what

480
00:17:23,270 --> 00:17:20,400
we call the spin plane double probes

481
00:17:25,110 --> 00:17:23,280
these go out 60 meters each each one

482
00:17:27,909 --> 00:17:25,120
there are four of them so that in the

483
00:17:29,590 --> 00:17:27,919
end mms looks about the size of a

484
00:17:31,510 --> 00:17:29,600
football field

485
00:17:33,750 --> 00:17:31,520
and finally we have the axial probe

486
00:17:37,270 --> 00:17:33,760
which is a unique uh

487
00:17:39,270 --> 00:17:37,280
element of mms to measure the full three

488
00:17:42,230 --> 00:17:39,280

3d or three-dimensional

489

00:17:44,230 --> 00:17:42,240

electric field on mms now to give you an

490

00:17:46,789 --> 00:17:44,240

idea of the sensitivity the

491

00:17:48,470 --> 00:17:46,799

magnetometers are accurate on the mms to

492

00:17:50,630 --> 00:17:48,480

a tenth of a nanotesla that's about a

493

00:17:52,150 --> 00:17:50,640

millionth of the earth's field

494

00:17:54,390 --> 00:17:52,160

and the earth's field is actually not

495

00:17:56,150 --> 00:17:54,400

very strong it's about a thousandth of

496

00:17:57,909 --> 00:17:56,160

your typical

497

00:17:59,990 --> 00:17:57,919

refrigerator magnet

498

00:18:02,549 --> 00:18:00,000

and the electric antennas are accurate

499

00:18:04,470 --> 00:18:02,559

to one volt per kilometer a typical

500

00:18:06,310 --> 00:18:04,480

electric fuel you have is about 100

501
00:18:08,470 --> 00:18:06,320
volts per millimeter like in your

502
00:18:10,470 --> 00:18:08,480
extension cord so this is a factor of

503
00:18:11,830 --> 00:18:10,480
100 million better than that on those

504
00:18:13,669 --> 00:18:11,840
instruments

505
00:18:16,070 --> 00:18:13,679
in the next still you can see one of

506
00:18:18,230 --> 00:18:16,080
those axial probes a lot of development

507
00:18:19,590 --> 00:18:18,240
went into this unique contribution

508
00:18:21,750 --> 00:18:19,600
that's an engineer from the university

509
00:18:23,830 --> 00:18:21,760
of colorado and you see the spiral

510
00:18:25,830 --> 00:18:23,840
nature of that boom it's constructed so

511
00:18:28,549 --> 00:18:25,840
that as the spacecraft spins

512
00:18:31,190 --> 00:18:28,559
the signature or the capture of sunlight

513
00:18:33,430 --> 00:18:31,200

on those booms stays exactly the same so

514

00:18:36,950 --> 00:18:33,440

that the photoemission from the surfaces

515

00:18:39,590 --> 00:18:36,960

does not change as the spacecraft spins

516

00:18:41,669 --> 00:18:39,600

so to illustrate the importance of these

517

00:18:43,350 --> 00:18:41,679

fields to the process of reconnection we

518

00:18:45,990 --> 00:18:43,360

have a little simplified

519

00:18:47,750 --> 00:18:46,000

lab distribution here lab demonstration

520

00:18:49,430 --> 00:18:47,760

that we'd like to show you

521

00:18:50,950 --> 00:18:49,440

now the equations that cover

522

00:18:52,950 --> 00:18:50,960

electromagnetic fields called

523

00:18:54,870 --> 00:18:52,960

maxwell's equations and maxwell's

524

00:18:56,710 --> 00:18:54,880

equations will tell us how this

525

00:18:58,870 --> 00:18:56,720

demonstration has many similarities

526
00:19:00,710 --> 00:18:58,880
reconnection also important differences

527
00:19:02,789 --> 00:19:00,720
and so we'll talk about that too

528
00:19:04,630 --> 00:19:02,799
so what we're going to see in this wire

529
00:19:06,070 --> 00:19:04,640
is i'm going to pass a current down this

530
00:19:07,270 --> 00:19:06,080
wire

531
00:19:11,270 --> 00:19:07,280
and

532
00:19:13,430 --> 00:19:11,280
do that there will start to be a

533
00:19:16,150 --> 00:19:13,440
dissipation in this wire what max

534
00:19:18,070 --> 00:19:16,160
equations tell us is in fact the current

535
00:19:20,870 --> 00:19:18,080
sets up in a magnetic field structure

536
00:19:23,669 --> 00:19:20,880
outside this wire and the electric field

537
00:19:26,230 --> 00:19:23,679
in the wire flows the magnetic field

538
00:19:28,150 --> 00:19:26,240

in energy into this wire to cause

539

00:19:29,830 --> 00:19:28,160

dissipation now i can start to smell the

540

00:19:30,710 --> 00:19:29,840

wire and soon you'll start to see it

541

00:19:32,150 --> 00:19:30,720

heat

542

00:19:34,549 --> 00:19:32,160

okay and that's what we're doing we're

543

00:19:36,950 --> 00:19:34,559

converting magnetic field energy into

544

00:19:40,310 --> 00:19:36,960

electrical energy or heat

545

00:19:42,549 --> 00:19:40,320

now uh it's the case that if i crank up

546

00:19:44,710 --> 00:19:42,559

the current large enough in this

547

00:19:46,150 --> 00:19:44,720

particular constraint

548

00:19:48,070 --> 00:19:46,160

demonstration

549

00:19:50,070 --> 00:19:48,080

soon you'll start to see the effects of

550

00:19:52,150 --> 00:19:50,080

this and then very soon

551
00:19:55,350 --> 00:19:52,160
we will have an explosion that's very

552
00:19:57,430 --> 00:19:55,360
much like uh reconnection we released in

553
00:19:58,870 --> 00:19:57,440
this case the energy of the tension in

554
00:20:01,350 --> 00:19:58,880
this wire

555
00:20:03,430 --> 00:20:01,360
but it's those you saw that hot spot

556
00:20:05,590 --> 00:20:03,440
where we have concentrated dissipation

557
00:20:08,070 --> 00:20:05,600
and that's what we're looking for in mms

558
00:20:10,070 --> 00:20:08,080
we're trying to find those hot spots out

559
00:20:11,510 --> 00:20:10,080
in space now you can't see them like we

560
00:20:13,430 --> 00:20:11,520
could in this wire because it's a

561
00:20:14,470 --> 00:20:13,440
rarefied plasma and that's the major

562
00:20:17,350 --> 00:20:14,480
difference

563
00:20:19,669 --> 00:20:17,360

between this demonstration and

564

00:20:21,990 --> 00:20:19,679

the case of looking for reconnection in

565

00:20:23,909 --> 00:20:22,000

plasmas it's quite a bit of difference

566

00:20:26,710 --> 00:20:23,919

uh in the sense that

567

00:20:29,350 --> 00:20:26,720

in this wire i understand what happens

568

00:20:30,870 --> 00:20:29,360

uh why this wire heats up and recalls

569

00:20:32,710 --> 00:20:30,880

this dissipation

570

00:20:34,789 --> 00:20:32,720

as it gets hotter since the wire is

571

00:20:36,710 --> 00:20:34,799

under tension it thins

572

00:20:38,390 --> 00:20:36,720

the resistance goes up but the current

573

00:20:40,390 --> 00:20:38,400

has stayed the same because i adjusted

574

00:20:42,230 --> 00:20:40,400

this power supply that way and so what

575

00:20:43,909 --> 00:20:42,240

happens eventually is all the

576

00:20:46,950 --> 00:20:43,919

dissipation goes into a very small

577

00:20:49,110 --> 00:20:46,960

region and then it separates the wire

578

00:20:52,149 --> 00:20:49,120

mms is investigating reconnection

579

00:20:54,870 --> 00:20:52,159

because we do not understand at all

580

00:20:56,870 --> 00:20:54,880

what causes the dissipation in plasmas

581

00:20:58,630 --> 00:20:56,880

if in fact if you look at current theory

582

00:21:01,430 --> 00:20:58,640

it should say it should never happen

583

00:21:03,909 --> 00:21:01,440

because a plasma is very much

584

00:21:06,310 --> 00:21:03,919

almost almost a superconductor not quite

585

00:21:08,310 --> 00:21:06,320

a very good conductor and it should

586

00:21:09,350 --> 00:21:08,320

never have dissipation like we saw in

587

00:21:11,990 --> 00:21:09,360

this distrib

588

00:21:14,149 --> 00:21:12,000

this demonstration it would be like all

589

00:21:17,029 --> 00:21:14,159

of a sudden all your high tension lines

590

00:21:18,710 --> 00:21:17,039

uh exploded for a reason that you didn't

591

00:21:20,230 --> 00:21:18,720

even know because they should be good

592

00:21:23,029 --> 00:21:20,240

conductors they should take the energy

593

00:21:25,350 --> 00:21:23,039

from the power plant uh to to to your

594

00:21:28,310 --> 00:21:25,360

home but all of a sudden they don't

595

00:21:30,789 --> 00:21:28,320

so what we seek to find in in

596

00:21:33,270 --> 00:21:30,799

mms is to find those hot spots and if we

597

00:21:35,190 --> 00:21:33,280

can get our four spacecraft with those

598

00:21:37,190 --> 00:21:35,200

sensitive instruments around those hot

599

00:21:38,870 --> 00:21:37,200

spots then we can understand what the

600

00:21:42,070 --> 00:21:38,880

electromagnetic fields are doing and

601
00:21:44,310 --> 00:21:42,080
telling us about that dissipation

602
00:21:46,070 --> 00:21:44,320
and the other remarkable thing about

603
00:21:47,110 --> 00:21:46,080
reconnection is that

604
00:21:49,190 --> 00:21:47,120
this

605
00:21:51,350 --> 00:21:49,200
dissipation is in heat or disorganized

606
00:21:53,110 --> 00:21:51,360
energy in fact it's remarkable in

607
00:21:55,909 --> 00:21:53,120
reconnection that you get organized

608
00:21:57,590 --> 00:21:55,919
energy organized plasma flows and dr

609
00:21:59,270 --> 00:21:57,600
pollock's instruments will measure those

610
00:22:01,750 --> 00:21:59,280
plasma flows

611
00:22:03,750 --> 00:22:01,760
via the fast plasma instrument and those

612
00:22:05,590 --> 00:22:03,760
plasma flows are almost at the what is

613
00:22:07,669 --> 00:22:05,600

the effective light speed in a plasma

614

00:22:09,270 --> 00:22:07,679

called the alphan speed and to know

615

00:22:11,590 --> 00:22:09,280

that speed we have to find the

616

00:22:13,190 --> 00:22:11,600

composition we do that via an instrument

617

00:22:15,590 --> 00:22:13,200

called the hot plasma composition

618

00:22:18,070 --> 00:22:15,600

analyzer that tells us how much oxygen

619

00:22:20,390 --> 00:22:18,080

helium and hydrogen they are in these

620

00:22:22,310 --> 00:22:20,400

regions and then the other remarkable

621

00:22:24,310 --> 00:22:22,320

thing is there's a lot of energetic

622

00:22:26,710 --> 00:22:24,320

electrons some of which you saw create

623

00:22:28,390 --> 00:22:26,720

aurora in those storms it's remarkable

624

00:22:29,430 --> 00:22:28,400

how much of that energy goes into those

625

00:22:32,950 --> 00:22:29,440

energetic

626
00:22:33,990 --> 00:22:32,960
particle detector to measure those

627
00:22:36,230 --> 00:22:34,000
particles

628
00:22:38,630 --> 00:22:36,240
so with that i'll turn it to craig to

629
00:22:40,789 --> 00:22:38,640
tell us more about those instruments

630
00:22:42,630 --> 00:22:40,799
thank you roy uh it's a great

631
00:22:44,789 --> 00:22:42,640
demonstration

632
00:22:47,029 --> 00:22:44,799
uh i'm as roy said the leader of the

633
00:22:49,909 --> 00:22:47,039
fast plasma investigation

634
00:22:51,350 --> 00:22:49,919
uh which involves a lot of hardware

635
00:22:53,029 --> 00:22:51,360
and that's what i'd like to talk about

636
00:22:55,430 --> 00:22:53,039
here is is really the

637
00:22:57,750 --> 00:22:55,440
the volume of hardware we have in this

638
00:23:00,070 --> 00:22:57,760

mission in these experiments it's it's

639

00:23:02,310 --> 00:23:00,080

really unprecedented

640

00:23:05,110 --> 00:23:02,320

and i want to try to give you a sense

641

00:23:06,390 --> 00:23:05,120

for why we have so much hardware

642

00:23:11,029 --> 00:23:06,400

and

643

00:23:14,149 --> 00:23:11,039

interesting video that uh

644

00:23:16,390 --> 00:23:14,159

shows sort of a frenetic uh activity in

645

00:23:17,830 --> 00:23:16,400

assembling some of the hardware

646

00:23:18,870 --> 00:23:17,840

so if i could have the first graphic

647

00:23:21,110 --> 00:23:18,880

please

648

00:23:22,789 --> 00:23:21,120

uh you've seen this graphic before what

649

00:23:25,270 --> 00:23:22,799

you're looking at here is a simplified

650

00:23:27,190 --> 00:23:25,280

diagram of the earth's magnetosphere

651

00:23:30,149 --> 00:23:27,200

the sun is off to the left

652

00:23:32,390 --> 00:23:30,159

and the earth is there obviously

653

00:23:34,630 --> 00:23:32,400

as the source of the earth's magnetic

654

00:23:36,549 --> 00:23:34,640

field and then there are the two boxes

655

00:23:38,789 --> 00:23:36,559

that dr birch pointed out

656

00:23:40,390 --> 00:23:38,799

one on the sunward side in what we call

657

00:23:42,149 --> 00:23:40,400

the magnetopause

658

00:23:44,070 --> 00:23:42,159

the other on the tailward side in the

659

00:23:46,149 --> 00:23:44,080

geomagnetic tail

660

00:23:48,390 --> 00:23:46,159

these are the locations

661

00:23:51,190 --> 00:23:48,400

where magnetic reconnection is expected

662

00:23:53,669 --> 00:23:51,200

to happen and these are the targets

663

00:23:55,270 --> 00:23:53,679

of what we call the regions of interest

664

00:23:56,789 --> 00:23:55,280

for our

665

00:23:59,430 --> 00:23:56,799

our flight mission

666

00:24:01,270 --> 00:23:59,440

now one thing to remember the location

667

00:24:03,029 --> 00:24:01,280

of the magnetopause at that box on the

668

00:24:05,350 --> 00:24:03,039

sunward side

669

00:24:08,630 --> 00:24:05,360

that's not at a fixed location

670

00:24:11,269 --> 00:24:08,640

it moves the solar wind which is uh

671

00:24:13,029 --> 00:24:11,279

always blowing past the earth at at very

672

00:24:14,470 --> 00:24:13,039

very high speeds

673

00:24:17,830 --> 00:24:14,480

approximately

674

00:24:20,230 --> 00:24:17,840

250 miles per second

675

00:24:23,510 --> 00:24:20,240

is not a steady wind it's a gusty

676

00:24:25,669 --> 00:24:23,520

dynamic wind it buffets the earth

677

00:24:27,190 --> 00:24:25,679

and therefore in response to that

678

00:24:31,029 --> 00:24:27,200

dynamic pressure

679

00:24:33,750 --> 00:24:31,039

the magnetopause moves back and forth

680

00:24:35,350 --> 00:24:33,760

very rapidly at the magnetos the

681

00:24:36,630 --> 00:24:35,360

magnetopause

682

00:24:38,230 --> 00:24:36,640

the boundary between the earth's

683

00:24:39,590 --> 00:24:38,240

magnetic field and the interplanetary

684

00:24:42,549 --> 00:24:39,600

magnetic field

685

00:24:46,070 --> 00:24:42,559

moves back and forth with typical speeds

686

00:24:47,990 --> 00:24:46,080

of 50 to 100 kilometers per second so

687

00:24:49,430 --> 00:24:48,000

we're we're looking for a very fast

688

00:24:50,950 --> 00:24:49,440

moving target

689

00:24:52,470 --> 00:24:50,960

right now if i could have the next chart

690

00:24:55,430 --> 00:24:52,480

please

691

00:24:56,230 --> 00:24:55,440

so in this chart uh you see

692

00:24:57,510 --> 00:24:56,240

sort of

693

00:25:00,549 --> 00:24:57,520

it it's a

694

00:25:02,789 --> 00:25:00,559

sequential zoom in if you will on the

695

00:25:03,909 --> 00:25:02,799

far right again is

696

00:25:06,470 --> 00:25:03,919

on on

697

00:25:08,470 --> 00:25:06,480

similar scale to the previous chart

698

00:25:10,789 --> 00:25:08,480

a diagram of the earth's magnetosphere

699

00:25:12,789 --> 00:25:10,799

earth is at the extreme right kind of

700

00:25:15,350 --> 00:25:12,799

colored orange there and you see a

701
00:25:16,870 --> 00:25:15,360
little blue box the roughly the same

702
00:25:17,909 --> 00:25:16,880
scale that i showed you in the last

703
00:25:19,909 --> 00:25:17,919
chart

704
00:25:21,029 --> 00:25:19,919
but then if you zoom into that blue box

705
00:25:23,510 --> 00:25:21,039
a little bit

706
00:25:25,430 --> 00:25:23,520
you see a region a more localized region

707
00:25:27,269 --> 00:25:25,440
of the magnetopause i don't know if you

708
00:25:30,070 --> 00:25:27,279
can read the scale sizes at the bottom

709
00:25:31,669 --> 00:25:30,080
of the figures on the far right panel is

710
00:25:35,110 --> 00:25:31,679
about a hundred thousand kilometers

711
00:25:36,789 --> 00:25:35,120
which is about 60 70 000 miles in the

712
00:25:41,110 --> 00:25:36,799
center panel we've zoomed down to where

713
00:25:43,110 --> 00:25:41,120

the width is about 500 kilometers or

714

00:25:45,909 --> 00:25:43,120

300 miles or so

715

00:25:48,630 --> 00:25:45,919

and then finally we zoom in again

716

00:25:50,390 --> 00:25:48,640

to the area that contains uh what jim

717

00:25:53,110 --> 00:25:50,400

referred to as the electron diffusion

718

00:25:54,710 --> 00:25:53,120

region and that box is only about 100

719

00:25:57,350 --> 00:25:54,720

kilometers across

720

00:26:00,230 --> 00:25:57,360

right and the place where the action all

721

00:26:02,870 --> 00:26:00,240

occurs within the diffusion region is

722

00:26:04,070 --> 00:26:02,880

only about 10 kilometers or six miles

723

00:26:06,310 --> 00:26:04,080

across

724

00:26:07,990 --> 00:26:06,320

so you got this little feature

725

00:26:10,789 --> 00:26:08,000

six miles across

726
00:26:12,710 --> 00:26:10,799
moving past you at

727
00:26:14,870 --> 00:26:12,720
50 miles per second

728
00:26:16,870 --> 00:26:14,880
right and you got to capture the details

729
00:26:18,710 --> 00:26:16,880
with four spacecraft

730
00:26:20,710 --> 00:26:18,720
inside that feature

731
00:26:21,590 --> 00:26:20,720
uh in order to understand what's going

732
00:26:24,390 --> 00:26:21,600
on

733
00:26:26,950 --> 00:26:24,400
four spacecraft gives you the 3d

734
00:26:29,909 --> 00:26:26,960
but on each spacecraft we need to make

735
00:26:32,230 --> 00:26:29,919
our measurements very very rapidly in

736
00:26:34,070 --> 00:26:32,240
order to capture the feature as it moves

737
00:26:36,230 --> 00:26:34,080
past us so if i could have the next

738
00:26:36,950 --> 00:26:36,240

chart please

739

00:26:40,710 --> 00:26:36,960

so

740

00:26:42,390 --> 00:26:40,720

elements

741

00:26:44,070 --> 00:26:42,400

of uh

742

00:26:46,870 --> 00:26:44,080

one of the instruments one of the

743

00:26:49,110 --> 00:26:46,880

sensors in the fast plasma investigation

744

00:26:51,590 --> 00:26:49,120

in the center of the figure you see what

745

00:26:54,950 --> 00:26:51,600

looks like kind of a two-headed box

746

00:26:58,230 --> 00:26:54,960

that's a dual electron spectrometer

747

00:27:00,470 --> 00:26:58,240

which is one of the two core instruments

748

00:27:02,470 --> 00:27:00,480

for the fast plasma investigation

749

00:27:05,110 --> 00:27:02,480

the dual electron spectrometer has two

750

00:27:06,950 --> 00:27:05,120

sensor heads therefore the word dual

751
00:27:08,789 --> 00:27:06,960
and in a measure it measures the fluxes

752
00:27:12,470 --> 00:27:08,799
of electrons and ions

753
00:27:15,430 --> 00:27:12,480
uh i'm sorry fluxes of electrons

754
00:27:18,070 --> 00:27:15,440
at a very rapid pace

755
00:27:19,029 --> 00:27:18,080
but not rapid enough by itself that one

756
00:27:21,029 --> 00:27:19,039
box

757
00:27:23,110 --> 00:27:21,039
in order to capture the features we need

758
00:27:24,310 --> 00:27:23,120
to capture as rapidly as we need to

759
00:27:26,549 --> 00:27:24,320
capture them

760
00:27:28,070 --> 00:27:26,559
so our approach to that

761
00:27:30,149 --> 00:27:28,080
typically

762
00:27:31,110 --> 00:27:30,159
the mms spacecraft will spin and they'll

763
00:27:34,230 --> 00:27:31,120

spin

764

00:27:37,269 --> 00:27:34,240

3rpm three rotations per minute about a

765

00:27:39,430 --> 00:27:37,279

20-second spin period that's far too

766

00:27:42,070 --> 00:27:39,440

long to wait to have your instrument

767

00:27:44,789 --> 00:27:42,080

spin around and get a view of all space

768

00:27:47,750 --> 00:27:44,799

so our approach has been to proliferate

769

00:27:51,190 --> 00:27:47,760

many instruments around the perimeter so

770

00:27:53,269 --> 00:27:51,200

we've built 16 of those dual electron

771

00:27:56,310 --> 00:27:53,279

spectrometers to measure the electron

772

00:27:58,230 --> 00:27:56,320

flows and fluxes and 16

773

00:28:00,310 --> 00:27:58,240

dual ion spectrometers which will

774

00:28:02,310 --> 00:28:00,320

measure very similar instruments but not

775

00:28:04,310 --> 00:28:02,320

identical and they'll measure the ion

776

00:28:06,870 --> 00:28:04,320

fluxes

777

00:28:09,510 --> 00:28:06,880

if you'd go to the next chart please

778

00:28:11,510 --> 00:28:09,520

so here's the four first four

779

00:28:14,389 --> 00:28:11,520

dual electron spectrometers that rolled

780

00:28:16,389 --> 00:28:14,399

off the line i call it a line but

781

00:28:19,029 --> 00:28:16,399

not really an assembly line they each

782

00:28:21,590 --> 00:28:19,039

take a lot of tender loving care that's

783

00:28:23,590 --> 00:28:21,600

myself on the left and our chief

784

00:28:25,110 --> 00:28:23,600

engineer on the project a guy by the

785

00:28:26,310 --> 00:28:25,120

name of ulrich gleese

786

00:28:30,950 --> 00:28:26,320

on your right

787

00:28:32,789 --> 00:28:30,960

and that was uh roughly december 2012

788

00:28:35,590 --> 00:28:32,799

when we heard had those four first four

789

00:28:36,549 --> 00:28:35,600

complete instruments on the clean bench

790

00:28:39,590 --> 00:28:36,559

now

791

00:28:40,389 --> 00:28:39,600

there's so many

792

00:28:41,590 --> 00:28:40,399

uh

793

00:28:43,669 --> 00:28:41,600

elements of the fast plasma

794

00:28:46,470 --> 00:28:43,679

investigation it's also true of the

795

00:28:48,710 --> 00:28:46,480

fields experiments the the boom

796

00:28:50,389 --> 00:28:48,720

deployments that roy just described you

797

00:28:54,389 --> 00:28:50,399

know four

798

00:28:57,190 --> 00:28:54,399

uh extending uh 60 meter booms on each

799

00:29:00,310 --> 00:28:57,200

of the four spacecraft that's 16 units

800

00:29:02,630 --> 00:29:00,320

to get together 16 of those axial booms

801
00:29:03,750 --> 00:29:02,640
which extend 30 meters out either

802
00:29:06,630 --> 00:29:03,760
direction

803
00:29:08,230 --> 00:29:06,640
just a whole lot of uh hardware has gone

804
00:29:10,630 --> 00:29:08,240
into this and that's one of the reasons

805
00:29:11,909 --> 00:29:10,640
why it's taken us this many years to get

806
00:29:13,350 --> 00:29:11,919
to this point where we're ready to

807
00:29:15,990 --> 00:29:13,360
actually fly it

808
00:29:18,070 --> 00:29:16,000
if i could have the next chart please

809
00:29:20,310 --> 00:29:18,080
so here's another stage of quite an

810
00:29:22,310 --> 00:29:20,320
advanced stage in the development of the

811
00:29:24,549 --> 00:29:22,320
mission what you see in this picture

812
00:29:26,950 --> 00:29:24,559
there are two mms spacecraft in the

813
00:29:29,590 --> 00:29:26,960

picture in the back of the the room

814

00:29:31,669 --> 00:29:29,600

there you see a giant vacuum chamber

815

00:29:34,549 --> 00:29:31,679

that's a thermal vacuum chamber where we

816

00:29:36,230 --> 00:29:34,559

test uh we put the entire spacecraft in

817

00:29:37,909 --> 00:29:36,240

there you can see the kind of black

818

00:29:39,590 --> 00:29:37,919

colored solar panels

819

00:29:41,430 --> 00:29:39,600

and we run it through about a two-week

820

00:29:43,750 --> 00:29:41,440

test

821

00:29:46,149 --> 00:29:43,760

cycling temperature up and down to

822

00:29:47,990 --> 00:29:46,159

ensure that the spacecraft can endure

823

00:29:50,310 --> 00:29:48,000

the temperature variations and rigors

824

00:29:51,269 --> 00:29:50,320

that it will encounter while it's uh in

825

00:29:52,950 --> 00:29:51,279

flight

826
00:29:55,750 --> 00:29:52,960
and then to the right

827
00:29:57,430 --> 00:29:55,760
you can see another spacecraft it's got

828
00:29:59,590 --> 00:29:57,440
the covers on the solar panels so they

829
00:30:01,510 --> 00:29:59,600
don't appear black red covers on the

830
00:30:02,950 --> 00:30:01,520
instrument apertures and that one's

831
00:30:04,950 --> 00:30:02,960
waiting in the wings it'll be the next

832
00:30:07,510 --> 00:30:04,960
one to go into the thermal vacuum

833
00:30:10,789 --> 00:30:07,520
chamber so all four spacecraft were run

834
00:30:13,510 --> 00:30:10,799
through this thermal vacuum sequence

835
00:30:15,909 --> 00:30:13,520
very successfully and very efficiently

836
00:30:17,750 --> 00:30:15,919
next chart please

837
00:30:20,310 --> 00:30:17,760
so in this chart we

838
00:30:21,990 --> 00:30:20,320

this is a in a clean room up at goddard

839

00:30:24,470 --> 00:30:22,000

space flight center again a very

840

00:30:27,190 --> 00:30:24,480

advanced stage you can see

841

00:30:30,389 --> 00:30:27,200

all four spacecraft all with their solar

842

00:30:31,750 --> 00:30:30,399

panel protective covers on

843

00:30:33,830 --> 00:30:31,760

sitting

844

00:30:37,669 --> 00:30:33,840

around the distributed around the floor

845

00:30:39,590 --> 00:30:37,679

of the clean room on platforms and

846

00:30:40,630 --> 00:30:39,600

that's just before a really important

847

00:30:45,510 --> 00:30:40,640

stage

848

00:30:47,909 --> 00:30:45,520

stacked up in a stack of four which is

849

00:30:51,110 --> 00:30:47,919

exactly their launch configuration

850

00:30:53,750 --> 00:30:51,120

in order to vibrate them and

851
00:30:56,310 --> 00:30:53,760
shake them real hard to ensure

852
00:30:57,269 --> 00:30:56,320
that they can withstand the vibratory uh

853
00:30:59,350 --> 00:30:57,279
rigors

854
00:31:01,029 --> 00:30:59,360
of the powered launch phase

855
00:31:02,789 --> 00:31:01,039
so what i'd like to do

856
00:31:06,389 --> 00:31:02,799
here is i won't speak much through it

857
00:31:07,510 --> 00:31:06,399
but i'll show you a time lapse video

858
00:31:09,990 --> 00:31:07,520
it's a

859
00:31:12,230 --> 00:31:10,000
three days compressed to one minute

860
00:31:15,430 --> 00:31:12,240
of the assembly

861
00:31:18,149 --> 00:31:15,440
of those four spacecraft into the four

862
00:31:20,149 --> 00:31:18,159
stack launch configuration

863
00:31:21,590 --> 00:31:20,159

and of course this all happens in a

864

00:31:22,950 --> 00:31:21,600

clean room

865

00:31:25,990 --> 00:31:22,960

uh

866

00:31:28,710 --> 00:31:26,000

uncomfortable working all day

867

00:31:30,230 --> 00:31:28,720

in those clean garbs with usually masks

868

00:31:31,909 --> 00:31:30,240

over your face and

869

00:31:33,269 --> 00:31:31,919

everything covered but it's necessary in

870

00:31:36,070 --> 00:31:33,279

order to keep the cleanliness of the

871

00:31:37,509 --> 00:31:36,080

spacecraft that we require

872

00:31:40,630 --> 00:31:37,519

many of these instruments are highly

873

00:31:42,710 --> 00:31:40,640

contamination sensitive

874

00:31:49,990 --> 00:31:42,720

so when i said frenetic activity this

875

00:31:54,870 --> 00:31:52,149

this uh this activity was was filmed

876

00:31:56,789 --> 00:31:54,880

using the gopro cameras

877

00:31:58,789 --> 00:31:56,799

they had to be moved occasionally in

878

00:32:10,789 --> 00:31:58,799

order to catch the right views

879

00:32:14,630 --> 00:32:12,549

a lot of work a lot of work over a

880

00:32:16,070 --> 00:32:14,640

period of years a lot of work just over

881

00:32:19,669 --> 00:32:16,080

those three days

882

00:32:21,509 --> 00:32:19,679

right and so now

883

00:32:23,750 --> 00:32:21,519

if you show the next chart please which

884

00:32:25,750 --> 00:32:23,760

i believe is my final chart

885

00:32:28,789 --> 00:32:25,760

there is the four stack

886

00:32:31,029 --> 00:32:28,799

of mms spacecraft

887

00:32:33,110 --> 00:32:31,039

on to the left and right you can see the

888

00:32:36,149 --> 00:32:33,120

two halves of the atlas

889

00:32:38,630 --> 00:32:36,159

shroud so this is immediately before

890

00:32:40,870 --> 00:32:38,640

encapsulation into the shroud

891

00:32:42,470 --> 00:32:40,880

just a couple of weeks ago now

892

00:32:44,310 --> 00:32:42,480

and

893

00:32:46,230 --> 00:32:44,320

that has now happened

894

00:32:48,470 --> 00:32:46,240

the shroud has been mounted on the top

895

00:32:49,590 --> 00:32:48,480

of the rocket and the rocket moved out

896

00:32:50,870 --> 00:32:49,600

to the pad

897

00:32:53,430 --> 00:32:50,880

and we're just

898

00:32:55,509 --> 00:32:53,440

absolutely thrilled to be at this stage

899

00:32:57,590 --> 00:32:55,519

after a lot of really hard work on the

900

00:32:58,549 --> 00:32:57,600

part of a whole lot of people

901
00:33:00,549 --> 00:32:58,559
and

902
00:33:01,990 --> 00:33:00,559
having described that stuff i'd like to

903
00:33:03,590 --> 00:33:02,000
turn it over to paul

904
00:33:05,110 --> 00:33:03,600
and he'll tell you a little more about

905
00:33:06,950 --> 00:33:05,120
science

906
00:33:08,389 --> 00:33:06,960
thank you craig so uh yeah i'm a

907
00:33:10,870 --> 00:33:08,399
scientist that studies magnetic

908
00:33:13,269 --> 00:33:10,880
reconnection um one of maybe a few

909
00:33:16,149 --> 00:33:13,279
thousand in the in the world that uh

910
00:33:18,149 --> 00:33:16,159
study this process and uh you know we're

911
00:33:19,029 --> 00:33:18,159
universities national labs across the

912
00:33:21,350 --> 00:33:19,039
world

913
00:33:22,950 --> 00:33:21,360

and uh there's a group of them just down

914

00:33:24,470 --> 00:33:22,960

the road that are having last minute

915

00:33:26,470 --> 00:33:24,480

meetings and i got to tell you the place

916

00:33:30,389 --> 00:33:26,480

is a buzz everyone is just really

917

00:33:33,190 --> 00:33:30,399

excited for this day for tomorrow and

918

00:33:35,350 --> 00:33:33,200

so you know what's so exciting about mms

919

00:33:36,310 --> 00:33:35,360

for us is that we're going to be able to

920

00:33:38,230 --> 00:33:36,320

see

921

00:33:39,909 --> 00:33:38,240

the region of reconnection where the

922

00:33:41,350 --> 00:33:39,919

magnetic field lines break and that's

923

00:33:43,909 --> 00:33:41,360

something we've never been able to see

924

00:33:45,430 --> 00:33:43,919

before and so it's just really exciting

925

00:33:47,990 --> 00:33:45,440

that the folks to the right have just

926
00:33:49,830 --> 00:33:48,000
done a fantastic job of getting this all

927
00:33:52,870 --> 00:33:49,840
ready basically building a lab and

928
00:33:55,269 --> 00:33:52,880
sending it a lab through space so so

929
00:33:56,950 --> 00:33:55,279
everyone's really excited about it

930
00:33:59,350 --> 00:33:56,960
what i wanted to do is kind of take you

931
00:34:00,549 --> 00:33:59,360
through some of the science that we've

932
00:34:02,070 --> 00:34:00,559
heard a little bit about but i want to

933
00:34:03,990 --> 00:34:02,080
go through a little more detail and

934
00:34:05,830 --> 00:34:04,000
maybe some detail about roy's

935
00:34:07,269 --> 00:34:05,840
demonstration here

936
00:34:09,669 --> 00:34:07,279
so when we hear about magnetic

937
00:34:11,349 --> 00:34:09,679
reconnection you know it doesn't you

938
00:34:13,270 --> 00:34:11,359

know it doesn't seem like something we

939

00:34:14,629 --> 00:34:13,280

can really grasp so i want to show you

940

00:34:16,869 --> 00:34:14,639

that it's actually something that you

941

00:34:18,310 --> 00:34:16,879

have at least some experience with if

942

00:34:20,230 --> 00:34:18,320

you've ever played with magnets so

943

00:34:21,750 --> 00:34:20,240

here's two magnets this one's shaped

944

00:34:22,869 --> 00:34:21,760

like the earth but there's a magnet

945

00:34:24,629 --> 00:34:22,879

inside

946

00:34:25,990 --> 00:34:24,639

so we all know from playing with magnets

947

00:34:27,829 --> 00:34:26,000

that if you bring them together and

948

00:34:30,710 --> 00:34:27,839

they're both oriented the same direction

949

00:34:32,790 --> 00:34:30,720

they push apart and if you flip them one

950

00:34:34,310 --> 00:34:32,800

upside down then they attract and so

951
00:34:37,190 --> 00:34:34,320
what's going on here is that you have

952
00:34:38,869 --> 00:34:37,200
magnetic fields coming out and around

953
00:34:40,710 --> 00:34:38,879
on both of these and so if they're

954
00:34:42,629 --> 00:34:40,720
pointed the same direction you squeeze

955
00:34:44,310 --> 00:34:42,639
those magnetic fields together and they

956
00:34:46,389 --> 00:34:44,320
basically push back and that's why you

957
00:34:48,230 --> 00:34:46,399
can't push the magnet together but when

958
00:34:49,909 --> 00:34:48,240
you flip them and one's opposite to the

959
00:34:51,669 --> 00:34:49,919
other the magnetic fields point in

960
00:34:52,790 --> 00:34:51,679
opposite directions right and what

961
00:34:54,310 --> 00:34:52,800
happens is

962
00:34:56,950 --> 00:34:54,320
if they're pointing opposite directions

963
00:34:58,950 --> 00:34:56,960

they join they break and they shoot out

964

00:34:59,990 --> 00:34:58,960

the top and the bottom and that's what

965

00:35:02,150 --> 00:35:00,000

allows

966

00:35:03,670 --> 00:35:02,160

since there's no less magnetic fields in

967

00:35:05,190 --> 00:35:03,680

between that allows them to come

968

00:35:06,310 --> 00:35:05,200

together and that's what you feel is the

969

00:35:08,470 --> 00:35:06,320

attraction

970

00:35:10,870 --> 00:35:08,480

so magnetic fields breaking is actually

971

00:35:11,910 --> 00:35:10,880

something that is somewhat familiar to

972

00:35:13,430 --> 00:35:11,920

us

973

00:35:15,430 --> 00:35:13,440

what's different about magnetic

974

00:35:17,670 --> 00:35:15,440

reconnection in space is that rather

975

00:35:18,790 --> 00:35:17,680

than this room where it's just made up

976
00:35:21,190 --> 00:35:18,800
of air

977
00:35:23,910 --> 00:35:21,200
in space it's made up of a plasma

978
00:35:26,710 --> 00:35:23,920
and a plasma is a really hot gas and hot

979
00:35:29,750 --> 00:35:26,720
gases like plasmas respond to magnetic

980
00:35:31,829 --> 00:35:29,760
fields so if in this room if we had a

981
00:35:33,430 --> 00:35:31,839
plasma instead of air

982
00:35:35,349 --> 00:35:33,440
as we bring these magnets together and

983
00:35:37,670 --> 00:35:35,359
they come together the magnetic fields

984
00:35:40,069 --> 00:35:37,680
would break and as we saw in some of the

985
00:35:41,670 --> 00:35:40,079
images you'd get a jet of plasma going

986
00:35:43,829 --> 00:35:41,680
up and down just shooting out the sides

987
00:35:46,150 --> 00:35:43,839
you get a spark kind of like what roy

988
00:35:47,750 --> 00:35:46,160

showed in his demonstration okay so

989

00:35:50,230 --> 00:35:47,760

those two things together basically give

990

00:35:52,710 --> 00:35:50,240

you magnetic reconnection

991

00:35:53,589 --> 00:35:52,720

so what i want to do next is show you uh

992

00:35:56,230 --> 00:35:53,599

some

993

00:35:58,310 --> 00:35:56,240

an animation of how that works in space

994

00:35:59,510 --> 00:35:58,320

in the near earth environment so if we

995

00:36:01,109 --> 00:35:59,520

can bring up

996

00:36:03,829 --> 00:36:01,119

this image

997

00:36:06,069 --> 00:36:03,839

in the middle is represented

998

00:36:07,910 --> 00:36:06,079

represents the earth and those big

999

00:36:10,550 --> 00:36:07,920

yellow lines represent magnetic field

1000

00:36:12,150 --> 00:36:10,560

lines so you can see a number of them go

1001
00:36:13,670 --> 00:36:12,160
from the top of the earth to the bottom

1002
00:36:15,270 --> 00:36:13,680
those are the ones within the

1003
00:36:16,870 --> 00:36:15,280
magnetosphere

1004
00:36:19,190 --> 00:36:16,880
on the left you see one that's kind of

1005
00:36:21,670 --> 00:36:19,200
open it doesn't connect to the earth so

1006
00:36:25,190 --> 00:36:21,680
this one is getting blown in

1007
00:36:26,870 --> 00:36:25,200
by the sun by the solar wind and it's

1008
00:36:28,870 --> 00:36:26,880
pointed in an opposite direction to the

1009
00:36:31,430 --> 00:36:28,880
earth's magnetic field and so what's

1010
00:36:33,030 --> 00:36:31,440
going to happen when it moves uh to the

1011
00:36:34,710 --> 00:36:33,040
right is it's going to that magnetic

1012
00:36:36,390 --> 00:36:34,720
field is going to break and that's

1013
00:36:38,390 --> 00:36:36,400

magnetic reconnection

1014

00:36:41,270 --> 00:36:38,400

so let's go ahead and roll the movie

1015

00:36:42,550 --> 00:36:41,280

and you can see it come in and break

1016

00:36:44,390 --> 00:36:42,560

and that's again the magnetic

1017

00:36:46,150 --> 00:36:44,400

reconnection process and you see it

1018

00:36:47,430 --> 00:36:46,160

doesn't stop there that was the dayside

1019

00:36:49,990 --> 00:36:47,440

one but now

1020

00:36:52,390 --> 00:36:50,000

those magnetic field lines get dragged

1021

00:36:54,310 --> 00:36:52,400

away from the sun to the magneto tail

1022

00:36:57,670 --> 00:36:54,320

and they're again opposite oppositely

1023

00:36:59,670 --> 00:36:57,680

directed and those break and it can

1024

00:37:00,870 --> 00:36:59,680

shoot particles back towards the earth

1025

00:37:03,190 --> 00:37:00,880

and we've heard that magnetic

1026
00:37:05,349 --> 00:37:03,200
reconnection plays a strong uh part of

1027
00:37:06,950 --> 00:37:05,359
space weather so it's shooting those

1028
00:37:08,470 --> 00:37:06,960
particles back towards earth that can

1029
00:37:11,030 --> 00:37:08,480
cause the problems with space weather

1030
00:37:14,630 --> 00:37:11,040
like satellites or

1031
00:37:17,430 --> 00:37:14,640
communication problems things like that

1032
00:37:21,589 --> 00:37:19,349
so the other thing you can see from that

1033
00:37:23,030 --> 00:37:21,599
animation is that

1034
00:37:25,190 --> 00:37:23,040
you have things happening on very

1035
00:37:27,190 --> 00:37:25,200
different scales and that's why the mms

1036
00:37:29,910 --> 00:37:27,200
mission is called mms magnet

1037
00:37:31,510 --> 00:37:29,920
magnetospheric multiscale so multiscale

1038
00:37:33,589 --> 00:37:31,520

refers to the idea that you have

1039

00:37:35,190 --> 00:37:33,599

something happening in a very small

1040

00:37:37,190 --> 00:37:35,200

region of space

1041

00:37:38,870 --> 00:37:37,200

where the magnetic field lines break and

1042

00:37:40,790 --> 00:37:38,880

it affects what's going on in a very

1043

00:37:43,750 --> 00:37:40,800

large region of space so as we've heard

1044

00:37:46,069 --> 00:37:43,760

the entire uh reconnection process

1045

00:37:47,990 --> 00:37:46,079

happens only over six miles you know 10

1046

00:37:49,510 --> 00:37:48,000

kilometers and the whole magnetosphere

1047

00:37:51,430 --> 00:37:49,520

is about 100 or sorry it's about a

1048

00:37:52,870 --> 00:37:51,440

million miles

1049

00:37:56,630 --> 00:37:52,880

so something that happens in a very

1050

00:37:58,630 --> 00:37:56,640

small place affects the large scale and

1051
00:38:00,069 --> 00:37:58,640
as we've heard we've had we have

1052
00:38:02,230 --> 00:38:00,079
instruments up there that measure the

1053
00:38:03,990 --> 00:38:02,240
large scale and what we've never had is

1054
00:38:05,990 --> 00:38:04,000
an instrument to measure the very

1055
00:38:07,510 --> 00:38:06,000
smallest scale so that's what mms is

1056
00:38:10,150 --> 00:38:07,520
going to be doing for us is measuring

1057
00:38:10,950 --> 00:38:10,160
those smallest scales

1058
00:38:12,470 --> 00:38:10,960
so

1059
00:38:14,470 --> 00:38:12,480
another thing i wanted to share with you

1060
00:38:16,069 --> 00:38:14,480
is we've talked about

1061
00:38:18,470 --> 00:38:16,079
solar flares and that reconnection

1062
00:38:20,310 --> 00:38:18,480
happens in on the sun and many other

1063
00:38:22,950 --> 00:38:20,320

places in the universe

1064

00:38:25,829 --> 00:38:22,960

it can happen in fusion devices

1065

00:38:27,510 --> 00:38:25,839

it happens at the edge of the solar

1066

00:38:29,270 --> 00:38:27,520

system where where it runs into

1067

00:38:31,270 --> 00:38:29,280

interstellar space

1068

00:38:33,030 --> 00:38:31,280

can happen at compact objects like

1069

00:38:34,630 --> 00:38:33,040

neutron stars and black holes these

1070

00:38:36,550 --> 00:38:34,640

kinds of things so i wanted to show you

1071

00:38:38,470 --> 00:38:36,560

an example of reconnection happening in

1072

00:38:41,030 --> 00:38:38,480

the sun so if we can bring up the next

1073

00:38:44,230 --> 00:38:41,040

image what we're looking at here is an

1074

00:38:46,150 --> 00:38:44,240

image from the nasa sdo satellite the

1075

00:38:47,589 --> 00:38:46,160

space or sorry the solar dynamics

1076

00:38:49,190 --> 00:38:47,599

observatory

1077

00:38:53,270 --> 00:38:49,200

this is what the sun would look like if

1078

00:38:55,430 --> 00:38:53,280

we could see in the ultraviolet range

1079

00:38:56,470 --> 00:38:55,440

and what we see here is a number of

1080

00:38:59,349 --> 00:38:56,480

loops

1081

00:39:01,670 --> 00:38:59,359

on the edges of the sun what that is is

1082

00:39:03,589 --> 00:39:01,680

a number of charged particles

1083

00:39:06,069 --> 00:39:03,599

they are giving off light and so we see

1084

00:39:07,910 --> 00:39:06,079

that light in the ultraviolet

1085

00:39:09,349 --> 00:39:07,920

but those particles are trapped to move

1086

00:39:10,870 --> 00:39:09,359

along magnetic field lines so what

1087

00:39:12,829 --> 00:39:10,880

that's really giving us information

1088

00:39:15,030 --> 00:39:12,839

about is the magnetic fields

1089

00:39:17,910 --> 00:39:15,040

themselves and so what you're going to

1090

00:39:19,589 --> 00:39:17,920

see in just a second is the telltale

1091

00:39:21,109 --> 00:39:19,599

signs of reconnection right in the

1092

00:39:22,950 --> 00:39:21,119

middle you'll see

1093

00:39:24,630 --> 00:39:22,960

material moving towards the center and

1094

00:39:25,910 --> 00:39:24,640

then you'll see it gets shot up the top

1095

00:39:27,190 --> 00:39:25,920

and the bottom just like if we were

1096

00:39:29,589 --> 00:39:27,200

bringing these magnets together and the

1097

00:39:33,589 --> 00:39:29,599

magnetic fields go to the top and bottom

1098

00:39:38,150 --> 00:39:35,510

so you can see the arrows are pointing

1099

00:39:40,230 --> 00:39:38,160

to where the material is coming together

1100

00:39:43,109 --> 00:39:40,240

and then you can see it getting shot out

1101

00:39:44,950 --> 00:39:43,119

the top and the bottom

1102

00:39:47,270 --> 00:39:44,960

so that shows very directly that

1103

00:39:49,589 --> 00:39:47,280

magnetic reconnection is happening in in

1104

00:39:51,190 --> 00:39:49,599

the sun and what's interesting here is

1105

00:39:53,750 --> 00:39:51,200

you can use another satellite mission

1106

00:39:56,710 --> 00:39:53,760

called the resi satellite

1107

00:39:58,470 --> 00:39:56,720

which measures x-rays so even hotter

1108

00:40:00,150 --> 00:39:58,480

material so

1109

00:40:02,550 --> 00:40:00,160

you see the orange blobs here let me

1110

00:40:04,390 --> 00:40:02,560

tell you what that means

1111

00:40:07,349 --> 00:40:04,400

what we were looking at initially was

1112

00:40:08,550 --> 00:40:07,359

about 18 million degrees and the rusty

1113

00:40:10,230 --> 00:40:08,560

satellite

1114

00:40:12,790 --> 00:40:10,240

looks at x-rays so it's much higher

1115

00:40:15,270 --> 00:40:12,800

energies it's about uh 200 million

1116

00:40:18,069 --> 00:40:15,280

degrees so what rescue tells us is where

1117

00:40:19,750 --> 00:40:18,079

the the most energetic particles are

1118

00:40:22,230 --> 00:40:19,760

and what we saw when those with those

1119

00:40:24,150 --> 00:40:22,240

blobs is that those blobs were telling

1120

00:40:26,230 --> 00:40:24,160

us that right near where reconnection

1121

00:40:28,630 --> 00:40:26,240

happens that's where the most energetic

1122

00:40:30,630 --> 00:40:28,640

particles are and so that tells us that

1123

00:40:32,390 --> 00:40:30,640

reconnection in the sun

1124

00:40:35,270 --> 00:40:32,400

in the atmosphere of the sun is

1125

00:40:37,109 --> 00:40:35,280

producing those high energetic highly

1126

00:40:39,510 --> 00:40:37,119

energetic particles

1127

00:40:41,109 --> 00:40:39,520

and so with mms you know we can't

1128

00:40:42,630 --> 00:40:41,119

directly measure what's going on in the

1129

00:40:45,349 --> 00:40:42,640

sun we can't stick a probe right there

1130

00:40:47,510 --> 00:40:45,359

but we can stick a probe in the earth's

1131

00:40:49,829 --> 00:40:47,520

magnetosphere and we can measure how

1132

00:40:52,710 --> 00:40:49,839

particles are accelerated by

1133

00:40:54,550 --> 00:40:52,720

reconnection in the magnetosphere so

1134

00:40:56,790 --> 00:40:54,560

by learning that we'll be able to

1135

00:40:59,190 --> 00:40:56,800

understand what happens in the sun

1136

00:41:02,150 --> 00:40:59,200

during solar flares

1137

00:41:04,230 --> 00:41:02,160

so just to give you a feel for

1138

00:41:07,829 --> 00:41:04,240

how much energy is released we saw in

1139

00:41:09,510 --> 00:41:07,839

roy's demo a nice spark

1140

00:41:11,349 --> 00:41:09,520

cosmically speaking that wasn't a huge

1141

00:41:13,430 --> 00:41:11,359

amount of energy

1142

00:41:15,430 --> 00:41:13,440

when we were talking about solar flares

1143

00:41:17,190 --> 00:41:15,440

the largest solar flares give off

1144

00:41:18,550 --> 00:41:17,200

absolutely huge amounts of energy and

1145

00:41:20,230 --> 00:41:18,560

that's all because of the reconnection

1146

00:41:22,470 --> 00:41:20,240

process

1147

00:41:24,870 --> 00:41:22,480

so some of the largest solar flares give

1148

00:41:27,670 --> 00:41:24,880

off the same amount of energy basically

1149

00:41:29,670 --> 00:41:27,680

it would take about 40 billion atomic

1150

00:41:31,829 --> 00:41:29,680

explosions to give you the same amount

1151

00:41:33,510 --> 00:41:31,839

of energy that is given off in a very

1152

00:41:35,190 --> 00:41:33,520

large solar flare

1153

00:41:37,190 --> 00:41:35,200

and solar flares happen over the scale

1154

00:41:40,470 --> 00:41:37,200

of about 20 minutes

1155

00:41:43,670 --> 00:41:40,480

so just insane amount of energy the most

1156

00:41:45,430 --> 00:41:43,680

energetic events in the solar system and

1157

00:41:47,349 --> 00:41:45,440

so that's why

1158

00:41:48,870 --> 00:41:47,359

you know learning about reconnection in

1159

00:41:50,870 --> 00:41:48,880

the magnetosphere is going to help us

1160

00:41:52,230 --> 00:41:50,880

understand reconnection in these other

1161

00:41:53,750 --> 00:41:52,240

places

1162

00:41:57,589 --> 00:41:53,760

so in summary

1163

00:41:59,190 --> 00:41:57,599

mms is just fantastically exciting for

1164

00:42:01,190 --> 00:41:59,200

scientists studying this because we're

1165

00:42:02,630 --> 00:42:01,200

finally going to get to see

1166

00:42:05,190 --> 00:42:02,640

what happens right where the magnetic

1167

00:42:07,430 --> 00:42:05,200

fields break we're going to be able to

1168

00:42:09,670 --> 00:42:07,440

measure how the charged particles gain

1169

00:42:11,670 --> 00:42:09,680

energy and it's really going to give us

1170

00:42:14,150 --> 00:42:11,680

a lot of perspective on how reconnection

1171

00:42:15,829 --> 00:42:14,160

happens all over the universe

1172

00:42:17,750 --> 00:42:15,839

so with that i'll pass it back to george

1173

00:42:20,550 --> 00:42:17,760

all right thank you paul

1174

00:42:22,390 --> 00:42:20,560

we're ready now to take questions

1175

00:42:24,390 --> 00:42:22,400

and uh when you get the microphone if

1176
00:42:28,069 --> 00:42:24,400
you would give us your name and also

1177
00:42:31,270 --> 00:42:28,079
your affiliation if you have one

1178
00:42:33,109 --> 00:42:31,280
questions out here in the front

1179
00:42:35,030 --> 00:42:33,119
hi ken kramer for american space and

1180
00:42:36,550 --> 00:42:35,040
universe today can can you talk about

1181
00:42:39,270 --> 00:42:36,560
these hot spots how will you be

1182
00:42:43,030 --> 00:42:39,280
maneuvering these spacecraft to search

1183
00:42:45,589 --> 00:42:43,040
for the hot spots and collect the data

1184
00:42:47,589 --> 00:42:45,599
uh well i'll take that question the uh

1185
00:42:49,349 --> 00:42:47,599
the as jim mentioned we maneuver them

1186
00:42:51,030 --> 00:42:49,359
into a pyramid shape to get a

1187
00:42:53,349 --> 00:42:51,040
three-dimensional view

1188
00:42:55,589 --> 00:42:53,359

and then we've constructed the mission

1189

00:42:57,670 --> 00:42:55,599

profile as i said in these two phases to

1190

00:42:59,349 --> 00:42:57,680

go to where we know

1191

00:43:01,910 --> 00:42:59,359

from previous missions it must be

1192

00:43:04,390 --> 00:43:01,920

occurring and then as craig said these

1193

00:43:06,710 --> 00:43:04,400

these hot spots move back and forth and

1194

00:43:09,030 --> 00:43:06,720

basically we sit there and wait until

1195

00:43:10,950 --> 00:43:09,040

they come by us but we know from

1196

00:43:12,630 --> 00:43:10,960

previous missions that

1197

00:43:14,950 --> 00:43:12,640

the probability of us encountering them

1198

00:43:17,190 --> 00:43:14,960

is very very high we expect to encounter

1199

00:43:19,349 --> 00:43:17,200

a few hundred of these mission uh

1200

00:43:21,910 --> 00:43:19,359

hotspots that we know we can isolate

1201

00:43:23,910 --> 00:43:21,920

what's really going on and that's uh

1202

00:43:25,589 --> 00:43:23,920

that's what we'll use the information

1203

00:43:26,470 --> 00:43:25,599

that's captured in a very small amount

1204

00:43:28,390 --> 00:43:26,480

of time

1205

00:43:29,910 --> 00:43:28,400

i don't know if jim mentioned that the

1206

00:43:31,990 --> 00:43:29,920

information from all these instruments

1207

00:43:34,309 --> 00:43:32,000

is so large that we can't actually get

1208

00:43:36,630 --> 00:43:34,319

it all to the ground we can only end up

1209

00:43:38,069 --> 00:43:36,640

getting about two percent of the real

1210

00:43:39,750 --> 00:43:38,079

information down to the ground because

1211

00:43:42,630 --> 00:43:39,760

there's so many instruments and so much

1212

00:43:45,750 --> 00:43:42,640

data occurring in that very small time

1213

00:43:47,670 --> 00:43:45,760

it's a sub second that we have to get

1214

00:43:49,270 --> 00:43:47,680

and so what we do is we have a process

1215

00:43:51,510 --> 00:43:49,280

to look at

1216

00:43:53,109 --> 00:43:51,520

indicators on the ground and say this is

1217

00:43:54,230 --> 00:43:53,119

the data we want

1218

00:43:55,750 --> 00:43:54,240

then we'll have an argument about

1219

00:43:57,349 --> 00:43:55,760

whether that data is

1220

00:43:59,190 --> 00:43:57,359

what we really want and we'll send some

1221

00:44:01,510 --> 00:43:59,200

of it down and we will keep doing that

1222

00:44:04,790 --> 00:44:01,520

until we find what we really need to

1223

00:44:08,230 --> 00:44:04,800

isolate the physics of reconnection

1224

00:44:10,790 --> 00:44:08,240

if i if i could add

1225

00:44:12,470 --> 00:44:10,800

what roy just described we do have a

1226

00:44:14,150 --> 00:44:12,480

process where we

1227

00:44:16,470 --> 00:44:14,160

essentially when we're in the region of

1228

00:44:19,109 --> 00:44:16,480

interest where we may encounter

1229

00:44:21,750 --> 00:44:19,119

reconnection we send down

1230

00:44:23,510 --> 00:44:21,760

a low resolution data set we call it the

1231

00:44:26,630 --> 00:44:23,520

fast survey data

1232

00:44:28,390 --> 00:44:26,640

and on a literally a daily basis

1233

00:44:31,910 --> 00:44:28,400

scientists will review the low

1234

00:44:33,270 --> 00:44:31,920

resolution and pick two minutes here 30

1235

00:44:37,270 --> 00:44:33,280

seconds there

1236

00:44:39,750 --> 00:44:37,280

we get about 15 minutes a day that we

1237

00:44:42,150 --> 00:44:39,760

can budget like that and so there's

1238

00:44:44,470 --> 00:44:42,160

scientists inspecting the low resolution

1239

00:44:45,589 --> 00:44:44,480

data while the higher resolution data is

1240

00:44:48,150 --> 00:44:45,599

stored

1241

00:44:50,390 --> 00:44:48,160

uh in memory on the spacecraft we'll

1242

00:44:52,069 --> 00:44:50,400

select these little intervals based on

1243

00:44:52,950 --> 00:44:52,079

inspection of the low resolution flight

1244

00:44:57,670 --> 00:44:52,960

data

1245

00:44:59,990 --> 00:44:57,680

from which we hope to glean the uh

1246

00:45:01,589 --> 00:45:00,000

details and understanding of the process

1247

00:45:02,630 --> 00:45:01,599

i'd like to add you ask an excellent

1248

00:45:05,270 --> 00:45:02,640

question you're going to see it takes

1249

00:45:07,030 --> 00:45:05,280

three of us to answer it

1250

00:45:09,829 --> 00:45:07,040

we can't drive these spacecraft through

1251
00:45:11,670 --> 00:45:09,839
that region of interest you have to

1252
00:45:14,069 --> 00:45:11,680
establish a pyramid on an orbit to orbit

1253
00:45:15,430 --> 00:45:14,079
basis so we get what we think is good we

1254
00:45:17,270 --> 00:45:15,440
go through now

1255
00:45:19,109 --> 00:45:17,280
roy and craig mentioned what we call a

1256
00:45:20,550 --> 00:45:19,119
scientist in the loop where scientists

1257
00:45:22,390 --> 00:45:20,560
on the ground look at low resolution

1258
00:45:23,990 --> 00:45:22,400
data and say here's a good boundary we

1259
00:45:25,670 --> 00:45:24,000
think this is good but what are they

1260
00:45:27,990 --> 00:45:25,680
comparing that to we also have a system

1261
00:45:30,069 --> 00:45:28,000
on board the spacecraft that can look

1262
00:45:31,349 --> 00:45:30,079
not at the low resolution data but can

1263
00:45:33,430 --> 00:45:31,359

look at the burst mode the highest

1264

00:45:35,510 --> 00:45:33,440
resolution data that we can take

1265

00:45:37,430 --> 00:45:35,520
that system on board with software is

1266

00:45:39,109 --> 00:45:37,440
selecting regions so what these people

1267

00:45:41,190 --> 00:45:39,119
on the ground is doing is really

1268

00:45:42,710 --> 00:45:41,200
deciding do we need to trump what the

1269

00:45:45,670 --> 00:45:42,720
onboard system

1270

00:45:48,150 --> 00:45:45,680
has decided to send down to us

1271

00:45:49,109 --> 00:45:48,160
and for this we needed a very large

1272

00:45:51,750 --> 00:45:49,119
memory

1273

00:45:54,630 --> 00:45:51,760
radiation hards 100 giga i mean about

1274

00:45:55,670 --> 00:45:54,640
100 gigabytes 96 gigabyte uh

1275

00:45:57,750 --> 00:45:55,680
memory

1276

00:46:00,150 --> 00:45:57,760

and we constructed this out of you're

1277

00:46:01,510 --> 00:46:00,160

familiar with these flash drives in your

1278

00:46:03,109 --> 00:46:01,520

laptop

1279

00:46:05,430 --> 00:46:03,119

because it was too expensive to get to

1280

00:46:07,430 --> 00:46:05,440

buy one at those specs and so we had a

1281

00:46:09,910 --> 00:46:07,440

clever engineer that said you know some

1282

00:46:11,910 --> 00:46:09,920

of these flash drives might be radiation

1283

00:46:13,589 --> 00:46:11,920

hard we don't know they bought a bunch

1284

00:46:14,790 --> 00:46:13,599

of them up took them to an accelerator

1285

00:46:17,430 --> 00:46:14,800

in france

1286

00:46:19,430 --> 00:46:17,440

and found out some were really hard

1287

00:46:22,069 --> 00:46:19,440

yeah some lots and so we bought up all

1288

00:46:23,670 --> 00:46:22,079

of that stuff and that's what's on there

1289

00:46:25,430 --> 00:46:23,680

and we're also turning into a line of

1290

00:46:28,950 --> 00:46:25,440

business we're selling those

1291

00:46:30,790 --> 00:46:28,960

memories to other folks now

1292

00:46:34,870 --> 00:46:30,800

yep right back here

1293

00:46:36,870 --> 00:46:34,880

historical imagery mark gotch canada

1294

00:46:38,710 --> 00:46:36,880

an amazing presentation you've given

1295

00:46:41,589 --> 00:46:38,720

this afternoon

1296

00:46:43,990 --> 00:46:41,599

to look at the amazing amounts of

1297

00:46:46,470 --> 00:46:44,000

hardware that are going to be installed

1298

00:46:49,030 --> 00:46:46,480

in these satellites and working sending

1299

00:46:51,109 --> 00:46:49,040

this information back is just incredible

1300

00:46:53,829 --> 00:46:51,119

but to ask you a question when these

1301
00:46:57,750 --> 00:46:53,839
satellites will be orbiting earth

1302
00:46:59,109 --> 00:46:57,760
and recording these magnetospheres

1303
00:47:03,030 --> 00:46:59,119
in reverse

1304
00:47:05,430 --> 00:47:03,040
from earth how far out into space

1305
00:47:08,950 --> 00:47:05,440
will these magnetospheres

1306
00:47:10,630 --> 00:47:08,960
being monitored in terms of

1307
00:47:11,670 --> 00:47:10,640
capturing the information with this

1308
00:47:13,670 --> 00:47:11,680
hardware

1309
00:47:14,950 --> 00:47:13,680
how far out into space

1310
00:47:16,630 --> 00:47:14,960
from earth

1311
00:47:18,710 --> 00:47:16,640
will it be

1312
00:47:19,910 --> 00:47:18,720
there what i showed in that animation of

1313
00:47:22,950 --> 00:47:19,920

the orbits

1314

00:47:25,190 --> 00:47:22,960

the largest distance we go to is 25

1315

00:47:27,829 --> 00:47:25,200

earth radii each earth radio has about 6

1316

00:47:29,910 --> 00:47:27,839

000 kilometers 6300

1317

00:47:31,829 --> 00:47:29,920

so uh you know it's like uh halfway to

1318

00:47:33,829 --> 00:47:31,839

the moon that's as far out as we go

1319

00:47:36,150 --> 00:47:33,839

beyond that uh reconnection happens only

1320

00:47:38,150 --> 00:47:36,160

rarely it still happens but we know from

1321

00:47:40,150 --> 00:47:38,160

previous missions statistically where it

1322

00:47:42,550 --> 00:47:40,160

most likely happens on the night side is

1323

00:47:47,349 --> 00:47:42,560

halfway to the moon and on the day size

1324

00:47:52,309 --> 00:47:49,829

right here ed ruskoski

1325

00:47:54,309 --> 00:47:52,319

social media how long do you plan to

1326

00:47:57,510 --> 00:47:54,319

take measurements with your vehicles and

1327

00:47:59,589 --> 00:47:57,520

also what is the planned mission life

1328

00:48:01,349 --> 00:47:59,599

it's a two-year mission

1329

00:48:02,950 --> 00:48:01,359

and we won't be out of fuel though we'll

1330

00:48:04,230 --> 00:48:02,960

still have fuel left

1331

00:48:05,430 --> 00:48:04,240

and

1332

00:48:07,670 --> 00:48:05,440

so if we

1333

00:48:09,510 --> 00:48:07,680

spacecraft healthy we would probably

1334

00:48:11,270 --> 00:48:09,520

propose to keep running it for a while

1335

00:48:13,349 --> 00:48:11,280

but as of now

1336

00:48:16,550 --> 00:48:13,359

two-year mission an additional year of

1337

00:48:17,670 --> 00:48:16,560

analysis of the data

1338

00:48:19,109 --> 00:48:17,680

right here

1339

00:48:20,710 --> 00:48:19,119

hi i'm yolanda kearney i'm the public

1340

00:48:22,950 --> 00:48:20,720

affairs officer at u.s embassy

1341

00:48:24,230 --> 00:48:22,960

bridgetown where i'm lucky i have an

1342

00:48:26,710 --> 00:48:24,240

ambassador who's a former physics

1343

00:48:28,549 --> 00:48:26,720

professor so um thank you for making it

1344

00:48:29,990 --> 00:48:28,559

all look easy so around the world at our

1345

00:48:31,910 --> 00:48:30,000

embassies we still have people who draw

1346

00:48:34,150 --> 00:48:31,920

a tremendous amount of

1347

00:48:36,150 --> 00:48:34,160

inspiration from nasa we were lucky

1348

00:48:37,829 --> 00:48:36,160

enough to host neil degrasse tyson for a

1349

00:48:39,750 --> 00:48:37,839

lecture in

1350

00:48:41,109 --> 00:48:39,760

november a little six-year-old came up

1351
00:48:43,510 --> 00:48:41,119
to him and asked him what if there were

1352
00:48:45,109 --> 00:48:43,520
no nasa so he gave a beautiful response

1353
00:48:47,109 --> 00:48:45,119
but i'd like to know what your message

1354
00:48:48,390 --> 00:48:47,119
is for us around the world as we talk

1355
00:48:50,549 --> 00:48:48,400
about the about

1356
00:48:53,589 --> 00:48:50,559
the influence of nasa still what if

1357
00:48:56,549 --> 00:48:53,599
there were no nasa

1358
00:48:57,589 --> 00:48:56,559
uh that's for jim or or roy or whoever

1359
00:49:00,150 --> 00:48:57,599
you asked me

1360
00:49:02,710 --> 00:49:00,160
that's a good question as well

1361
00:49:08,069 --> 00:49:02,720
well you know i don't i still remember

1362
00:49:12,710 --> 00:49:10,870
i've been at this game a long time

1363
00:49:15,750 --> 00:49:12,720

and uh so you know and then there was a

1364

00:49:17,750 --> 00:49:15,760

naca it was mostly aeronautics

1365

00:49:19,270 --> 00:49:17,760

thing and so what got people interested

1366

00:49:20,309 --> 00:49:19,280

was the space race of course the

1367

00:49:21,990 --> 00:49:20,319

russians put

1368

00:49:23,990 --> 00:49:22,000

a sputnik up and well we had to get a

1369

00:49:25,990 --> 00:49:24,000

satellite up and then they put a man in

1370

00:49:27,589 --> 00:49:26,000

our well we had to do that it was mostly

1371

00:49:29,030 --> 00:49:27,599

like that but as

1372

00:49:31,109 --> 00:49:29,040

time went by

1373

00:49:32,150 --> 00:49:31,119

there was a very excellent science

1374

00:49:34,230 --> 00:49:32,160

program

1375

00:49:36,950 --> 00:49:34,240

developed in nasa it's like a

1376
00:49:38,390 --> 00:49:36,960
national science foundation embedded

1377
00:49:40,230 --> 00:49:38,400
in nasa

1378
00:49:43,270 --> 00:49:40,240
and everything is done it's a

1379
00:49:44,870 --> 00:49:43,280
meritocracy everything is competed

1380
00:49:46,390 --> 00:49:44,880
every mission we do like this one was

1381
00:49:47,910 --> 00:49:46,400
heavy competition

1382
00:49:49,990 --> 00:49:47,920
to pick the people who do it and so

1383
00:49:52,549 --> 00:49:50,000
nothing is just given to anybody so

1384
00:49:54,950 --> 00:49:52,559
people are very interested in the space

1385
00:49:56,390 --> 00:49:54,960
science and they're willing to

1386
00:49:57,750 --> 00:49:56,400
to you know go to school learn more

1387
00:49:59,829 --> 00:49:57,760
about it and compete with other people

1388
00:50:02,470 --> 00:49:59,839

to get these to do these missions

1389

00:50:03,430 --> 00:50:02,480

if nasa cease to exist i think what we

1390

00:50:04,790 --> 00:50:03,440

know

1391

00:50:09,349 --> 00:50:04,800

about the

1392

00:50:12,069 --> 00:50:09,359

it would just cease we wouldn't have we

1393

00:50:13,349 --> 00:50:12,079

wouldn't know anymore

1394

00:50:15,030 --> 00:50:13,359

it i mean it used to be close to the

1395

00:50:16,390 --> 00:50:15,040

earth there's a you know the navy and

1396

00:50:18,390 --> 00:50:16,400

the air force fly some satellites but

1397

00:50:20,309 --> 00:50:18,400

all that kind of stuff we mostly know

1398

00:50:21,510 --> 00:50:20,319

about but farther out we wouldn't we'd

1399

00:50:23,750 --> 00:50:21,520

be looking

1400

00:50:25,910 --> 00:50:23,760

to the europeans the japanese the

1401

00:50:28,230 --> 00:50:25,920

indians the chinese would be reading

1402

00:50:30,630 --> 00:50:28,240

their journals instead of ours sorry

1403

00:50:35,750 --> 00:50:30,640

no problem i think i'll add and um sorry

1404

00:50:40,549 --> 00:50:36,790

um

1405

00:50:42,870 --> 00:50:40,559

i i think that that nasa provides

1406

00:50:45,109 --> 00:50:42,880

a fundamental

1407

00:50:46,790 --> 00:50:45,119

uh impetus for for science in this in

1408

00:50:48,069 --> 00:50:46,800

this country i think that it's a

1409

00:50:50,549 --> 00:50:48,079

partnership

1410

00:50:53,109 --> 00:50:50,559

uh you see a representative here i work

1411

00:50:55,589 --> 00:50:53,119

for nasa jim for a company

1412

00:50:59,430 --> 00:50:55,599

roy for university so you see the the

1413

00:51:01,270 --> 00:50:59,440

difference i think nasa provides a a a a

1414

00:51:03,349 --> 00:51:01,280

force that that

1415

00:51:06,790 --> 00:51:03,359

helps unify and and

1416

00:51:08,630 --> 00:51:06,800

provide uh inspiration to to the nation

1417

00:51:10,549 --> 00:51:08,640

to do this great science so i think that

1418

00:51:12,390 --> 00:51:10,559

at the time that you know what what

1419

00:51:14,870 --> 00:51:12,400

happened at nasa i think you'd lose

1420

00:51:16,549 --> 00:51:14,880

something you you rely

1421

00:51:17,750 --> 00:51:16,559

the individuals are spread throughout

1422

00:51:19,829 --> 00:51:17,760

they're at the they're at the

1423

00:51:22,790 --> 00:51:19,839

universities they're at the uh corporate

1424

00:51:24,150 --> 00:51:22,800

world but i think that the nasa's role

1425

00:51:27,750 --> 00:51:24,160

is really to

1426

00:51:29,270 --> 00:51:27,760

to to lead help bleed uh people into a

1427

00:51:32,309 --> 00:51:29,280

common direction that will really

1428

00:51:34,870 --> 00:51:32,319

benefit the whole nation in in

1429

00:51:37,349 --> 00:51:34,880

in unsuspecting ways we really don't

1430

00:51:38,950 --> 00:51:37,359

know as you heard here today we're

1431

00:51:40,870 --> 00:51:38,960

really interested in in the fundamental

1432

00:51:43,190 --> 00:51:40,880

physics of magnetic reconnection and

1433

00:51:45,829 --> 00:51:43,200

then how it relates to activity in space

1434

00:51:48,150 --> 00:51:45,839

but yet there may be an offshoot of

1435

00:51:49,510 --> 00:51:48,160

understanding about uh fusion reactors

1436

00:51:51,270 --> 00:51:49,520

here on the ground

1437

00:51:54,069 --> 00:51:51,280

throughout nasa's history there has

1438

00:51:56,710 --> 00:51:54,079

always been that that

1439

00:51:59,109 --> 00:51:56,720

dual nature of pure science and yet uh

1440

00:52:01,510 --> 00:51:59,119

practical applications so i think that's

1441

00:52:02,950 --> 00:52:01,520

i would say the role

1442

00:52:04,390 --> 00:52:02,960

if i could respond

1443

00:52:06,069 --> 00:52:04,400

because i teach undergraduates on a

1444

00:52:08,390 --> 00:52:06,079

regular basis and

1445

00:52:10,390 --> 00:52:08,400

and graduate students too occasionally

1446

00:52:11,990 --> 00:52:10,400

but i can just say very simply nasa

1447

00:52:14,230 --> 00:52:12,000

provides really that spark for

1448

00:52:17,270 --> 00:52:14,240

imagination which is really important

1449

00:52:21,670 --> 00:52:19,430

any further questions

1450

00:52:23,510 --> 00:52:21,680

yes certainly um

1451

00:52:26,790 --> 00:52:23,520

just an hour or two ago

1452

00:52:29,990 --> 00:52:26,800

i was lucky enough to visit the um

1453

00:52:31,670 --> 00:52:30,000

the apollo saturn 5 center here on

1454

00:52:34,470 --> 00:52:31,680

kennedy space center

1455

00:52:35,270 --> 00:52:34,480

and uh i took the occasion to to see

1456

00:52:37,270 --> 00:52:35,280

this

1457

00:52:39,510 --> 00:52:37,280

14-minute video

1458

00:52:40,870 --> 00:52:39,520

show that they have about the moon

1459

00:52:42,230 --> 00:52:40,880

landings

1460

00:52:44,309 --> 00:52:42,240

and um

1461

00:52:45,910 --> 00:52:44,319

and through that video and at the end of

1462

00:52:47,910 --> 00:52:45,920

it there were they there was some

1463

00:52:49,109 --> 00:52:47,920

interviews with astronauts

1464

00:52:51,349 --> 00:52:49,119

and

1465

00:52:56,309 --> 00:52:51,359

alan shepard

1466

00:52:57,990 --> 00:52:56,319

related his experience

1467

00:53:01,190 --> 00:52:58,000

standing on the moon

1468

00:53:02,470 --> 00:53:01,200

looking back at the earth and

1469

00:53:03,990 --> 00:53:02,480

and uh

1470

00:53:06,390 --> 00:53:04,000

contemplating

1471

00:53:09,109 --> 00:53:06,400

how unfortunate it is

1472

00:53:10,549 --> 00:53:09,119

that back there on that small lifeboat

1473

00:53:12,309 --> 00:53:10,559

in space

1474

00:53:13,589 --> 00:53:12,319

people are busy fighting each other in

1475

00:53:14,549 --> 00:53:13,599

conflict

1476
00:53:17,270 --> 00:53:14,559
and

1477
00:53:18,710 --> 00:53:17,280
he said he actually shed tears

1478
00:53:20,710 --> 00:53:18,720
and i think that

1479
00:53:22,230 --> 00:53:20,720
one of the important functions

1480
00:53:24,470 --> 00:53:22,240
of nasa

1481
00:53:26,230 --> 00:53:24,480
really is to

1482
00:53:27,750 --> 00:53:26,240
give ourselves an opportunity to see

1483
00:53:29,750 --> 00:53:27,760
ourselves in

1484
00:53:33,030 --> 00:53:29,760
a broader context

1485
00:53:34,710 --> 00:53:33,040
and understand that

1486
00:53:37,030 --> 00:53:34,720
you know this is sort of a lifeboat

1487
00:53:38,069 --> 00:53:37,040
earth and

1488
00:53:41,109 --> 00:53:38,079

to

1489

00:53:42,630 --> 00:53:41,119
perhaps imagine a little bit better

1490

00:53:44,950 --> 00:53:42,640
the futility

1491

00:53:46,150 --> 00:53:44,960
of the conflict that we engage in all

1492

00:53:48,069 --> 00:53:46,160
too often

1493

00:53:50,470 --> 00:53:48,079
and so i think that

1494

00:53:53,510 --> 00:53:50,480
that that's something that nasa

1495

00:53:57,430 --> 00:53:55,270
many people's consciousness and will

1496

00:53:59,270 --> 00:53:57,440
continue to do so in the future and i

1497

00:54:02,309 --> 00:53:59,280
think that's a really important

1498

00:54:04,069 --> 00:54:02,319
role for nasa

1499

00:54:05,990 --> 00:54:04,079
okay right here

1500

00:54:08,150 --> 00:54:06,000
uh yes chris haber uh haber digital

1501
00:54:11,190 --> 00:54:08,160
media i was hoping if you guys could go

1502
00:54:13,030 --> 00:54:11,200
through uh basically the timeline of the

1503
00:54:14,950 --> 00:54:13,040
science from back in the 40s when the

1504
00:54:16,870 --> 00:54:14,960
phenomenon was discovered

1505
00:54:19,270 --> 00:54:16,880
through some of the previous missions

1506
00:54:21,990 --> 00:54:19,280
that have worked on it up to the decadal

1507
00:54:22,950 --> 00:54:22,000
survey that's uh that brought us to here

1508
00:54:25,829 --> 00:54:22,960
and then

1509
00:54:27,510 --> 00:54:25,839
milestones throughout the mission

1510
00:54:30,230 --> 00:54:27,520
i think paul is a good question sure

1511
00:54:31,990 --> 00:54:30,240
i'll take that one um so yeah so uh

1512
00:54:33,990 --> 00:54:32,000
reconnection was discovered in the 40s

1513
00:54:35,829 --> 00:54:34,000

is from people studying solar flares

1514

00:54:37,349 --> 00:54:35,839

they realize that

1515

00:54:39,270 --> 00:54:37,359

where the flares are coming from is

1516

00:54:40,870 --> 00:54:39,280

where the magnetic fields were pointing

1517

00:54:43,430 --> 00:54:40,880

in opposite directions and that's what

1518

00:54:45,190 --> 00:54:43,440

got got people started thinking about

1519

00:54:46,870 --> 00:54:45,200

that process

1520

00:54:48,950 --> 00:54:46,880

almost immediately they realized that

1521

00:54:51,670 --> 00:54:48,960

the same process would happen at the

1522

00:54:54,710 --> 00:54:51,680

earth's magnetosphere so in the early

1523

00:54:58,069 --> 00:54:54,720

sorry the the late 40s and early 50s

1524

00:54:59,990 --> 00:54:58,079

and uh so basically by the mid 60s there

1525

00:55:01,829 --> 00:55:00,000

were a lot of the theory was sort of

1526
00:55:03,510 --> 00:55:01,839
worked out and they kind of thought they

1527
00:55:04,950 --> 00:55:03,520
understood it

1528
00:55:07,589 --> 00:55:04,960
and then it

1529
00:55:10,630 --> 00:55:07,599
but not everyone believed it yet

1530
00:55:13,430 --> 00:55:10,640
and so it took into the late 70s when

1531
00:55:16,069 --> 00:55:13,440
the icy satellites were up and they

1532
00:55:18,069 --> 00:55:16,079
measured not they they weren't measuring

1533
00:55:19,990 --> 00:55:18,079
the smallest scales of reconnection but

1534
00:55:21,430 --> 00:55:20,000
they measured after effects of

1535
00:55:22,549 --> 00:55:21,440
reconnection and that's when people

1536
00:55:25,750 --> 00:55:22,559
really started believing that

1537
00:55:27,430 --> 00:55:25,760
reconnection was happening

1538
00:55:29,589 --> 00:55:27,440

so since then it's really sort of

1539

00:55:31,589 --> 00:55:29,599

exploded as a field and

1540

00:55:33,430 --> 00:55:31,599

there are a number of satellites jeff

1541

00:55:37,990 --> 00:55:33,440

showed the

1542

00:55:43,109 --> 00:55:40,470

system observatory thank you

1543

00:55:44,549 --> 00:55:43,119

and so a lot of those satellites as

1544

00:55:46,069 --> 00:55:44,559

they're going around

1545

00:55:49,109 --> 00:55:46,079

the magnetosphere they detect

1546

00:55:51,430 --> 00:55:49,119

reconnection so um you know so we can

1547

00:55:54,870 --> 00:55:51,440

see like we've heard we can see a lot of

1548

00:55:57,190 --> 00:55:54,880

what's going on uh at the large scale

1549

00:55:59,030 --> 00:55:57,200

and as you get closer down to the

1550

00:56:00,789 --> 00:55:59,040

smaller scale but what's been missing

1551
00:56:03,589 --> 00:56:00,799
from that is the smallest scale so

1552
00:56:04,870 --> 00:56:03,599
that's how mms fits into that

1553
00:56:07,030 --> 00:56:04,880
okay we're going to take a couple of

1554
00:56:08,549 --> 00:56:07,040
questions from social media and then

1555
00:56:09,630 --> 00:56:08,559
we'll come back here

1556
00:56:11,190 --> 00:56:09,640
uh

1557
00:56:12,710 --> 00:56:11,200
calacofieldwithspace.com i have two

1558
00:56:15,430 --> 00:56:12,720
questions um first of all just curious

1559
00:56:17,510 --> 00:56:15,440
if there'll be any joint observations or

1560
00:56:20,230 --> 00:56:17,520
i don't know cross-referencing you know

1561
00:56:22,390 --> 00:56:20,240
if mms sees an event looking to see if

1562
00:56:24,630 --> 00:56:22,400
there's a geomagnetic storm associated

1563
00:56:26,309 --> 00:56:24,640

with it or auroras or anything like that

1564

00:56:28,150 --> 00:56:26,319

um you know if other satellites will be

1565

00:56:30,309 --> 00:56:28,160

able to see anything to do with these

1566

00:56:32,710 --> 00:56:30,319

events and secondly have you thought

1567

00:56:36,150 --> 00:56:32,720

about what would happen if mms got hit

1568

00:56:38,549 --> 00:56:36,160

with a coronal mass ejection

1569

00:56:40,069 --> 00:56:38,559

okay well i can answer unless jeff

1570

00:56:42,390 --> 00:56:40,079

would like to but

1571

00:56:44,470 --> 00:56:42,400

he has this heliophysics

1572

00:56:46,150 --> 00:56:44,480

system observatory so all the spacecraft

1573

00:56:48,150 --> 00:56:46,160

that are already up there and we'll join

1574

00:56:50,230 --> 00:56:48,160

that fleet when we get up there and so

1575

00:56:52,390 --> 00:56:50,240

all of these spacecraft can see these

1576

00:56:54,309 --> 00:56:52,400

effects and so it'd be a lot of work

1577

00:56:56,549 --> 00:56:54,319

done by researchers and

1578

00:56:58,630 --> 00:56:56,559

correlating data between among different

1579

00:57:00,069 --> 00:56:58,640

spacecraft you know that we have up

1580

00:57:03,030 --> 00:57:00,079

there

1581

00:57:06,069 --> 00:57:03,040

we have designed mms to withstand these

1582

00:57:08,230 --> 00:57:06,079

events coronal mass ejections that you

1583

00:57:10,230 --> 00:57:08,240

have primarily we do it by having a

1584

00:57:12,470 --> 00:57:10,240

uniform conducting surface

1585

00:57:14,470 --> 00:57:12,480

on the spacecraft we have a device on

1586

00:57:16,870 --> 00:57:14,480

there that emits ions to keep the

1587

00:57:19,270 --> 00:57:16,880

spacecraft potential from rising above

1588

00:57:21,030 --> 00:57:19,280

four volts uh positive

1589

00:57:23,510 --> 00:57:21,040

and so uh if it does i mean the

1590

00:57:25,430 --> 00:57:23,520

spacecraft could charge up to kilovolts

1591

00:57:27,510 --> 00:57:25,440

as long as it's uniform

1592

00:57:29,349 --> 00:57:27,520

what causes problems with spacecraft is

1593

00:57:30,630 --> 00:57:29,359

this side is charged one way and it

1594

00:57:32,150 --> 00:57:30,640

charges the other way and you get a

1595

00:57:33,109 --> 00:57:32,160

lightning bolt across that can be a

1596

00:57:35,190 --> 00:57:33,119

problem

1597

00:57:37,349 --> 00:57:35,200

but that's the way you avoid that is to

1598

00:57:38,630 --> 00:57:37,359

minimize or eliminate insulators on the

1599

00:57:41,270 --> 00:57:38,640

outside

1600

00:57:43,750 --> 00:57:41,280

and have a uniform conducting surface

1601
00:57:45,750 --> 00:57:43,760
maybe jeff can add and i'll just add we

1602
00:57:48,230 --> 00:57:45,760
um a number of our spacecraft that we

1603
00:57:51,270 --> 00:57:48,240
have currently flying have have utilized

1604
00:57:54,150 --> 00:57:51,280
these designs where we and and have had

1605
00:57:55,990 --> 00:57:54,160
cmes solar storms wash over them and we

1606
00:57:57,510 --> 00:57:56,000
do it on purposely so that they can

1607
00:57:59,270 --> 00:57:57,520
understand them we can we can actually

1608
00:58:01,430 --> 00:57:59,280
measure them we can see them from a

1609
00:58:03,030 --> 00:58:01,440
distance with remote sensing instruments

1610
00:58:04,230 --> 00:58:03,040
but we also have in-situ ones which

1611
00:58:06,390 --> 00:58:04,240
actually measure

1612
00:58:09,510 --> 00:58:06,400
the the plasma conditions the the

1613
00:58:11,589 --> 00:58:09,520

composition the magnetic field uh for

1614

00:58:13,510 --> 00:58:11,599

example our a spacecraft or soho

1615

00:58:15,190 --> 00:58:13,520

spacecraft these other spacecraft have

1616

00:58:17,750 --> 00:58:15,200

already existed so so we know how to

1617

00:58:20,230 --> 00:58:17,760

design so there won't be any damage and

1618

00:58:22,230 --> 00:58:20,240

as jim said uh indeed it's our fleet

1619

00:58:23,910 --> 00:58:22,240

working together it's that system we

1620

00:58:25,750 --> 00:58:23,920

have a series of buoys basically think

1621

00:58:27,510 --> 00:58:25,760

of buoys throughout

1622

00:58:29,430 --> 00:58:27,520

interplanetary space

1623

00:58:31,829 --> 00:58:29,440

all working together looking following

1624

00:58:33,670 --> 00:58:31,839

this entire series of events so it is

1625

00:58:35,190 --> 00:58:33,680

very key to have that it's an

1626
00:58:37,270 --> 00:58:35,200
understanding

1627
00:58:38,630 --> 00:58:37,280
okay questions on twitter i'm going to

1628
00:58:40,069 --> 00:58:38,640
combine two questions that came in

1629
00:58:42,309 --> 00:58:40,079
through twitter through hashtag mag

1630
00:58:44,950 --> 00:58:42,319
recon together one is when does the

1631
00:58:47,750 --> 00:58:44,960
first bit of science data come back into

1632
00:58:49,510 --> 00:58:47,760
y'all and the other question is mms is a

1633
00:58:51,190 --> 00:58:49,520
planned two-year mission with fuel to

1634
00:58:53,190 --> 00:58:51,200
spare what else would you want to

1635
00:58:54,789 --> 00:58:53,200
measure

1636
00:58:56,710 --> 00:58:54,799
let me answer the first one we're all

1637
00:58:58,150 --> 00:58:56,720
thrilled i'm going to see data on monday

1638
00:59:00,950 --> 00:58:58,160

these guys assure me i'm going to see

1639

00:59:05,670 --> 00:59:02,309

i don't think i'll see it until about

1640

00:59:09,910 --> 00:59:07,430

yeah and what else might we look for

1641

00:59:11,750 --> 00:59:09,920

let's say an extended mission is that i

1642

00:59:13,910 --> 00:59:11,760

think that's what was uh

1643

00:59:15,750 --> 00:59:13,920

was asked well this mission is designed

1644

00:59:18,470 --> 00:59:15,760

explicitly to look for one thing and

1645

00:59:19,990 --> 00:59:18,480

look for it in great detail and so any

1646

00:59:21,510 --> 00:59:20,000

other thing that we find will be there

1647

00:59:22,710 --> 00:59:21,520

will be surprises

1648

00:59:25,109 --> 00:59:22,720

we'll measure things that were

1649

00:59:27,670 --> 00:59:25,119

unanticipated and then we'll investigate

1650

00:59:29,750 --> 00:59:27,680

those in more detail

1651
00:59:30,710 --> 00:59:29,760
i'll just add that every mission we

1652
00:59:32,309 --> 00:59:30,720
launch

1653
00:59:34,549 --> 00:59:32,319
always comes up with something

1654
00:59:36,549 --> 00:59:34,559
unexpected that we just had not

1655
00:59:38,230 --> 00:59:36,559
participated we designed it to solve a

1656
00:59:39,990 --> 00:59:38,240
problem but

1657
00:59:41,510 --> 00:59:40,000
something new always comes our way

1658
00:59:43,109 --> 00:59:41,520
something new and exciting we love we

1659
00:59:45,190 --> 00:59:43,119
love new things we love where it points

1660
00:59:47,190 --> 00:59:45,200
out that we didn't understand this other

1661
00:59:49,349 --> 00:59:47,200
process or this related process i mean

1662
00:59:50,309 --> 00:59:49,359
that's how we make advances so we're

1663
00:59:52,390 --> 00:59:50,319

we're

1664

00:59:54,390 --> 00:59:52,400

happen

1665

00:59:56,549 --> 00:59:54,400

see what we don't know

1666

00:59:57,990 --> 00:59:56,559

okay another question on twitter and

1667

01:00:00,870 --> 00:59:58,000

another one that came in through hashtag

1668

01:00:02,789 --> 01:00:00,880

mag recon jim burch mentioned using gps

1669

01:00:05,829 --> 01:00:02,799

to help guide the spacecraft how exactly

1670

01:00:08,309 --> 01:00:05,839

does that work is it like my car

1671

01:00:10,710 --> 01:00:08,319

yes it is but you have to have a much

1672

01:00:12,470 --> 01:00:10,720

more accurate gps system we call it the

1673

01:00:14,950 --> 01:00:12,480

navigator there's some project people

1674

01:00:17,270 --> 01:00:14,960

here who will correct me if i'm wrong

1675

01:00:19,829 --> 01:00:17,280

but the gps satellites are well below

1676

01:00:22,309 --> 01:00:19,839

mms earth about four earth radii and

1677

01:00:24,230 --> 01:00:22,319

we're at 12 to 25 depending on the face

1678

01:00:26,789 --> 01:00:24,240

of our orbit but we can look down into

1679

01:00:28,069 --> 01:00:26,799

that constellation of gps spacecraft and

1680

01:00:30,870 --> 01:00:28,079

if we make the measurements of their

1681

01:00:33,270 --> 01:00:30,880

signals accurately enough we can measure

1682

01:00:35,910 --> 01:00:33,280

our spacecraft positions down to 100

1683

01:00:39,270 --> 01:00:35,920

meters so we have separations as small

1684

01:00:41,910 --> 01:00:39,280

as 10 kilometers we need accuracy of 100

1685

01:00:45,829 --> 01:00:41,920

meters and we can do that with that

1686

01:00:48,549 --> 01:00:47,430

okay you've got any more

1687

01:00:50,390 --> 01:00:48,559

all right then we'll take another

1688

01:00:52,630 --> 01:00:50,400

question right here brian roo with

1689

01:00:54,549 --> 01:00:52,640

social media what kind of computing

1690

01:00:56,230 --> 01:00:54,559

power is going to be used to parse this

1691

01:00:58,150 --> 01:00:56,240

data as it comes down from the four

1692

01:00:59,750 --> 01:00:58,160

spacecraft and where might that be

1693

01:01:01,030 --> 01:00:59,760

located

1694

01:01:03,589 --> 01:01:01,040

you mean on board

1695

01:01:05,430 --> 01:01:03,599

no on earth on earth on the earth on the

1696

01:01:07,430 --> 01:01:05,440

earth it's very advanced and i don't

1697

01:01:08,549 --> 01:01:07,440

know who here is best qualified to talk

1698

01:01:10,630 --> 01:01:08,559

about it

1699

01:01:12,950 --> 01:01:10,640

well we have a we have a

1700

01:01:15,109 --> 01:01:12,960

a data center uh each system has a data

1701

01:01:16,390 --> 01:01:15,119

center it's coordinated with nasa data

1702

01:01:19,270 --> 01:01:16,400

centers to

1703

01:01:22,470 --> 01:01:19,280

ingest the data and to reduce it to to

1704

01:01:25,190 --> 01:01:22,480

uh to a form that we can start talking

1705

01:01:28,390 --> 01:01:25,200

in a sensible scientific manner

1706

01:01:31,670 --> 01:01:28,400

about the data but we also have with

1707

01:01:32,870 --> 01:01:31,680

the the team a theory and modeling

1708

01:01:37,430 --> 01:01:32,880

component

1709

01:01:39,349 --> 01:01:37,440

very large simulations that jim showed

1710

01:01:41,349 --> 01:01:39,359

that do they we we constantly compare

1711

01:01:43,430 --> 01:01:41,359

our measurements to those simulations

1712

01:01:45,030 --> 01:01:43,440

and they're run all over uh actually the

1713

01:01:46,789 --> 01:01:45,040

world and some of the very largest

1714

01:01:49,430 --> 01:01:46,799

supercomputers because it takes a very

1715

01:01:50,870 --> 01:01:49,440

long time uh i mean a very lot of

1716

01:01:52,950 --> 01:01:50,880

computing power to run some of those

1717

01:01:54,710 --> 01:01:52,960

simulations as jim mentioned they're

1718

01:01:57,670 --> 01:01:54,720

really limited in their in their

1719

01:01:59,190 --> 01:01:57,680

duration simply because the plasma is so

1720

01:02:00,150 --> 01:01:59,200

complicated

1721

01:02:02,069 --> 01:02:00,160

that

1722

01:02:03,430 --> 01:02:02,079

the simulation can only take a piece of

1723

01:02:05,109 --> 01:02:03,440

it and we have to go look at the real

1724

01:02:06,789 --> 01:02:05,119

world and compare that to those

1725

01:02:09,030 --> 01:02:06,799

simulations but

1726
01:02:11,829 --> 01:02:09,040
as uh i think paul mentioned we we have

1727
01:02:13,750 --> 01:02:11,839
a meeting that's going on uh uh at this

1728
01:02:15,670 --> 01:02:13,760
present time this morning of uh people

1729
01:02:16,950 --> 01:02:15,680
all over the world who were uh talking

1730
01:02:18,390 --> 01:02:16,960
about their simulations and where

1731
01:02:19,750 --> 01:02:18,400
they're where they're run in various

1732
01:02:22,549 --> 01:02:19,760
different places and

1733
01:02:24,789 --> 01:02:22,559
anxious very anxious to compare it with

1734
01:02:25,750 --> 01:02:24,799
mother nature

1735
01:02:27,349 --> 01:02:25,760
all right

1736
01:02:29,910 --> 01:02:27,359
we'll take one last question right here

1737
01:02:32,150 --> 01:02:29,920
and then we'll wrap it up

1738
01:02:34,789 --> 01:02:32,160

uh david vanderpool social media are

1739

01:02:36,390 --> 01:02:34,799

there other missions um other programs

1740

01:02:38,549 --> 01:02:36,400

that will be leveraging the data that

1741

01:02:40,950 --> 01:02:38,559

you gather here is there sharing of the

1742

01:02:44,950 --> 01:02:40,960

data that you gather

1743

01:02:46,309 --> 01:02:44,960

across your colleagues beyond mms

1744

01:02:48,150 --> 01:02:46,319

that's an excellent question there's

1745

01:02:50,069 --> 01:02:48,160

some existing missions like the european

1746

01:02:52,710 --> 01:02:50,079

cluster mission which has a similar

1747

01:02:53,829 --> 01:02:52,720

thing it's got uh you know coarser

1748

01:02:55,910 --> 01:02:53,839

resolution

1749

01:02:58,230 --> 01:02:55,920

and a lot of things but i think if we're

1750

01:02:59,910 --> 01:02:58,240

in the same region of space

1751

01:03:02,870 --> 01:02:59,920

we can do a lot with cluster the other

1752

01:03:05,829 --> 01:03:02,880

one is thinnest in fact themis did some

1753

01:03:08,309 --> 01:03:05,839

maneuvers about a year ago to put put

1754

01:03:10,150 --> 01:03:08,319

them in alignment with mms so that we

1755

01:03:12,230 --> 01:03:10,160

launched we have our

1756

01:03:14,470 --> 01:03:12,240

spacecraft skimming the dayside

1757

01:03:17,029 --> 01:03:14,480

magnetopause themselves that same time

1758

01:03:19,109 --> 01:03:17,039

will be exactly 180 degrees out of phase

1759

01:03:20,390 --> 01:03:19,119

we're at noon they'll be at midnight

1760

01:03:22,150 --> 01:03:20,400

and so you know we'll look at

1761

01:03:24,069 --> 01:03:22,160

reconnection at the day side and they'll

1762

01:03:25,670 --> 01:03:24,079

look at the effects on the night side

1763

01:03:28,630 --> 01:03:25,680

and vice versa as they go around so

1764

01:03:30,549 --> 01:03:28,640

they're apogees 12 re exactly the same

1765

01:03:32,390 --> 01:03:30,559

as our dayside apogee

1766

01:03:33,750 --> 01:03:32,400

and so we look forward to a lot of

1767

01:03:35,349 --> 01:03:33,760

correlations with them and they really

1768

01:03:37,190 --> 01:03:35,359

took the initiative because their

1769

01:03:38,630 --> 01:03:37,200

spacecraft had been going for their

1770

01:03:40,150 --> 01:03:38,640

mission had been going for something

1771

01:03:42,069 --> 01:03:40,160

like seven years of course they're

1772

01:03:43,750 --> 01:03:42,079

looking for something new to do they had

1773

01:03:44,789 --> 01:03:43,760

five spacecraft they sent two off to the

1774

01:03:46,150 --> 01:03:44,799

moon and

1775

01:03:47,829 --> 01:03:46,160

they uh

1776

01:03:49,349 --> 01:03:47,839

all of a sudden here we come it was

1777

01:03:51,430 --> 01:03:49,359

really their idea

1778

01:03:53,910 --> 01:03:51,440

to sink these missions up

1779

01:03:56,309 --> 01:03:53,920

and so now we're doing it

1780

01:03:58,789 --> 01:03:56,319

the last part to answer your question is

1781

01:04:01,190 --> 01:03:58,799

also the data as soon as it's validated

1782

01:04:02,789 --> 01:04:01,200

and calibrated is publicly released so

1783

01:04:05,029 --> 01:04:02,799

scientists around the world actually

1784

01:04:07,270 --> 01:04:05,039

have access to the data it is not kept

1785

01:04:09,670 --> 01:04:07,280

to to nasa or the mms team it is

1786

01:04:12,710 --> 01:04:09,680

actually distributed for anyone uh to

1787

01:04:14,710 --> 01:04:12,720

look at the data um to run their own

1788

01:04:16,470 --> 01:04:14,720

models uh

1789

01:04:17,990 --> 01:04:16,480

and there are also many people are

1790

01:04:20,630 --> 01:04:18,000

invited to work with the team on

1791

01:04:22,870 --> 01:04:20,640

developing models so it is it really is

1792

01:04:24,870 --> 01:04:22,880

an international in that

1793

01:04:26,309 --> 01:04:24,880

endeavor

1794

01:04:28,230 --> 01:04:26,319

all right we're out of time so that's

1795

01:04:30,870 --> 01:04:28,240

going to wrap up our briefing and a

1796

01:04:33,109 --> 01:04:30,880

brief programming note our nasa tv

1797

01:04:35,510 --> 01:04:33,119

launch coverage will begin on thursday