



1  
00:00:01,666 --> 00:00:04,666  
[music playing]

2  
00:00:16,233 --> 00:00:18,666  
- IT'S REALLY  
MY VERY, VERY GREAT PLEASURE

3  
00:00:18,666 --> 00:00:22,300  
TO INTRODUCE OUR--  
OUR SPEAKER TODAY

4  
00:00:22,300 --> 00:00:23,933  
WHO'S GONNA TALK ABOUT A TOPIC

5  
00:00:23,933 --> 00:00:26,233  
OF INCREDIBLE INTEREST  
AND CONCERN.

6  
00:00:26,233 --> 00:00:28,733  
AND I'D ALSO LIKE TO WELCOME  
EVERYBODY

7  
00:00:28,733 --> 00:00:32,433  
TO THE--THE--THIS IS, I THINK,  
ABOUT THE FOURTH OR FIFTH

8  
00:00:32,433 --> 00:00:35,633  
DISTINGUISHED LECTURE IN OUR  
75TH-ANNIVERSARY CELEBRATIONS

9  
00:00:35,633 --> 00:00:37,233  
OF AMES RESEARCH CENTER

10  
00:00:37,233 --> 00:00:38,833  
ON THE DIRECTOR'S COLLOQUIUM  
SERIES.

11  
00:00:38,833 --> 00:00:42,200  
SO, YOU KNOW, 75 YEARS,

YOU AIN'T SEEN NOTHIN' YET.

12

00:00:42,200 --> 00:00:44,133

JUST WAIT FOR THE NEXT 150.

[laughter]

13

00:00:44,133 --> 00:00:46,666

IF WE SURVIVE ASTEROIDS,

THAT'S...

14

00:00:46,666 --> 00:00:50,900

NOW, OUR SPEAKER DOESN'T NEED

MUCH INTRODUCTION

15

00:00:50,900 --> 00:00:52,800

BUT I'LL DO THAT ANYHOW.

16

00:00:52,800 --> 00:00:55,700

RUSTY SCHWEICKART RECEIVED

HIS BACHELOR OF SCIENCE DEGREE

17

00:00:55,700 --> 00:00:57,600

IN AERONAUTICAL ENGINEERING

18

00:00:57,600 --> 00:01:01,600

AND HIS--IN 1956,

19

00:01:01,600 --> 00:01:03,833

AND HIS MASTER OF SCIENCE

IN AERONAUTICS AND ASTRONAUTICS

20

00:01:03,833 --> 00:01:05,500

IN 1963.

21

00:01:05,500 --> 00:01:08,633

BOTH FROM--THERE'S A SMALL

EAST COAST COLLEGE

22

00:01:08,633 --> 00:01:09,633

YOU MIGHT HAVE HEARD OF.

23

00:01:09,633 --> 00:01:11,466

M.I.T.,  
I THINK IT WAS CALLED.

24

00:01:11,466 --> 00:01:13,066

I THINK IT'S STILL THERE,  
ISN'T IT?

25

00:01:13,066 --> 00:01:14,833

- YES.  
- YES.

26

00:01:14,833 --> 00:01:18,333

[laughs] THAT--  
THAT'S NOT A BAD START.

27

00:01:18,333 --> 00:01:20,033

YOU HEAR THAT,  
YOU STANFORD GUYS?

28

00:01:20,033 --> 00:01:21,966

[laughter]

29

00:01:21,966 --> 00:01:24,133

RUSTY SERVED AS A FIGHTER PILOT  
IN THE U.S. AIR FORCE

30

00:01:24,133 --> 00:01:25,933

AND THE MASSACHUSETTS  
AIR NATIONAL GUARD

31

00:01:25,933 --> 00:01:28,100

FROM 1956 TO 1963.

32

00:01:28,100 --> 00:01:30,466

HE JOINED NASA  
AS AN ASTRONAUT

33

00:01:30,466 --> 00:01:33,033  
IN OCTOBER 1963.

34

00:01:33,033 --> 00:01:35,766  
HE SERVED AS LUNAR MODULE PILOT  
FOR APOLLO 9

35

00:01:35,766 --> 00:01:39,166  
IN MARCH 3 TO 13, 1969,

36

00:01:39,166 --> 00:01:41,966  
LOGGING 241 HOURS IN SPACE.

37

00:01:41,966 --> 00:01:44,833  
THIS WAS THE THIRD MANNED FLIGHT  
OF THE APOLLO SERIES

38

00:01:44,833 --> 00:01:47,166  
AND THE FIRST MANNED FLIGHT  
OF THE LUNAR MODULE.

39

00:01:47,166 --> 00:01:49,400  
IN 1977,

40

00:01:49,400 --> 00:01:52,266  
RUSTY WORKED ON THE STAFF  
OF GOVERNOR JERRY BROWN--

41

00:01:52,266 --> 00:01:54,333  
YOU MIGHT HAVE HEARD  
OF THAT NAME.

42

00:01:54,333 --> 00:01:56,300  
HE'S BACK AGAIN--  
OF CALIFORNIA.

43

00:01:56,300 --> 00:02:00,400  
IN 1979, RUSTY WAS APPOINTED  
COMMISSIONER OF ENERGY

44

00:02:00,400 --> 00:02:02,233  
FOR THE STATE OF CALIFORNIA

45

00:02:02,233 --> 00:02:04,966  
AND RESPONSIBLE FOR ALL ASPECTS  
OF ENERGY PRODUCTION.

46

00:02:04,966 --> 00:02:06,800  
IN 1985,

47

00:02:06,800 --> 00:02:10,400  
HE FOUNDED THE ASSOCIATION  
OF SPACE EXPLORERS, A.S.E.

48

00:02:10,400 --> 00:02:12,933  
AND HE PARTICULARLY FOUNDED

49

00:02:12,933 --> 00:02:15,200  
THE A.S.E. NEAR EARTH OBJECTS  
COMMITTEE,

50

00:02:15,200 --> 00:02:17,733  
WHICH SUBMITTED TO  
THE UNITED NATIONS COMMITTEE

51

00:02:17,733 --> 00:02:19,900  
ON THE PEACEFUL USES  
OF OUTER SPACE,

52

00:02:19,900 --> 00:02:21,433  
BETTER KNOWN AS COPUOS,

53

00:02:21,433 --> 00:02:23,366  
THE SEMINAL REPORT

54

00:02:23,366 --> 00:02:25,900  
"ASTEROID THREATS:  
A CALL FOR GLOBAL RESPONSE."

55  
00:02:25,900 --> 00:02:28,933  
HE IS COFOUNDER OF THE NONPROFIT  
B612 FOUNDATION

56  
00:02:28,933 --> 00:02:30,666  
WITH ED LU,  
WHO IS ALSO HERE,

57  
00:02:30,666 --> 00:02:32,633  
ALSO AN ASTRONAUT,

58  
00:02:32,633 --> 00:02:34,800  
AND SERVED AS ITS CHAIRMAN  
UNTIL 2011,

59  
00:02:34,800 --> 00:02:38,766  
IS CURRENTLY CHAIR EMERITUS  
ON THE BOARD OF DIRECTORS.

60  
00:02:38,766 --> 00:02:40,500  
HIS TALK TODAY IS ENTITLED

61  
00:02:40,500 --> 00:02:42,900  
"DINOSAUR SYNDROME  
AVOIDANCE PROJECT--"

62  
00:02:42,900 --> 00:02:45,300  
WHAT A COOL NAME--

63  
00:02:45,300 --> 00:02:46,700  
"HOW GOZIT?"

64  
00:02:46,700 --> 00:02:49,866  
WITHOUT FURTHER ADO, RUSTY,  
WELCOME BACK...

65  
00:02:49,866 --> 00:02:52,866  
[applause]

66

00:02:56,600 --> 00:02:59,700

- OKAY, AS PETE SAID,

67

00:02:59,700 --> 00:03:03,100

WE'RE GONNA DO A SUMMARY HERE  
OF THE--

68

00:03:03,100 --> 00:03:06,266

WHAT I CALL THE ASTRONAUT  
SYNDROME AVOIDANCE PROJECT,

69

00:03:06,266 --> 00:03:10,500

WHICH MEANS, DON'T GET KILLED  
BY ASTEROIDS.

70

00:03:10,500 --> 00:03:11,900

OR EXTINCTED,  
NOT JUST KILLED,

71

00:03:11,900 --> 00:03:15,333

BUT DRIVEN INTO EXTINCTION.

72

00:03:15,333 --> 00:03:18,333

THIS IS GONNA BE TOP LEVEL  
AND COMPREHENSIVE,

73

00:03:18,333 --> 00:03:20,566

WHICH MEANS IT'S IMPOSSIBLE  
TO GET IT DONE IN THE TIME,

74

00:03:20,566 --> 00:03:22,300

BUT WE'RE GONNA TRY  
TO DO IT FAST

75

00:03:22,300 --> 00:03:24,500

AND LEAVE TIME FOR Q&A.

76

00:03:24,500 --> 00:03:27,833

LET ME SAY THAT IT'S SPECIAL  
PRIVILEGE BEING HERE TODAY,

77

00:03:27,833 --> 00:03:31,166  
BECAUSE 45 YEARS AGO TODAY

78

00:03:31,166 --> 00:03:34,466  
THE APOLLO 11 CREW  
WAS ON THEIR WAY TO THE MOON.

79

00:03:34,466 --> 00:03:37,066  
THEY LAUNCHED YESTERDAY  
45 YEARS AGO,

80

00:03:37,066 --> 00:03:39,966  
AND ON SUNDAY THEY WILL,  
45 YEARS AGO,

81

00:03:39,966 --> 00:03:41,766  
LAND ON THE MOON.

82

00:03:41,766 --> 00:03:44,200  
I FLEW IN MARCH OF THAT YEAR,

83

00:03:44,200 --> 00:03:46,300  
AND IT WAS  
A TREMENDOUS PRIVILEGE

84

00:03:46,300 --> 00:03:49,166  
TO BE PART OF APOLLO  
AND THAT GREAT TIME.

85

00:03:49,166 --> 00:03:51,333  
I'LL SAY SOMETHING MORE  
ABOUT IT LATER.

86

00:03:51,333 --> 00:03:54,533  
SO I'M WEARING TWO HATS  
FOR THIS TALK.

87

00:03:54,533 --> 00:03:56,233

THE B612 FOUNDATION,

88

00:03:56,233 --> 00:03:59,033

WHICH ED IS NOW LEADING,

89

00:03:59,033 --> 00:04:01,800

DEALS WITH THE TECHNICAL ISSUES

90

00:04:01,800 --> 00:04:03,700

OF PLANETARY DEFENSE.

91

00:04:03,700 --> 00:04:06,566

WHEREAS THE ASSOCIATION  
OF SPACE EXPLORERS,

92

00:04:06,566 --> 00:04:08,200

WHICH IS OUR PROFESSIONAL  
ORGANIZATION

93

00:04:08,200 --> 00:04:09,966

OF ASTRONAUTS AND COSMONAUTS,

94

00:04:09,966 --> 00:04:12,933

HAS BEEN DEALING,  
FOR THE LAST EIGHT YEARS,

95

00:04:12,933 --> 00:04:15,300

WITH THE GEOPOLITICAL ELEMENTS.

96

00:04:15,300 --> 00:04:17,366

AGAIN, WE'RE GONNA  
GET INTO THAT,

97

00:04:17,366 --> 00:04:21,366

BUT FIRST,  
THIS IS A MANDATORY MESSAGE

98

00:04:21,366 --> 00:04:23,466

FROM MY WIFE,  
WHO UNFORTUNATELY

99

00:04:23,466 --> 00:04:25,866

COULDN'T BE WITH US TODAY.

100

00:04:25,866 --> 00:04:27,500

IT SAYS AT THE BOTTOM,

101

00:04:27,500 --> 00:04:29,700

"MY HUSBAND HAS A MORBID FEAR  
OF ASTEROIDS."

102

00:04:29,700 --> 00:04:31,766

[laughter]

103

00:04:31,766 --> 00:04:33,800

WE'LL IGNORE THAT.

104

00:04:33,800 --> 00:04:36,133

LET'S SEE  
IF THE INTERFACE WORKS.

105

00:04:36,133 --> 00:04:39,700

OKAY, SO POPULAR CONCEPTION OF  
WHAT HAPPENED TO THE ASTEROIDS

106

00:04:39,700 --> 00:04:41,966

"WHOA, DUDE, CHECK OUT  
THIS AWESOME ASTEROID..."

107

00:04:41,966 --> 00:04:43,766

IT'S GETTING BIGGER  
BY THE SECOND.

108

00:04:43,766 --> 00:04:45,233

HURRY UP BEFORE YOU MISS IT."

109

00:04:45,233 --> 00:04:47,933  
BUT THE ONE I LIKE IS

110  
00:04:47,933 --> 00:04:50,933  
MR. DINOSAUR LOOKING  
AT MRS. DINOSAUR

111  
00:04:50,933 --> 00:04:52,933  
AND SAYING, "THAT DRESS  
KIND OF MAKES YOU LOOK FAT."

112  
00:04:52,933 --> 00:04:53,933  
[laughter]

113  
00:04:53,933 --> 00:04:56,166  
THAT'LL DO IT.

114  
00:04:56,166 --> 00:04:58,033  
SO THIS IS WHAT  
WE'RE TALKING ABOUT.

115  
00:04:58,033 --> 00:05:00,700  
THIS HAPPENED--

116  
00:05:00,700 --> 00:05:02,366  
HAPPENS MILLIONS--

117  
00:05:02,366 --> 00:05:05,266  
HAS HAPPENED MILLIONS OF TIMES  
IN THE HISTORY OF THE EARTH,

118  
00:05:05,266 --> 00:05:07,166  
NOT EXACTLY LIKE THIS.

119  
00:05:07,166 --> 00:05:09,900  
THAT'S A PRETTY BIG ASTEROID,  
AND YOU'LL NOTICE CITY LIGHTS,

120  
00:05:09,900 --> 00:05:12,900

AND SO THAT DIDN'T HAPPEN  
WHEN THOSE WERE AROUND.

121  
00:05:12,900 --> 00:05:17,233  
BUT OTHER THAN THAT,  
YOU GET THE IDEA.

122  
00:05:17,233 --> 00:05:20,966  
WHEN I GREW UP AND WAS THE AGE  
OF MOST OF THE PEOPLE

123  
00:05:20,966 --> 00:05:23,166  
IN THIS--SOME OF THE PEOPLE  
IN THIS ROOM,

124  
00:05:23,166 --> 00:05:25,133  
THE KIDS ANYWAY,

125  
00:05:25,133 --> 00:05:27,400  
OUR SOLAR SYSTEM  
WAS NINE PLANETS AND THE SUN.

126  
00:05:27,400 --> 00:05:29,966  
EVERYTHING WAS WELL-BEHAVED,

127  
00:05:29,966 --> 00:05:32,000  
YOU KNOW,  
AND WE HAD NINE OF 'EM.

128  
00:05:32,000 --> 00:05:34,566  
NOW, WE ONLY HAVE EIGHT PLANETS,

129  
00:05:34,566 --> 00:05:36,700  
THANKS TO NEIL TYSON.

130  
00:05:36,700 --> 00:05:39,466  
[laughter]  
BUT THAT'S NOT THE SOLAR SYSTEM.

131

00:05:39,466 --> 00:05:42,233

THE SOLAR SYSTEM  
REALLY LOOKS LIKE THIS

132

00:05:42,233 --> 00:05:45,233

WITH THE MAIN ASTEROID BELT  
AND THE INNER PLANETS

133

00:05:45,233 --> 00:05:49,266

OF MERCURY, VENUS,  
EARTH, AND MARS.

134

00:05:49,266 --> 00:05:53,233

AND THE RED DOTS ARE THE ONES  
THAT CONCERN US,

135

00:05:53,233 --> 00:05:55,266

THE ONES  
IN THE INNER SOLAR SYSTEM

136

00:05:55,266 --> 00:05:57,866

THAT ARE NEAR EARTH ASTEROIDS.

137

00:05:57,866 --> 00:06:00,700

THOSE CROSS THE ORBIT  
OF THE EARTH,

138

00:06:00,700 --> 00:06:04,300

AND IF THEY CROSS THE ORBIT  
OF THE EARTH,

139

00:06:04,300 --> 00:06:07,266

THEN THERE IS A POTENTIAL  
FOR IMPACT.

140

00:06:07,266 --> 00:06:10,566

AND THOSE ARE THE ONES WHICH  
WE HAVE BEEN RECENTLY LOOKING AT

141

00:06:10,566 --> 00:06:14,833

AND THE SUBJECT OF OUR WHOLE  
ISSUE OF PLANETARY DEFENSE

142

00:06:14,833 --> 00:06:18,133  
AND PROTECTING THE EARTH  
FROM THOSE IMPACTS.

143

00:06:18,133 --> 00:06:22,133  
WELL, THE EVIDENCE  
FOR THOSE RED OBJECTS

144

00:06:22,133 --> 00:06:25,300  
THAT SWOOP INTO THE INNER PART  
OF THE SOLAR SYSTEM

145

00:06:25,300 --> 00:06:27,966  
AND COME PAST THE EARTH  
AND THE MOON

146

00:06:27,966 --> 00:06:30,333  
ARE ALL OF THE CRATERS  
ON THE MOON.

147

00:06:30,333 --> 00:06:33,100  
YOU DON'T HAVE TO BE  
A ROCKET SCIENTIST TO RECOGNIZE

148

00:06:33,100 --> 00:06:36,533  
THAT THERE HAVE BEEN  
ONE HECK OF A LOT OF IMPACTS

149

00:06:36,533 --> 00:06:40,200  
ON EVERY BODY THAT YOU SEE

150

00:06:40,200 --> 00:06:42,833  
WHERE THERE--  
YOU CAN SEE A SURFACE,

151

00:06:42,833 --> 00:06:45,966  
WHERE IT'S A SOLID SURFACE

AND NOT A GASEOUS SURFACE.

152

00:06:45,966 --> 00:06:49,000

THIS IS AN INTERESTING SHOT  
OF THE BACK SIDE OF THE MOON.

153

00:06:49,000 --> 00:06:51,233

AND OF COURSE, YOU CAN SEE

154

00:06:51,233 --> 00:06:55,100

THAT THE CRATERS  
ARE NOT ONLY ALL OVER IT,

155

00:06:55,100 --> 00:06:56,800

BUT THEY OVERLAP ONE ANOTHER.

156

00:06:56,800 --> 00:07:00,066

I MEAN, YOU GOT CRATERS  
ON CRATERS ON CRATERS.

157

00:07:00,066 --> 00:07:02,266

AGAIN, YOU DON'T HAVE TO BE  
A ROCKET SCIENTIST

158

00:07:02,266 --> 00:07:03,733

TO REALIZE THAT IF--

159

00:07:03,733 --> 00:07:06,166

THAT WE WOULD LOOK LIKE THAT  
IF WE DIDN'T HAVE AN ATMOSPHERE

160

00:07:06,166 --> 00:07:08,366

AND TECTONIC PLATES

161

00:07:08,366 --> 00:07:10,433

AND WEATHER  
AND ALL OF THE REST OF IT

162

00:07:10,433 --> 00:07:12,966

THAT PROTECT THE EARTH

163

00:07:12,966 --> 00:07:16,133

FROM THE SMALLER ASTEROIDS  
IMPACTING

164

00:07:16,133 --> 00:07:18,600

AND THAT ERASE THE LARGER ONES

165

00:07:18,600 --> 00:07:22,000

THAT DID IMPACT AND MAKE HOLES  
IN THE SURFACE OF THE EARTH.

166

00:07:22,000 --> 00:07:24,300

IT DIDN'T ERASE ALL OF THEM.

167

00:07:24,300 --> 00:07:26,100

WE'LL SEE ONE IN A MOMENT.

168

00:07:26,100 --> 00:07:29,133

ASTEROIDS COME  
IN MANY DIFFERENT SIZES

169

00:07:29,133 --> 00:07:30,733

AND SHAPES,

170

00:07:30,733 --> 00:07:32,466

ALL OF WHICH ARE INTERESTING.

171

00:07:32,466 --> 00:07:36,600

THE BIGGEST ONES HERE  
ARE MAIN BELT ASTEROIDS.

172

00:07:36,600 --> 00:07:38,766

THEY DON'T COME IN--

173

00:07:38,766 --> 00:07:42,400

WE DON'T HAVE ANY THAT ARE  
HUNDREDS OF KILOMETERS ACROSS

174

00:07:42,400 --> 00:07:44,900

THAT COME IN  
ACROSS THE EARTH'S ORBIT.

175

00:07:44,900 --> 00:07:47,766

BUT THIS ONE UP HERE IS EROS,

176

00:07:47,766 --> 00:07:51,566

IS THE SECOND-LARGEST  
NEAR EARTH ASTEROID

177

00:07:51,566 --> 00:07:53,433

OR NEAR EARTH OBJECT--

178

00:07:53,433 --> 00:07:55,900

I'LL USE THOSE TERMS  
INTERCHANGEABLY--

179

00:07:55,900 --> 00:07:58,833

AND THAT'S 33 KILOMETERS LONG.

180

00:07:58,833 --> 00:08:01,400

SO THAT'S--  
FIGURE THE BIGGEST ONE.

181

00:08:01,400 --> 00:08:04,633

IN FACT, THE BIGGEST ONE'S  
ABOUT THE SAME DIMENSION

182

00:08:04,633 --> 00:08:06,766

IT'S JUST MORE SPHERICAL  
THAN THAT,

183

00:08:06,766 --> 00:08:08,433

SO IT'S  
A LITTLE MORE MASSIVE.

184

00:08:08,433 --> 00:08:10,966

BUT I, IN PARTICULAR,  
WANT TO CALL YOUR ATTENTION

185  
00:08:10,966 --> 00:08:13,733  
TO ONE THAT'S ON THIS CHART

186  
00:08:13,733 --> 00:08:15,466  
CALLED ITOKAWA

187  
00:08:15,466 --> 00:08:17,866  
AND ITOKAWA,  
THE JAPANESE HAVE VISITED--

188  
00:08:17,866 --> 00:08:19,566  
WE'LL SEE A PICTURE OF IT  
IN A MOMENT.

189  
00:08:19,566 --> 00:08:22,833  
IT'S A DOT THAT YOU  
CAN'T EVEN SEE ON THIS SCREEN.

190  
00:08:22,833 --> 00:08:26,700  
IT'S--IT'S ABOUT A PIXEL  
IN SIZE UP THERE.

191  
00:08:28,233 --> 00:08:30,266  
AND HERE IT IS CLOSE UP,

192  
00:08:30,266 --> 00:08:34,533  
TAKEN--PICTURE TAKEN  
BY THE JAPANESE.

193  
00:08:34,533 --> 00:08:38,633  
LIKE THIS OBJECT HERE...

194  
00:08:40,733 --> 00:08:42,733  
THIS IS PROBABLY WHAT WE CALL

195  
00:08:42,733 --> 00:08:44,700

A CONTACT BINARY,

196

00:08:44,700 --> 00:08:47,000  
THAT IS IN ALL LIKELIHOOD

197

00:08:47,000 --> 00:08:48,733  
THERE'S A BIG MASS IN HERE

198

00:08:48,733 --> 00:08:50,933  
WITH A BUNCH OF ROCKS  
AND DUST AND EVERYTHING

199

00:08:50,933 --> 00:08:52,466  
AND ANOTHER BIG MASS HERE.

200

00:08:52,466 --> 00:08:55,166  
SO THESE ARE REALLY  
TWO OBJECTS

201

00:08:55,166 --> 00:08:57,233  
KIND OF THAT  
GOT STUCK TOGETHER.

202

00:08:57,233 --> 00:08:58,700  
WE CALL IT A CONTACT BINARY.

203

00:08:58,700 --> 00:09:02,400  
AND A LOT OF THE ASTEROIDS,  
AND APPARENTLY,

204

00:09:02,400 --> 00:09:05,866  
EVEN THE COMETS SHOW  
THAT CHARACTERISTIC

205

00:09:05,866 --> 00:09:08,433  
OF BEING CONTACT BINARIES.

206

00:09:08,433 --> 00:09:11,866  
SO YOU'RE DEALING WITH SOMETHING

THAT'S 520 METERS,

207

00:09:11,866 --> 00:09:15,366  
OR SOMETHING ON THE ORDER  
OF 1,700 FEET

208

00:09:15,366 --> 00:09:16,900  
FROM ONE END TO THE OTHER.

209

00:09:16,900 --> 00:09:19,966  
TO GIVE YOU  
SOME RELATIVE SCALE,

210

00:09:19,966 --> 00:09:21,366  
THERE'S HANGAR ONE

211

00:09:21,366 --> 00:09:23,633  
OUTSIDE THE DOOR HERE, OKAY?

212

00:09:23,633 --> 00:09:26,133  
SO YOU PICTURE  
HOW BIG HANGAR ONE IS

213

00:09:26,133 --> 00:09:29,500  
AND NOW YOU'VE GOT  
THE RELATIVE SIZE THERE

214

00:09:29,500 --> 00:09:31,833  
WITH--WITH ITOKAWA.

215

00:09:31,833 --> 00:09:33,900  
BEFORE WE LEAVE THIS,  
I WANT TO SHOW YOU,

216

00:09:33,900 --> 00:09:38,300  
THAT'S ABOUT  
A 20-METER-LONG BOULDER

217

00:09:38,300 --> 00:09:39,933

ON THE SURFACE

218

00:09:39,933 --> 00:09:42,600  
AND THAT'S ABOUT THE SIZE  
OF THE OBJECT

219

00:09:42,600 --> 00:09:46,700  
THAT CAME IN OVER CHELYABINSK  
LAST FEBRUARY.

220

00:09:46,700 --> 00:09:49,333  
YOU'VE ALL SEEN  
THE--THE MOVIES

221

00:09:49,333 --> 00:09:52,333  
OF WHAT HAPPENED  
LAST FEBRUARY THE 13TH--

222

00:09:52,333 --> 00:09:54,333  
FEBRUARY 15TH, EXCUSE ME,

223

00:09:54,333 --> 00:09:56,933  
9:00 IN THE MORNING.

224

00:09:56,933 --> 00:09:58,433  
IT WAS A VERY INTERESTING DAY

225

00:09:58,433 --> 00:10:00,566  
BECAUSE ASTRONOMERS  
ALL OVER THE WORLD

226

00:10:00,566 --> 00:10:03,766  
WERE WAITING FOR ASTEROIDS  
TO HAPPEN THAT DAY.

227

00:10:03,766 --> 00:10:05,700  
BUT IN FACT,  
IT WAS THIS ONE,

228

00:10:05,700 --> 00:10:08,533  
WHICH WAS DA14,

229  
00:10:08,533 --> 00:10:10,533  
WHICH WAS COMING  
SORT OF BY THE EARTH

230  
00:10:10,533 --> 00:10:13,233  
VERY, VERY CLOSE  
SOUTH TO NORTH.

231  
00:10:13,233 --> 00:10:15,600  
AND SO EVERYBODY  
HAD ALL THEIR TELESCOPES

232  
00:10:15,600 --> 00:10:17,300  
AND THEIR THIS, THAT,  
AND THE OTHER THING

233  
00:10:17,300 --> 00:10:19,566  
READY TO CAPTURE THIS ASTEROID,

234  
00:10:19,566 --> 00:10:21,733  
AND THEN, LO AND BEHOLD,

235  
00:10:21,733 --> 00:10:24,433  
EARLY--EARLY, EARLY  
IN THE MORNING

236  
00:10:24,433 --> 00:10:27,700  
THE TWITTERVERSE CAME ALIVE

237  
00:10:27,700 --> 00:10:31,100  
AND IT TURNED OUT  
THAT ONE THIS SIZE

238  
00:10:31,100 --> 00:10:33,633  
ACTUALLY CAME IN  
THAT SAME DAY

239

00:10:33,633 --> 00:10:35,033

THAT THIS ONE  
WENT BY THE EARTH.

240

00:10:35,033 --> 00:10:38,233

ONE THAT SIZE  
HIT OVER CHELYABINSK

241

00:10:38,233 --> 00:10:39,900

IN--IN RUSSIA.

242

00:10:39,900 --> 00:10:42,666

NOW, DON'T ASK ME,  
WHY RUSSIA?

243

00:10:42,666 --> 00:10:44,133

WE'RE VERY HAPPY  
THAT MOST ASTEROIDS

244

00:10:44,133 --> 00:10:46,300

SEEM TO HIT IN RUSSIA.

245

00:10:46,300 --> 00:10:48,200

[laughter]

246

00:10:48,200 --> 00:10:50,633

PARTICULARLY APPROPRIATE GIVEN  
THE GEOPOLITICAL SITUATION

247

00:10:50,633 --> 00:10:52,966

AT THE MOMENT.

248

00:10:52,966 --> 00:10:56,700

IN ANY EVENT,  
YOU CAN SEE BY THE SHADOW

249

00:10:56,700 --> 00:10:59,533

THIS IS ABOUT 45 METERS,

250

00:10:59,533 --> 00:11:03,800  
OR 45 YARDS IN DIMENSION.

251

00:11:03,800 --> 00:11:06,666  
THIS ONE'S ONLY ABOUT 60 FEET,

252

00:11:06,666 --> 00:11:10,833  
OR 20 METERS  
IN--IN LENGTH.

253

00:11:10,833 --> 00:11:14,600  
AND YET, WHEN THAT CAME IN  
OVER RUSSIA--

254

00:11:16,533 --> 00:11:18,833  
AGAIN, UNFORTUNATELY,  
THE MOVIE ISN'T HERE,

255

00:11:18,833 --> 00:11:20,533  
BUT ALL OF YOU KNOW

256

00:11:20,533 --> 00:11:24,066  
THAT THIS THING  
CAME STREAKING THROUGH THE SKY

257

00:11:24,066 --> 00:11:26,100  
MUCH, MUCH BRIGHTER--

258

00:11:26,100 --> 00:11:29,066  
AN ORDER OF MAGNITUDE  
BRIGHTER THAN THE SUN.

259

00:11:29,066 --> 00:11:31,400  
EVERYONE SAID,  
"WHAT THE HECK HAPPENED?"

260

00:11:31,400 --> 00:11:33,933  
AND HERE'S THIS BIG STREAK  
DOWN THROUGH THE SKY

261

00:11:33,933 --> 00:11:36,166  
AND EVERYONE RAN  
OVER TO THE WINDOWS

262

00:11:36,166 --> 00:11:37,766  
TO LOOK OUT  
AND SEE WHAT HAPPENED

263

00:11:37,766 --> 00:11:39,633  
AND THEN THE SHOCK WAVE HIT,

264

00:11:39,633 --> 00:11:41,133  
BROKE ALL THE WINDOWS,

265

00:11:41,133 --> 00:11:42,900  
AND CUT EVERYBODY'S FACE.

266

00:11:42,900 --> 00:11:45,933  
SO YOU HAVE A LOT OF PEOPLE  
WITH SUPERFICIAL CUTS

267

00:11:45,933 --> 00:11:47,633  
AND A LOT  
OF SUPERFICIAL DAMAGE

268

00:11:47,633 --> 00:11:51,600  
TO SOMETHING LIKE  
1,700 BUILDINGS.

269

00:11:51,600 --> 00:11:54,933  
BUT THAT WAS  
A VERY, VERY SMALL ASTEROID,

270

00:11:54,933 --> 00:11:56,600  
IN FACT.

271

00:11:56,600 --> 00:11:59,466  
WE DID NOT EXPECT

THAT AN ASTEROID THAT SIZE

272

00:11:59,466 --> 00:12:01,866  
COULD DO THE KIND OF DAMAGE  
THAT IT DID.

273

00:12:01,866 --> 00:12:05,233  
AND SO THE EXPERIENCE  
LAST YEAR--PARDON ME--

274

00:12:05,233 --> 00:12:07,166  
THE EXPERIENCE LAST YEAR  
IN CHELYABINSK

275

00:12:07,166 --> 00:12:09,166  
TOLD US THAT, IN FACT,

276

00:12:09,166 --> 00:12:12,533  
EVEN THE SMALL ONES CAN DO  
A BIT MORE DAMAGE

277

00:12:12,533 --> 00:12:15,266  
THAN WE THOUGHT WAS POSSIBLE.

278

00:12:15,266 --> 00:12:17,633  
THEY ALSO HAPPEN TO HIT  
A LITTLE MORE FREQUENTLY

279

00:12:17,633 --> 00:12:19,200  
THAN--THAN WE THOUGHT.

280

00:12:19,200 --> 00:12:22,300  
I'LL MENTION THAT  
A LITTLE FURTHER ON.

281

00:12:22,300 --> 00:12:26,433  
WELL, THE--THE ONE  
THAT WAS THE SIZE OF DA14,

282

00:12:26,433 --> 00:12:30,266  
ABOUT 45 METERS IN DIAMETER,

283

00:12:30,266 --> 00:12:33,700  
IS THE SIZE OF THE ONE  
THAT HAPPENED IN 1908.

284

00:12:33,700 --> 00:12:35,533  
IT CAME DOWN,  
AGAIN, IN RUSSIA,

285

00:12:35,533 --> 00:12:37,533  
IN SIBERIA--

286

00:12:37,533 --> 00:12:39,600  
THE SO-CALLED TUNGUSKA EVENT.

287

00:12:39,600 --> 00:12:41,833  
AND THESE ARE SORT OF--

288

00:12:41,833 --> 00:12:45,433  
THAT'S AN ARTIST'S, UH...

289

00:12:45,433 --> 00:12:47,366  
RENDITION OF IT.

290

00:12:47,366 --> 00:12:49,466  
BUT THIS IS ACTUALLY  
A PHOTOGRAPH

291

00:12:49,466 --> 00:12:53,666  
OF THE FOREST  
WHICH WAS LAID DOWN

292

00:12:53,666 --> 00:12:55,800  
360 DEGREES--

293

00:12:55,800 --> 00:12:58,366  
ABOUT 800 SQUARE MILES

294

00:12:58,366 --> 00:13:01,666  
OF SIBERIAN FOREST  
WAS BLOWN DOWN

295

00:13:01,666 --> 00:13:04,666  
AND IGNITED AND BURNED.

296

00:13:04,666 --> 00:13:08,900  
AND IF THAT HAD HAPPENED  
OVER A CITY,

297

00:13:08,900 --> 00:13:12,233  
HERE, THAT IMPACT ZONE  
IS SUPERPOSED ON--

298

00:13:12,233 --> 00:13:14,966  
I THINK THAT'S LONDON,  
ISN'T IT?

299

00:13:14,966 --> 00:13:16,800  
OR IS IT WASHINGTON, D.C.?

300

00:13:16,800 --> 00:13:18,466  
IT LOOKS LIKE LONDON.

301

00:13:18,466 --> 00:13:22,600  
SO YOU CAN SEE THAT  
THAT AREA OF TOTAL DESTRUCTION

302

00:13:22,600 --> 00:13:27,000  
WOULD BE BIGGER THAN SOMETHING  
LIKE ANY METROPOLITAN AREA

303

00:13:27,000 --> 00:13:29,566  
ON THE EARTH.

304

00:13:29,566 --> 00:13:33,233  
AND IF YOU KNOCK DOWN TREES

LIKE THAT WITH THE SHOCK WAVE,

305

00:13:33,233 --> 00:13:35,933

LET ME TELL YOU, YOU KNOCK DOWN  
PEOPLE AND BUILDINGS AS WELL.

306

00:13:35,933 --> 00:13:38,500

SO GENERALLY SPEAKING,

307

00:13:38,500 --> 00:13:42,266

ASTEROIDS OF THAT SIZE  
WE REFER TO--

308

00:13:42,266 --> 00:13:44,933

I SHOULD SAY, THE CONGRESS,  
THANK HEAVEN,

309

00:13:44,933 --> 00:13:47,666

REFER TO THEM AS CITY KILLERS.

310

00:13:47,666 --> 00:13:51,466

SO WE HAVE HAPPILY ADOPTED  
THE TERM CITY KILLER.

311

00:13:51,466 --> 00:13:54,000

THAT IS NOT TO IMPLY  
THAT THESE THINGS

312

00:13:54,000 --> 00:13:55,900

ALWAYS HIT OVER CITIES.

313

00:13:55,900 --> 00:13:57,466

THEY OBVIOUSLY DON'T.

314

00:13:57,466 --> 00:14:00,533

BUT IF THEY DID, IT WOULD  
BASICALLY WIPE OUT

315

00:14:00,533 --> 00:14:03,266

EVERYTHING IN SUCH A CITY.

316

00:14:03,266 --> 00:14:06,600

NOW, SOME OF YOU HAVE SEEN  
METEOR CRATER.

317

00:14:06,600 --> 00:14:09,866

AS I SAID, THERE ARE  
SOME IMPACT CRATERS

318

00:14:09,866 --> 00:14:12,733

THAT HAVE HAPPENED  
RELATIVELY RECENTLY

319

00:14:12,733 --> 00:14:16,333

THAT ARE STILL AVAILABLE

320

00:14:16,333 --> 00:14:18,033

TO--TO SEE HERE ON EARTH.

321

00:14:18,033 --> 00:14:21,866

THERE ARE PROBABLY ABOUT  
BETWEEN 190 AND 200 OF THEM

322

00:14:21,866 --> 00:14:23,400

THAT YOU CAN SEE.

323

00:14:23,400 --> 00:14:25,466

THIS IS A PRETTY DRAMATIC ONE.

324

00:14:25,466 --> 00:14:28,266

IT'S ABOUT A MILE ACROSS,  
NOT QUITE.

325

00:14:28,266 --> 00:14:31,366

AND THERE IS  
A VISITORS CENTER HERE,

326

00:14:31,366 --> 00:14:34,266

AND FOR THOSE OF YOU  
WHO MIGHT

327

00:14:34,266 --> 00:14:36,333

DRIVE THROUGH ARIZONA  
ANY TIME,

328

00:14:36,333 --> 00:14:39,500

DIVERT AND GO THERE  
IF YOU HAVEN'T BEEN THERE.

329

00:14:39,500 --> 00:14:42,966

IT IS WELL WORTH  
GOING TO SEE METEOR CRATER.

330

00:14:42,966 --> 00:14:45,800

THIS, AGAIN, WAS ABOUT THE SIZE  
OF THE ONE

331

00:14:45,800 --> 00:14:47,966

THAT CAME IN OVER RUSSIA,  
THE TUNGUSKA EVENT.

332

00:14:47,966 --> 00:14:49,566

THIS IS A CITY KILLER.

333

00:14:49,566 --> 00:14:52,566

AND YOU COULD JUST PICTURE--  
YOU KNOW, THE SHOCK AREA

334

00:14:52,566 --> 00:14:54,333

THAT WOULD HAVE KILLED  
ANYTHING LIVING

335

00:14:54,333 --> 00:14:58,533

IS WAY OUTSIDE  
JUST THE HOLE IN THE GROUND.

336

00:14:58,533 --> 00:15:02,833

AND ABOUT HALF OF THE ENERGY

OF THIS ASTEROID AS IT CAME IN

337

00:15:02,833 --> 00:15:05,433

ALREADY DISSIPATED  
INTO THE ATMOSPHERE

338

00:15:05,433 --> 00:15:07,366

BY THE TIME IT HIT,

339

00:15:07,366 --> 00:15:09,366

SO THE--THE HOLE IN THE GROUND  
YOU'RE SEEING

340

00:15:09,366 --> 00:15:12,133

IS REALLY ONLY ABOUT  
HALF OF THE ENERGY INVOLVED.

341

00:15:12,133 --> 00:15:14,833

THAT WAS PROBABLY ABOUT--  
I DON'T KNOW.

342

00:15:14,833 --> 00:15:19,200

WHAT ARE WE SAYING, 3 OR 5  
MEGATONS OR SOMETHING LIKE THAT?

343

00:15:19,200 --> 00:15:21,766

UM, OKAY, SO LET ME--

344

00:15:21,766 --> 00:15:23,900

LET ME EMPHASIZE  
A COUPLE OF THINGS HERE.

345

00:15:23,900 --> 00:15:27,200

THIS--NUMBER ONE,  
ASTEROIDS AREN'T SOMETHING

346

00:15:27,200 --> 00:15:29,666

THAT HIT THE EARTH  
WAY BACK THEN

347

00:15:29,666 --> 00:15:31,366  
AND NO LONGER HAPPEN.

348

00:15:31,366 --> 00:15:33,733  
THIS IS AN ONGOING PROCESS,

349

00:15:33,733 --> 00:15:36,933  
AND IT'S AN ONGOING PROCESS  
AT ALL SIZES.

350

00:15:36,933 --> 00:15:39,500  
IT'S NOT JUST THE LITTLE ONES  
THAT HIT TODAY.

351

00:15:39,500 --> 00:15:42,366  
WE'RE--THERE'S STILL  
THE BIG ONES OUT THERE

352

00:15:42,366 --> 00:15:46,300  
AND THE FLUX,  
THAT IS THE RATE

353

00:15:46,300 --> 00:15:50,066  
AT WHICH THESE THINGS IMPACT  
HISTORICALLY,

354

00:15:50,066 --> 00:15:52,133  
IS ESSENTIALLY CONSTANT.

355

00:15:52,133 --> 00:15:55,333  
SO WE ARE, FRANKLY,  
AT RISK

356

00:15:55,333 --> 00:15:58,933  
WITH MILLIONS OF OBJECTS  
OUT THERE

357

00:15:58,933 --> 00:16:03,000  
EVERYWHERE FROM SOMETHING

AS SMALL AS, SAY, 25 METERS

358

00:16:03,000 --> 00:16:05,133  
ALL THE UP TO SOMETHING

359

00:16:05,133 --> 00:16:07,500  
ON THE ORDER  
OF 10 KILOMETERS.

360

00:16:07,500 --> 00:16:09,566  
THAT'S ABOUT  
THE SIZE OF THE ONE

361

00:16:09,566 --> 00:16:12,033  
THAT CAUSED  
THE MASS EXTINCTION

362

00:16:12,033 --> 00:16:15,666  
THAT WIPED OUT THE DINOSAURS  
65 MILLION YEARS AGO.

363

00:16:17,033 --> 00:16:19,733  
THOSE HIT ABOUT ONCE  
EVERY 100 MILLION YEARS

364

00:16:19,733 --> 00:16:23,266  
AND THEY HAVE ABOUT  
100 MILLION TONS--

365

00:16:23,266 --> 00:16:26,300  
MEGATONS OF TNT EQUIVALENT.

366

00:16:26,300 --> 00:16:28,200  
I MEAN, THAT'S--  
THAT'S UNBELIEVABLE.

367

00:16:28,200 --> 00:16:30,833  
THAT--THAT--THAT SIZE EVENT

368

00:16:30,833 --> 00:16:34,300  
WIPES OUT  
MOST OF LIFE ON EARTH.

369  
00:16:34,300 --> 00:16:37,500  
AND IT DID IT  
PROBABLY SEVERAL TIMES.

370  
00:16:37,500 --> 00:16:39,733  
CERTAINLY IT DID IT

371  
00:16:39,733 --> 00:16:42,966  
AT THE K-T EXTINCTION  
65 MILLION YEARS AGO.

372  
00:16:42,966 --> 00:16:46,566  
THAT'S A LONG TIME BETWEEN  
IMPACTS, HOWEVER,

373  
00:16:46,566 --> 00:16:49,100  
AND SO LIFE  
GROWS BACK UP AGAIN

374  
00:16:49,100 --> 00:16:52,066  
AND DIVERSIFIES AND THEN  
IT GETS WIPED OUT AGAIN.

375  
00:16:52,066 --> 00:16:55,500  
I MEAN, THIS IS A PROCESS THAT'S  
HAPPENED MANY TIMES TO LIFE

376  
00:16:55,500 --> 00:16:58,533  
AS IT'S EMERGED HERE  
AND DEVELOPED ON THE EARTH.

377  
00:16:58,533 --> 00:17:00,933  
AT THE SMALLER END, HOWEVER,

378  
00:17:00,933 --> 00:17:04,166  
YOU'RE TALKING OBJECTS

LIKE THE ONE A LITTLE BIT LARGER

379

00:17:04,166 --> 00:17:06,900

THAN THE ONE THAT HIT  
OVER CHELYABINSK A YEAR AGO,

380

00:17:06,900 --> 00:17:10,733

THAT HAPPENS ABOUT  
ONCE EVERY 70 YEARS.

381

00:17:10,733 --> 00:17:15,000

A CITY KILLER, ABOUT 50 METERS  
OR A LITTLE BIT SMALLER,

382

00:17:15,000 --> 00:17:19,466

HAPPENS ABOUT ONCE  
EVERY 200 TO 300 YEARS.

383

00:17:19,466 --> 00:17:22,800

NOW AGAIN,  
I WANT TO EMPHASIZE

384

00:17:22,800 --> 00:17:25,533

THAT THESE CITY KILLER  
ASTEROIDS,

385

00:17:25,533 --> 00:17:27,066

WHILE THEY HIT ONCE  
EVERY TWO OR THREE--

386

00:17:27,066 --> 00:17:29,166

200 YEARS OR SO,

387

00:17:29,166 --> 00:17:31,366

THEY ONLY HIT A CITY

388

00:17:31,366 --> 00:17:33,466

ABOUT 2/10 OF 1% OF THE TIME,

389

00:17:33,466 --> 00:17:36,466  
OR MAYBE ONCE EVERY 50,000  
TO 100,000 YEARS

390  
00:17:36,466 --> 00:17:38,000  
A CITY WOULD GET WIPED OUT.

391  
00:17:38,000 --> 00:17:40,866  
BUT WE HAVE A GOOD IDEA  
OF THIS POPULATION.

392  
00:17:40,866 --> 00:17:42,866  
WE'VE BEEN LOOKING  
AT THESE THINGS.

393  
00:17:42,866 --> 00:17:46,166  
WE KNOW STATISTICALLY  
WHAT'S OUT THERE,

394  
00:17:46,166 --> 00:17:49,200  
BUT IF WE WANT TO PROTECT  
THE EARTH FROM IMPACTS,

395  
00:17:49,200 --> 00:17:52,000  
YOU CAN'T PROTECT YOURSELF  
FROM A STATISTIC.

396  
00:17:52,000 --> 00:17:54,366  
YOU'VE GOT TO KNOW  
SPECIFICALLY

397  
00:17:54,366 --> 00:17:56,166  
WHAT'S COMING AT YOU,

398  
00:17:56,166 --> 00:17:59,266  
HOW OFTEN, WHEN,  
HOW MUCH ENERGY, ET CETERA.

399  
00:17:59,266 --> 00:18:03,566  
SO THE--THE WHOLE PROCESS

## OF PLANETARY DEFENSE

400

00:18:03,566 --> 00:18:08,066  
AND PROTECTING THE EARTH  
FROM ASTEROID IMPACTS

401

00:18:08,066 --> 00:18:12,266  
BOILS DOWN TO THREE  
FUNDAMENTAL CHALLENGES

402

00:18:12,266 --> 00:18:14,500  
THAT WE HAVE TO MEET.

403

00:18:14,500 --> 00:18:17,333  
WE HAVE TO--WE HAVE TO KNOW

404

00:18:17,333 --> 00:18:20,133  
THE--WHERE THEY ARE

405

00:18:20,133 --> 00:18:23,733  
AND WHAT THEIR TRAJECTORY IS

406

00:18:23,733 --> 00:18:25,800  
AND PROJECT AHEAD AND SAY,  
IS THIS ONE GOING TO HIT?

407

00:18:25,800 --> 00:18:27,633  
AND IF SO, WHEN,  
ET CETERA.

408

00:18:27,633 --> 00:18:30,466  
THAT IS AN EARLY WARNING  
PROCESS.

409

00:18:32,166 --> 00:18:33,866  
THE--THE NEXT THING,  
OF COURSE,

410

00:18:33,866 --> 00:18:35,900

IF YOU KNOW SOMETHING'S  
COMING AT YOU,

411

00:18:35,900 --> 00:18:37,766  
IS YOU'VE GOT TO BE ABLE  
TO DO SOMETHING ABOUT IT,

412

00:18:37,766 --> 00:18:40,400  
AND THAT'S  
A DEFLECTION CAPABILITY.

413

00:18:40,400 --> 00:18:43,933  
YOU GOT TO BE ABLE  
TO CHANGE THE TRAJECTORY

414

00:18:43,933 --> 00:18:46,066  
OF THAT ASTEROID SLIGHTLY

415

00:18:46,066 --> 00:18:48,666  
SO THAT IT MISSES THE EARTH  
INSTEAD OF HITTING IT,

416

00:18:48,666 --> 00:18:50,966  
AND WE CALL THAT DEFLECTION.

417

00:18:50,966 --> 00:18:53,833  
THOSE TWO ARE BASICALLY  
TECHNICAL ISSUES.

418

00:18:53,833 --> 00:18:56,966  
THE THIRD ONE IS REALLY  
A GEOPOLITICAL ISSUE,

419

00:18:56,966 --> 00:18:59,466  
AND THAT IS SOMEBODY'S--

420

00:18:59,466 --> 00:19:01,633  
YOU CAN KNOW SOMETHING'S  
COMING AT YOU,

421  
00:19:01,633 --> 00:19:03,400  
YOU CAN HAVE SOMETHING  
TO DO ABOUT IT,

422  
00:19:03,400 --> 00:19:05,533  
BUT SOMEBODY'S GOTTA  
MAKE THE DECISION.

423  
00:19:05,533 --> 00:19:07,300  
WHO PAYS FOR IT?

424  
00:19:07,300 --> 00:19:09,866  
WHO HANDLES THE LIABILITY  
IF SOMETHING GOES WRONG?

425  
00:19:09,866 --> 00:19:12,533  
WHO TAKES THE RESPONSIBILITY?

426  
00:19:12,533 --> 00:19:15,266  
THERE ARE ALL KINDS--  
THERE ARE A MILLION QUESTIONS--

427  
00:19:15,266 --> 00:19:18,000  
GEOPOLITICAL QUESTIONS  
THAT COME UP IN IT,

428  
00:19:18,000 --> 00:19:21,633  
AND WE'RE GONNA HIT THAT  
VERY BRIEFLY.

429  
00:19:21,633 --> 00:19:24,433  
SO THE FIRST TWO  
OF THESE TECHNICAL ISSUES

430  
00:19:24,433 --> 00:19:27,400  
ARE THE THINGS  
THAT THE B612 FOUNDATION

431  
00:19:27,400 --> 00:19:28,966

HAS BEEN WORKING

432

00:19:28,966 --> 00:19:31,400  
FOR THE LAST  
TEN YEARS,

433

00:19:31,400 --> 00:19:34,333  
EARLY WARNING IN PARTICULAR  
FOR THE LAST TWO YEARS,

434

00:19:34,333 --> 00:19:36,433  
UNDER ED'S LEADERSHIP.

435

00:19:36,433 --> 00:19:40,833  
THE THIRD ISSUE, THE STANDING  
GEOPOLITICAL PROCESS,

436

00:19:40,833 --> 00:19:43,500  
THE ASSOCIATION  
OF SPACE EXPLORERS

437

00:19:43,500 --> 00:19:46,233  
HAS BEEN DEALING WITH,  
WITH THE UNITED NATIONS,

438

00:19:46,233 --> 00:19:48,100  
OR THROUGH THE UNITED NATIONS,

439

00:19:48,100 --> 00:19:50,733  
AND I'LL, AGAIN,  
SUMMARIZE THAT WORK

440

00:19:50,733 --> 00:19:53,700  
AND TELL YOU WHERE WE STAND.

441

00:19:53,700 --> 00:19:57,166  
OKAY, SO EARLY WARNING,  
WE TAKE THOSE ONE AT A TIME.

442

00:19:57,166 --> 00:20:00,000  
EARLY WARNING WE'VE BEEN DOING  
THROUGH TELESCOPES

443  
00:20:00,000 --> 00:20:02,466  
LOCATED HERE ON THE GROUND,  
USUALLY OUT IN THE DESERT.

444  
00:20:02,466 --> 00:20:05,800  
AND THERE ARE A NUMBER OF THESE  
AROUND THE WORLD,

445  
00:20:05,800 --> 00:20:07,833  
MOST OF THEM IN THE U.S.,

446  
00:20:07,833 --> 00:20:09,700  
BUT SOME OF THEM IN HAWAII.

447  
00:20:09,700 --> 00:20:12,200  
ONCE IN A WHILE--

448  
00:20:12,200 --> 00:20:14,266  
THAT ONE IS IN HAWAII.

449  
00:20:14,266 --> 00:20:16,200  
COME ON.  
OKAY, THERE WE GO.

450  
00:20:16,200 --> 00:20:19,733  
ONCE IN A WHILE, IF THEY COME  
CLOSE ENOUGH TO THE EARTH,

451  
00:20:19,733 --> 00:20:23,433  
WE CAN NOT JUST LOOK AT THEM  
WITH OPTICAL TELESCOPES,

452  
00:20:23,433 --> 00:20:25,033  
BUT WE CAN GET RADAR ON THEM.

453

00:20:25,033 --> 00:20:28,800  
AND THIS IS THE BIG ARECIBO  
RADAR DISH

454  
00:20:28,800 --> 00:20:30,733  
IN PUERTO RICO.

455  
00:20:30,733 --> 00:20:33,966  
AND THERE ARE A COUPLE OF RADAR  
SYSTEMS AROUND THE WORLD,

456  
00:20:33,966 --> 00:20:36,566  
AND THEY TELL US A--THEY GIVE US  
A LOT OF GOOD INFORMATION,

457  
00:20:36,566 --> 00:20:39,133  
BECAUSE RADAR WILL GIVE YOU  
PRECISE INFORMATION

458  
00:20:39,133 --> 00:20:41,333  
ON THE RANGE  
TO ONE OF THESE THINGS,

459  
00:20:41,333 --> 00:20:43,533  
HOW FAR IT IS PRECISELY.

460  
00:20:43,533 --> 00:20:46,533  
WHEREAS OPTICAL, YOU DON'T GET  
MUCH INFORMATION ON RANGE,

461  
00:20:46,533 --> 00:20:49,300  
BUT YOU GET WHERE IT--POINTING  
UP AND DOWN, LEFT AND RIGHT.

462  
00:20:49,300 --> 00:20:54,266  
SO THE TWO OF THESE,  
OPTICAL AND--AND RADAR

463  
00:20:54,266 --> 00:20:56,933  
ARE A GREAT COMBINATION.

464

00:20:56,933 --> 00:20:58,733

BUT AGAIN, YOU'RE LOCKED  
TO THE EARTH,

465

00:20:58,733 --> 00:21:01,866

AND THERE ARE SOME REAL PROBLEMS  
WITH THAT.

466

00:21:01,866 --> 00:21:04,866

THERE'S BEEN ONE TELESCOPE  
CALLED WISE,

467

00:21:04,866 --> 00:21:08,300

WHICH IS A WIDE AREA--  
WIDE--

468

00:21:08,300 --> 00:21:09,866

LET'S SEE.  
WHAT DOES IT STAND FOR?

469

00:21:09,866 --> 00:21:13,833

WIDE INFRARED SPACE  
SOMETHING OR OTHER.

470

00:21:13,833 --> 00:21:16,400

IN ANY CASE, IT'S  
AN INFRARED TELESCOPE IN SPACE.

471

00:21:16,400 --> 00:21:19,533

IT WAS REALLY BUILT TO DO  
ASTRONOMICAL WORK,

472

00:21:19,533 --> 00:21:23,033

BUT IN ADDITION, IT PICKED UP  
A NUMBER OF ASTEROIDS.

473

00:21:23,033 --> 00:21:26,133

BUT AGAIN, ALL OF THESE THINGS  
ARE VERY LIMITED,

474

00:21:26,133 --> 00:21:30,366

AND TO DATE,  
WE HAVE ONLY FOUND ABOUT 1%

475

00:21:30,366 --> 00:21:34,666

OF THE ASTEROIDS THAT THREATEN  
LIFE HERE ON EARTH

476

00:21:34,666 --> 00:21:36,633

IF THEY HIT.

477

00:21:36,633 --> 00:21:40,966

AND SO A COUPLE OF YEARS AGO,

478

00:21:40,966 --> 00:21:43,400

B612 FOUNDATION  
UNDER ED'S LEADERSHIP

479

00:21:43,400 --> 00:21:46,166

DECIDED TO SHIFT FROM THE WORK  
THAT WE HAD BEEN DOING

480

00:21:46,166 --> 00:21:48,933

ON DEFLECTION  
TO FOCUS ON FINDING THEM,

481

00:21:48,933 --> 00:21:50,866

BECAUSE IF  
YOU DON'T FIND 'EM,

482

00:21:50,866 --> 00:21:53,400

THERE'S NOTHING ELSE  
THAT COUNTS.

483

00:21:53,400 --> 00:21:55,033

I MEAN, YOU GOTTA KNOW  
WHAT'S COMING AT YOU.

484

00:21:55,033 --> 00:21:58,066

AND SO WE SHIFTED  
OUR PRIORITIES

485

00:21:58,066 --> 00:22:02,000

AND DECIDED TO COME UP WITH,  
AND PUT INTO SPACE,

486

00:22:02,000 --> 00:22:05,733

A TELESCOPE WHICH WOULD FIND  
THE BULK OF THE ASTEROIDS

487

00:22:05,733 --> 00:22:09,933

THAT REALLY POSE A THREAT  
TO LIFE ON THE PLANET.

488

00:22:09,933 --> 00:22:11,966

AND THIS IS  
OUR SENTINEL TELESCOPE

489

00:22:11,966 --> 00:22:14,433

OF B612 FOUNDATION.

490

00:22:14,433 --> 00:22:17,033

IT'S BASED ON A KEPLER BUS.

491

00:22:17,033 --> 00:22:20,700

I'LL--I'LL SHOW YOU  
AN ANIMATION HERE.

492

00:22:20,700 --> 00:22:25,233

AGAIN, THIS IS  
AN INFRARED TELESCOPE IN SPACE

493

00:22:25,233 --> 00:22:27,533

WITH--COMMUNICATES  
WITH THE GROUND.

494

00:22:27,533 --> 00:22:30,166

WE PUT IT IN AN ORBIT

CLOSER TO THE SUN,

495

00:22:30,166 --> 00:22:33,033

ABOUT THE DISTANCE  
FROM THE SUN AS VENUS,

496

00:22:33,033 --> 00:22:36,600

AND IT HAS ITS BACK  
ALWAYS FACING THE SUN

497

00:22:36,600 --> 00:22:39,033

LOOKING OUTWARD  
AWAY FROM THE SUN.

498

00:22:39,033 --> 00:22:41,733

AND OF COURSE, IF YOU'RE  
IN AROUND THE DISTANCE OF VENUS

499

00:22:41,733 --> 00:22:43,666

AND LOOKING  
AWAY FROM THE SUN,

500

00:22:43,666 --> 00:22:46,100

YOU'RE GONNA HAVE THE EARTH'S  
ORBIT OUT THERE IN FRONT OF YOU

501

00:22:46,100 --> 00:22:48,500

ALL THE WAY AROUND THE SUN.

502

00:22:48,500 --> 00:22:50,333

IN INFRARED,

503

00:22:50,333 --> 00:22:54,100

WE'RE NOT TALKING ABOUT  
REFLECTED INFRARED SUNLIGHT

504

00:22:54,100 --> 00:22:56,066

THAT REFLECTS OFF ASTEROIDS,

505

00:22:56,066 --> 00:22:58,733  
WE'RE TALKING ABOUT THE HEAT  
THAT'S--

506  
00:22:58,733 --> 00:23:02,066  
THAT'S EMITTED BY THESE  
ASTEROIDS AS THEY GO AROUND.

507  
00:23:02,066 --> 00:23:03,900  
THE SUN WILL TAKE

508  
00:23:03,900 --> 00:23:06,633  
WHAT'S ABOUT THE BRIGHTNESS  
OF A PIECE OF CHARCOAL

509  
00:23:06,633 --> 00:23:09,566  
AND IT WILL MAKE IT VERY HOT,  
OKAY?

510  
00:23:09,566 --> 00:23:12,633  
IT'S ABOUT LIKE TOUCHING THE  
ROOF OF YOUR CAR ON A SUMMER DAY

511  
00:23:12,633 --> 00:23:14,866  
OR WALKING ON BLACK ASPHALT,  
YOU KNOW?

512  
00:23:14,866 --> 00:23:16,566  
IT'S PRETTY HOT.

513  
00:23:16,566 --> 00:23:18,700  
AND THOSE ASTEROIDS  
WILL SHOW UP

514  
00:23:18,700 --> 00:23:22,166  
AS BRIGHT SPOTS  
ON A VERY, VERY BLACK SKY.

515  
00:23:22,166 --> 00:23:25,033  
SO INFRARED--

THE COMBINATION OF INFRARED

516

00:23:25,033 --> 00:23:27,966

AND BEING INSIDE THE EARTH'S  
ORBIT LOOKING OUT

517

00:23:27,966 --> 00:23:31,566

IS THE COMBINATION  
THAT SENTINEL WILL USE

518

00:23:31,566 --> 00:23:34,266

IN ORDER TO DETECT  
ALL OF THE ASTEROIDS

519

00:23:34,266 --> 00:23:36,733

OF--OF SUFFICIENT SIZE

520

00:23:36,733 --> 00:23:38,533

THAT CROSS THE EARTH'S ORBIT.

521

00:23:38,533 --> 00:23:40,100

HERE'S THE EARTH'S ORBIT.

522

00:23:40,100 --> 00:23:43,366

THIS IS THE ORBIT OF SENTINEL.

523

00:23:43,366 --> 00:23:45,766

AND IT'S LOOKING AWAY  
FROM THE SUN, AS YOU CAN SEE,

524

00:23:45,766 --> 00:23:48,733

AND IT SEES THE EARTH'S ORBIT  
ALL THE WAY AROUND.

525

00:23:48,733 --> 00:23:52,300

AND WE BASICALLY LOOK AT  
AND DISCOVER

526

00:23:52,300 --> 00:23:55,233

ALL OF THE ASTEROIDS  
THAT CROSS THE EARTH'S ORBIT.

527

00:23:55,233 --> 00:23:56,966  
WE THEN TRACK THEM

528

00:23:56,966 --> 00:23:59,733  
AND YOU CAN THEN PREDICT  
100 YEARS AHEAD OF TIME

529

00:23:59,733 --> 00:24:02,933  
WHETHER OR NOT  
EACH OF THOSE ASTEROIDS

530

00:24:02,933 --> 00:24:06,800  
POSES AN IMPACT THREAT.

531

00:24:06,800 --> 00:24:08,533  
OKAY, IF WE GO ON--

532

00:24:08,533 --> 00:24:10,800  
ALL RIGHT, SO THIS IS  
BASICALLY THE RECORD

533

00:24:10,800 --> 00:24:14,566  
OF WHAT'S BEEN DONE SO FAR.

534

00:24:14,566 --> 00:24:18,433  
THESE ARE THE KNOWN  
EARTH ASTEROIDS

535

00:24:18,433 --> 00:24:21,566  
UP THROUGH

536

00:24:21,566 --> 00:24:24,433  
DECEMBER OF 2013.

537

00:24:24,433 --> 00:24:26,600  
OVER 10,000 ASTEROID--

538

00:24:26,600 --> 00:24:28,600

TOTAL ASTEROIDS  
HAVE BEEN DISCOVERED.

539

00:24:28,600 --> 00:24:30,766

THE LARGE ONES HERE,  
THE RED ONES,

540

00:24:30,766 --> 00:24:34,600

WE'VE DISCOVERED ABOUT 95%

541

00:24:34,600 --> 00:24:36,833

OF ALL OF THESE LARGE ONES

542

00:24:36,833 --> 00:24:38,833

OVER 1 KILOMETER.

543

00:24:38,833 --> 00:24:41,866

BUT THAT'S  
A VERY SMALL PERCENTAGE

544

00:24:41,866 --> 00:24:44,000

OF THE TOTAL  
ASTEROID POPULATION

545

00:24:44,000 --> 00:24:46,800

THAT CAN DO REAL DAMAGE  
IF IT HITS.

546

00:24:46,800 --> 00:24:50,400

AND YOU CAN SEE THAT--  
THAT OVER A PERIOD

547

00:24:50,400 --> 00:24:52,633

OF 15 YEARS OR SO

548

00:24:52,633 --> 00:24:55,933

WE'VE ONLY DISCOVERED

ABOUT A THOUSAND,

549

00:24:55,933 --> 00:24:57,633

OR 10,000, EXCUSE ME.

550

00:24:57,633 --> 00:25:01,533

AND AS I SAID, THERE ARE MANY,  
MANY MORE OF THEM OUT THERE.

551

00:25:01,533 --> 00:25:04,533

AND HERE, IF WE GO OUT TO 2025

552

00:25:04,533 --> 00:25:07,133

AND ASSUME SENTINEL,  
THAT LINE,

553

00:25:07,133 --> 00:25:09,933

THIS--THIS POINT HERE  
COMES WAY DOWN THERE

554

00:25:09,933 --> 00:25:12,700

AND THEN THE TOTAL POPULATION  
WE'RE GONNA DISCOVER

555

00:25:12,700 --> 00:25:15,066

GOES WAY OUT THE ROOF  
OF THE BUILDING HERE.

556

00:25:15,066 --> 00:25:19,000

WE WILL HAVE DISCOVERED  
OVER A MILLION ASTEROIDS

557

00:25:19,000 --> 00:25:22,066

BY 2025,  
100 TIMES MORE

558

00:25:22,066 --> 00:25:25,333

THAN WE'VE DISCOVERED  
IN THE PAST TEN YEARS.

559

00:25:25,333 --> 00:25:28,400

AND OF THOSE OVER A MILLION,

560

00:25:28,400 --> 00:25:31,100

ABOUT 300,000 OF THEM

561

00:25:31,100 --> 00:25:34,466

WILL BE THE CITY KILLER SIZE  
OR LARGER.

562

00:25:34,466 --> 00:25:38,300

SO WE'RE TALKING ABOUT  
A HUGE POPULATION.

563

00:25:38,300 --> 00:25:41,200

OF THAT 300,000,

564

00:25:41,200 --> 00:25:44,633

ABOUT 4% OF THEM WILL HAVE A--

565

00:25:44,633 --> 00:25:47,000

SOME, NOT--LISTEN CAREFULLY--

566

00:25:47,000 --> 00:25:49,733

SOME "NON-ZERO" PROBABILITY

567

00:25:49,733 --> 00:25:51,600

OF IMPACTING THE EARTH.

568

00:25:51,600 --> 00:25:53,833

IN OTHER WORDS, SOME PROBABILITY  
OF IMPACTING THE EARTH

569

00:25:53,833 --> 00:25:56,300

IN THE NEXT 100 YEARS.

570

00:25:56,300 --> 00:25:59,600

THAT'S ABOUT THE STATISTICS THAT

HAVE BEEN DEVELOPED SO FAR.

571

00:25:59,600 --> 00:26:02,766  
SO WE CAN EXPECT,  
AFTER 2025,

572

00:26:02,766 --> 00:26:04,700  
WE WILL HAVE AN INVENTORY

573

00:26:04,700 --> 00:26:07,500  
OF SOMEWHERE AROUND  
12,000 ASTEROIDS

574

00:26:07,500 --> 00:26:09,800  
THAT HAVE SOME PROBABILITY

575

00:26:09,800 --> 00:26:11,733  
OF HITTING THE EARTH  
IN THE NEXT 100 YEARS.

576

00:26:11,733 --> 00:26:13,933  
AND WE'VE GOT TO WATCH THOSE  
CAREFULLY

577

00:26:13,933 --> 00:26:16,166  
AND TRACK THEM  
AND IF, IN FACT,

578

00:26:16,166 --> 00:26:19,933  
THAT PROBABILITY INCREASES  
BEYOND A CERTAIN THRESHOLD,

579

00:26:19,933 --> 00:26:23,400  
WE'RE GONNA HAVE TO TAKE ACTION  
TO DEFLECT THEM.

580

00:26:23,400 --> 00:26:26,633  
OKAY, SO WHAT DO WE TALK ABOUT  
WITH DEFLECTION?

581  
00:26:26,633 --> 00:26:30,733  
HERE'S WHERE I'M GOING TO GET  
INTO A LITTLE BIT OF--

582  
00:26:30,733 --> 00:26:32,933  
OF TECHNOLOGY,  
BUT NOT MUCH.

583  
00:26:32,933 --> 00:26:34,700  
IT'S VERY SUPERFICIAL,

584  
00:26:34,700 --> 00:26:37,100  
BUT THIS WILL HELP YOU  
UNDERSTAND

585  
00:26:37,100 --> 00:26:39,700  
THE GEOMETRY OF THE PROBLEM  
THAT WE'RE--

586  
00:26:39,700 --> 00:26:41,300  
THAT WE'RE DEALING WITH.

587  
00:26:41,300 --> 00:26:43,200  
SO IF THE SUN IS UP THERE,

588  
00:26:43,200 --> 00:26:45,933  
THE EARTH'S ORBITING LIKE THIS  
ALONG THE GREEN LINE,

589  
00:26:45,933 --> 00:26:47,566  
LET'S SAY WE HAVE  
AN ASTEROID

590  
00:26:47,566 --> 00:26:49,700  
THAT'S CROSSING  
THE EARTH'S ORBIT

591  
00:26:49,700 --> 00:26:51,866  
ON ITS OWN TRAJECTORY

LIKE THIS.

592

00:26:51,866 --> 00:26:53,766  
OF COURSE, THERE'S ANOTHER SET  
OF ASTEROIDS

593

00:26:53,766 --> 00:26:55,466  
ACROSS THE OTHER DIRECTION.

594

00:26:55,466 --> 00:26:57,300  
BUT WE'LL TAKE ONE HERE--

595

00:26:57,300 --> 00:27:00,400  
ONE THAT'S COMING OUTSIDE IN  
TOWARD THE EARTH.

596

00:27:00,400 --> 00:27:05,133  
AND OF COURSE, IF THE EARTH  
IS AT THAT INTERSECTION--

597

00:27:05,133 --> 00:27:07,100  
AND LET ME HESITATE  
FOR A MOMENT.

598

00:27:07,100 --> 00:27:09,100  
THAT INTERSECTION  
IS VERY SPECIAL,

599

00:27:09,100 --> 00:27:13,900  
BECAUSE CLEARLY, THIS IS  
A TWO-DIMENSIONAL PLOT, OKAY?

600

00:27:13,900 --> 00:27:15,700  
BUT--SO THE QUESTION IS,

601

00:27:15,700 --> 00:27:17,666  
AT THAT INTERSECTION,

602

00:27:17,666 --> 00:27:20,266

HOW FAR APART  
ARE THOSE TWO LINES?

603  
00:27:20,266 --> 00:27:22,166

HOW FAR APART  
ARE THOSE ORBITS

604  
00:27:22,166 --> 00:27:24,266

WHERE THEY INTERSECT  
IN TWO DIMENSIONS?

605  
00:27:24,266 --> 00:27:27,733  
AND ABOUT 4% OF THE TIME

606  
00:27:27,733 --> 00:27:30,600  
THE DISTANCE  
BETWEEN THOSE TWO LINES,

607  
00:27:30,600 --> 00:27:32,266  
VERTICALLY IF YOU WILL,

608  
00:27:32,266 --> 00:27:35,466  
IS LESS THAN  
ONE EARTH RADIUS.

609  
00:27:35,466 --> 00:27:37,400  
IN OTHER WORDS,

610  
00:27:37,400 --> 00:27:40,833  
IN THOSE 4% OF CASES  
THAT WE'VE SEEN SO FAR,

611  
00:27:40,833 --> 00:27:43,166  
IF THE AIR--  
IF THE ASTEROID

612  
00:27:43,166 --> 00:27:45,566  
AND THE EARTH ARE THERE  
AT THAT INTERSECTION

613  
00:27:45,566 --> 00:27:47,700  
AT THE SAME TIME,  
THEY'RE GONNA HIT.

614  
00:27:47,700 --> 00:27:49,800  
AND THAT'S WHAT A--

615  
00:27:49,800 --> 00:27:52,566  
THAT'S WHAT AN IMPACT IS.

616  
00:27:52,566 --> 00:27:54,333  
LET'S GO BACK HERE.

617  
00:27:54,333 --> 00:27:56,666  
LET'S--LET'S SAY WE'VE GOT  
AN ASTEROID

618  
00:27:56,666 --> 00:27:59,766  
AND WE'RE ABLE TO PROJECT AHEAD  
20 YEARS

619  
00:27:59,766 --> 00:28:02,700  
THAT THIS ASTEROID  
IS GONNA BE HERE

620  
00:28:02,700 --> 00:28:04,866  
AT THE TIME THAT THE EARTH  
IS HERE

621  
00:28:04,866 --> 00:28:07,700  
GOING ALONG THIS PATH  
20 YEARS FROM NOW.

622  
00:28:07,700 --> 00:28:11,766  
AND AS WE GO FORWARD, YOU KNOW,  
SAY, A WEEK OR TWO AT A TIME,

623  
00:28:11,766 --> 00:28:14,066  
THAT'S THE PROGRESSION.

624

00:28:14,066 --> 00:28:16,866

THE EARTH MOVES ALONG ITS ORBIT,  
THE ASTEROID ALONG ITS ORBIT.

625

00:28:16,866 --> 00:28:19,766

AND OF COURSE, IF THEY BOTH GET  
TO THE INTERSECTION

626

00:28:19,766 --> 00:28:22,600

AT THE SAME TIME,  
YOU'VE GOT AN IMPACT.

627

00:28:24,033 --> 00:28:26,033

OKAY, NOW, LET ME POINT OUT

628

00:28:26,033 --> 00:28:29,333

THAT THIS IS OBVIOUSLY  
AN ISSUE OF TIMING,

629

00:28:29,333 --> 00:28:33,166

BECAUSE IF THE ASTEROID WERE  
A LITTLE BIT SLOWER,

630

00:28:33,166 --> 00:28:35,400

A LITTLE BIT BEHIND  
THOSE POINTS,

631

00:28:35,400 --> 00:28:37,333

THE EARTH WOULD GET THROUGH  
THE INTERSECTION

632

00:28:37,333 --> 00:28:39,200

BEFORE THE ASTEROID GOT THERE.

633

00:28:39,200 --> 00:28:40,633

OR IF THE ASTEROID

634

00:28:40,633 --> 00:28:42,700

WERE JUST A LITTLE BIT AHEAD  
OF THESE POINTS,

635

00:28:42,700 --> 00:28:45,033  
THEN THE ASTEROID WOULD  
GET THROUGH THE INTERSECTION

636

00:28:45,033 --> 00:28:47,066  
BEFORE THE EARTH GOT THERE.

637

00:28:47,066 --> 00:28:48,700  
SO IF WE KNOW THAT  
THERE'S GOING TO BE--

638

00:28:48,700 --> 00:28:51,100  
IF WE'RE PROJECTING AHEAD  
AND WE'RE GONNA SEE

639

00:28:51,100 --> 00:28:52,166  
THAT THERE'S GONNA BE  
A COLLISION,

640

00:28:52,166 --> 00:28:54,866  
THE WHOLE CHALLENGE  
OF DEFLECTION

641

00:28:54,866 --> 00:28:57,200  
IS TO CHANGE THE ORBIT--

642

00:28:57,200 --> 00:29:00,800  
CHANGE THE SPEED OF THAT  
ASTEROID JUST A LITTLE BIT

643

00:29:00,800 --> 00:29:03,933  
SO THAT 20 YEARS LATER  
AT THIS TIME,

644

00:29:03,933 --> 00:29:07,266  
THE ASTEROID ARRIVES  
AT THE INTERSECTION

645

00:29:07,266 --> 00:29:09,766

BEFORE THE EARTH DOES  
AND GETS THROUGH IT

646

00:29:09,766 --> 00:29:11,200

BEFORE THE LEADING EDGE  
OF THE EARTH

647

00:29:11,200 --> 00:29:14,666

OR THAT WE CAUSE IT TO ARRIVE  
A LITTLE BIT SLOWER

648

00:29:14,666 --> 00:29:16,600

TO BE A LITTLE BEHIND  
THIS POINT,

649

00:29:16,600 --> 00:29:19,900

AND THEREFORE, IT WILL ALLOW  
THE TRAILING EDGE OF THE EARTH

650

00:29:19,900 --> 00:29:23,233

TO GET THROUGH THE INTERSECTION  
BEFORE IT ARRIVES.

651

00:29:23,233 --> 00:29:25,633

IT TAKES THE EARTH  
ABOUT EIGHT MINUTES

652

00:29:25,633 --> 00:29:29,066

FROM THE TIME THE LEADING EDGE  
GETS TO THE INTERSECTION

653

00:29:29,066 --> 00:29:30,833

TILL THE TRAILING EDGE  
GOES THROUGH IT.

654

00:29:30,833 --> 00:29:33,066

SO THE REAL QUESTION IS,

655

00:29:33,066 --> 00:29:36,900  
CHANGING THAT ASTEROID'S  
ARRIVAL TIME HERE,

656

00:29:36,900 --> 00:29:39,000  
20 YEARS DOWNSTREAM,

657

00:29:39,000 --> 00:29:40,633  
BY SOMETHING LIKE  
EIGHT MINUTES.

658

00:29:40,633 --> 00:29:42,900  
AND THAT WILL ALLOW--  
THAT'S A DEFLECTION.

659

00:29:42,900 --> 00:29:45,966  
WE HAVE SUCCESSFULLY PREVENTED  
AN IMPACT IF WE DO THAT.

660

00:29:45,966 --> 00:29:48,366  
WELL, HOW DO WE CHANGE THE SPEED  
OF AN ASTEROID?

661

00:29:48,366 --> 00:29:50,033  
BEFORE I LEAVE THIS DIAGRAM,

662

00:29:50,033 --> 00:29:52,000  
I WANT--I'M GONNA ASK YOU  
IN A COUPLE MINUTES

663

00:29:52,000 --> 00:29:55,033  
TO THINK OF YOURSELF  
ON THIS ASTEROID

664

00:29:55,033 --> 00:29:57,733  
LOOKING AT THE EARTH  
AS YOU GET CLOSER AND CLOSER.

665

00:29:57,733 --> 00:29:59,933

YOU'RE GONNA BE  
ON THIS ASTEROID

666

00:29:59,933 --> 00:30:03,133  
RIDING TOWARD THE EARTH  
IN JUST A MOMENT.

667

00:30:03,133 --> 00:30:05,300  
BUT TO GO BACK TO DEFLECTION,

668

00:30:05,300 --> 00:30:09,366  
OKAY, HOW DO WE CHANGE  
AN ASTEROID'S SPEED?

669

00:30:09,366 --> 00:30:11,466  
WELL, RUN INTO IT.

670

00:30:11,466 --> 00:30:14,500  
KINETIC IMPACT, YOU SIMPLY  
LAUNCH A SPACECRAFT--

671

00:30:14,500 --> 00:30:17,533  
A BUNCH OF WATER, SAND,  
ELECTRONICS,

672

00:30:17,533 --> 00:30:18,966  
WHATEVER YOU'VE GOT,  
DOESN'T MATTER--

673

00:30:18,966 --> 00:30:22,166  
YOU JUST LAUNCH SOMETHING  
AND RUN INTO THE SUCKER.

674

00:30:22,166 --> 00:30:23,766  
REAR-END IT, OKAY?

675

00:30:23,766 --> 00:30:26,600  
REAR-END IT IF YOU WANT  
TO MAKE IT GO FASTER,

676

00:30:26,600 --> 00:30:29,566

OR FRONT-END IT IF YOU WANT  
TO MAKE IT GO SLOWER.

677

00:30:29,566 --> 00:30:32,566

PRETTY SIMPLE,  
AND NOT EXACTLY--

678

00:30:32,566 --> 00:30:34,200

IT IS ROCKET SCIENCE,

679

00:30:34,200 --> 00:30:37,533

BUT IT'S SORT OF  
ROCKET NONSCIENCE, I GUESS.

680

00:30:37,533 --> 00:30:39,966

OKAY, WELL, THAT'S--  
THAT'S PRETTY ROBUST.

681

00:30:39,966 --> 00:30:42,600

YOU CAN LAUNCH A BIG MASS AND  
YOU CAN RUN INTO IT PRETTY FAST

682

00:30:42,600 --> 00:30:44,900

AND YOU CAN PROBABLY CHANGE  
ITS--ITS SPEED

683

00:30:44,900 --> 00:30:47,166

BY, YOU KNOW, A FRACTION  
OF A MILE AN HOUR,

684

00:30:47,166 --> 00:30:48,800

AND THAT'S ENOUGH.

685

00:30:48,800 --> 00:30:50,466

IT DOESN'T TAKE MUCH  
OF A CHANGE OF SPEED,

686

00:30:50,466 --> 00:30:53,033

BUT THOSE SUCKERS  
ARE PRETTY BIG, SO...

687  
00:30:53,033 --> 00:30:56,733  
OKAY, ON--OOPS,  
LET ME GO BACK ONE HERE.

688  
00:30:56,733 --> 00:31:00,433  
AAH. WENT THE WRONG WAY.

689  
00:31:02,200 --> 00:31:05,100  
OKAY, PARDON ME  
FOR STEPPING THROUGH THIS AGAIN.

690  
00:31:06,933 --> 00:31:10,666  
OKAY, SO THE PROBLEM  
WITH THE KINETIC IMPACT--

691  
00:31:10,666 --> 00:31:13,133  
I'M GONNA CATCH UP WITH YOU HERE  
FOR A MOMENT.

692  
00:31:13,133 --> 00:31:15,666  
THE PROBLEM  
WITH THE KINETIC IMPACT

693  
00:31:15,666 --> 00:31:18,066  
IS THAT WHILE  
IT'S PRETTY ROBUST,

694  
00:31:18,066 --> 00:31:20,633  
YOU CAN GET  
A PRETTY GOOD IMPACT

695  
00:31:20,633 --> 00:31:22,933  
AND CHANGE OF VELOCITY,  
IT'S IMPRECISE.

696  
00:31:22,933 --> 00:31:25,100  
YOU DON'T KNOW EXACTLY

WHAT'S GONNA HAPPEN

697

00:31:25,100 --> 00:31:26,766

AND WHAT YOU DON'T WANNA DO

698

00:31:26,766 --> 00:31:29,133

IS JUST LEAVE THIS THING  
IN SOME RANDOM ORBIT.

699

00:31:29,133 --> 00:31:31,200

YOU WANT TO KNOW AHEAD OF TIME

700

00:31:31,200 --> 00:31:34,433

WHAT THE ORBIT CHANGE IS  
PRECISELY

701

00:31:34,433 --> 00:31:36,000

THAT YOU GIVE IT.

702

00:31:36,000 --> 00:31:38,966

SO THE WAY YOU USE  
THESE TWO THINGS IN CONJUNCTION,

703

00:31:38,966 --> 00:31:42,466

WE GET A BRUTE FORCE CHANGE  
IN VELOCITY HERE

704

00:31:42,466 --> 00:31:44,733

AND THEN WE USE  
A GRAVITY TRACTOR

705

00:31:44,733 --> 00:31:47,300

WHERE WE HAVE  
A LITTLE SPACECRAFT--

706

00:31:47,300 --> 00:31:49,166

LET'S SAY WE GOT  
AN ASTEROID HERE,

707

00:31:49,166 --> 00:31:51,266  
AND WE GOT A LITTLE BITTY  
SPACECRAFT,

708  
00:31:51,266 --> 00:31:53,433  
WE GO UP THERE  
AND WE HOVER IN FRONT--

709  
00:31:53,433 --> 00:31:54,900  
LET'S SAY THE ASTEROID'S  
MOVING THIS WAY--

710  
00:31:54,900 --> 00:31:56,800  
WE HOVER IN FRONT OF IT,

711  
00:31:56,800 --> 00:31:59,600  
AND IF WE STAY THERE,  
WE HAVE LITTLE THRUSTERS

712  
00:31:59,600 --> 00:32:02,133  
AND WE STAY IN FRONT OF IT  
AT A FIXED POSITION,

713  
00:32:02,133 --> 00:32:05,466  
THE MUTUAL GRAVITY  
BETWEEN THIS OBJECT--

714  
00:32:05,466 --> 00:32:08,100  
THIS SPACECRAFT  
AND OUR ASTEROID

715  
00:32:08,100 --> 00:32:10,700  
IS JUST ENOUGH THAT  
THAT GRAVITY

716  
00:32:10,700 --> 00:32:14,500  
IS NOW PULLING THE ASTEROID  
WITH US, BEHIND US.

717  
00:32:14,500 --> 00:32:18,133

SO WE'RE USING GRAVITY,  
VERY WEAK GRAVITY FORCE

718

00:32:18,133 --> 00:32:20,966

AS A TOW ROPE WITHOUT  
EVER TOUCHING THE ASTEROID.

719

00:32:20,966 --> 00:32:23,033

WE DON'T LAND ON IT.  
WE DON'T CARE IF IT'S TUMBLING.

720

00:32:23,033 --> 00:32:24,800

WE DON'T CARE  
WHAT IT'S MADE OF.

721

00:32:24,800 --> 00:32:26,600

IT CAN BE DUST.  
IT CAN BE BIG ROCKS.

722

00:32:26,600 --> 00:32:28,300

WE DON'T GIVE A DAMN.

723

00:32:28,300 --> 00:32:31,866

AS LONG AS IT'S GOT MASS,  
WE'RE GONNA HAVE GRAVITY EFFECT,

724

00:32:31,866 --> 00:32:33,233

WHICH IS GONNA TOW IT,

725

00:32:33,233 --> 00:32:36,266

AND MAKE A VERY SMALL  
BUT PRECISE CHANGE

726

00:32:36,266 --> 00:32:38,200

IN THE ORBIT.

727

00:32:38,200 --> 00:32:40,233

THAT'S WHAT DEFLECTION  
IS ABOUT--

728

00:32:40,233 --> 00:32:43,233

CHANGING THE SPEED  
A PRECISE AMOUNT

729

00:32:43,233 --> 00:32:45,100

IN ORDER TO MISS THE EARTH.

730

00:32:45,100 --> 00:32:47,966

OF COURSE, IF IT'S TOO BIG,  
WE USE THE BIG DOG.

731

00:32:47,966 --> 00:32:49,833

WE WON'T TALK ABOUT THAT ONE.

732

00:32:49,833 --> 00:32:53,400

WE DON'T LIKE IT.  
NOBODY LIKES IT.

733

00:32:53,400 --> 00:32:55,500

BUT YOU KNOW,  
IT'S ALWAYS THERE

734

00:32:55,500 --> 00:32:58,766

IN CASE THE ASTEROID  
IS TOO BIG.

735

00:32:58,766 --> 00:33:02,466

ALL RIGHT, NOW WE'RE GONNA GO  
TO THE THIRD ELEMENT.

736

00:33:02,466 --> 00:33:04,100

WE CAN KNOW  
SOMETHING'S COMING AT US.

737

00:33:04,100 --> 00:33:06,333

WE HAVE SOMETHING  
WE CAN DO ABOUT IT.

738

00:33:09,833 --> 00:33:08,166

WHO DOES IT?

739

00:33:09,833 --> 00:33:11,200

WHO PAYS FOR IT?

740

00:33:11,200 --> 00:33:13,300

ALL THAT, OKAY?

741

00:33:13,300 --> 00:33:15,366

NOW, YOU--

NOW, I'M TAKING YOU--

742

00:33:15,366 --> 00:33:17,100

YOU'RE RIDING ON THE ASTEROID,  
REMEMBER,

743

00:33:17,100 --> 00:33:18,800

AND YOU'RE COMING  
TOWARD THE EARTH.

744

00:33:18,800 --> 00:33:20,866

YOU'RE LOOKING AT THE EARTH  
AS YOU GET CLOSER AND CLOSER.

745

00:33:20,866 --> 00:33:22,833

HERE'S YOUR VIEW OF THE EARTH.

746

00:33:22,833 --> 00:33:24,266

THIS IS JUST AN EXAMPLE.

747

00:33:24,266 --> 00:33:26,400

THE EARTH COULD BE  
ANY ORIENTATION HERE,

748

00:33:26,400 --> 00:33:29,133

BUT LET'S JUST TAKE THIS  
AS AN EXAMPLE.

749

00:33:29,133 --> 00:33:32,333

AND LET'S JUST SAY  
THAT IS THE PLANE

750  
00:33:32,333 --> 00:33:34,366  
OF THE ASTEROID'S ORBIT.

751  
00:33:34,366 --> 00:33:37,266  
YOU ARE APPROACHING THE EARTH  
IN THIS PLANE

752  
00:33:37,266 --> 00:33:39,366  
THAT CUTS THROUGH THE EARTH

753  
00:33:39,366 --> 00:33:41,266  
AT THAT POINT,

754  
00:33:41,266 --> 00:33:43,600  
AT THAT--ALONG THAT LINE,  
OKAY?

755  
00:33:43,600 --> 00:33:47,433  
SO NOW,  
IF YOU HIT THE EARTH--

756  
00:33:47,433 --> 00:33:48,966  
IF YOU HIT THE EARTH,

757  
00:33:48,966 --> 00:33:51,566  
YOU'RE GOING TO HIT SOMEWHERE  
BETWEEN THE TRAILING EDGE HERE--

758  
00:33:51,566 --> 00:33:53,266  
THE EARTH IS MOVING  
TO THE RIGHT--

759  
00:33:53,266 --> 00:33:54,933  
AND THE LEADING EDGE.

760  
00:33:54,933 --> 00:33:57,633

YOU'RE GONNA HIT  
ALONG THAT LINE, OKAY?

761  
00:33:57,633 --> 00:34:01,600  
THAT RED LINE WE CALL  
THE RISK CORRIDOR.

762  
00:34:01,600 --> 00:34:04,566  
AND IN FACT,  
WE DON'T KNOW PRECISELY

763  
00:34:04,566 --> 00:34:06,633  
WHAT THE TIMING IS.

764  
00:34:06,633 --> 00:34:10,200  
SO IN FACT, YOU MAY BE ON  
A TRAJECTORY THAT TAKES YOU OUT

765  
00:34:10,200 --> 00:34:12,900  
AND YOU PASS  
IN FRONT OF THE EARTH

766  
00:34:12,900 --> 00:34:14,633  
AND GO THROUGH THE INTERSECTION  
FIRST.

767  
00:34:14,633 --> 00:34:17,633  
OR YOU MAY ACTUALLY ARRIVE  
AT THE INTERSECTION

768  
00:34:17,633 --> 00:34:19,166  
AFTER THE EARTH,

769  
00:34:19,166 --> 00:34:21,533  
IN WHICH CASE, YOU'RE GONNA  
ACTUALLY BE OUT HERE.

770  
00:34:21,533 --> 00:34:24,466  
SO YOU'RE GONNA BE  
SOMEWHERE ALONG THIS LINE

771

00:34:24,466 --> 00:34:26,800  
BUT WE DON'T KNOW  
EXACTLY WHERE

772

00:34:26,800 --> 00:34:29,900  
UNTIL WE GET UP THERE  
AND MEASURE PRECISELY

773

00:34:29,900 --> 00:34:32,033  
WHAT YOUR TRAJECTORY IS.

774

00:34:32,033 --> 00:34:34,500  
LET'S JUST SAY,  
FOR EXAMPLE,

775

00:34:34,500 --> 00:34:36,766  
WE'RE GONNA HAVE AN IMPACT,  
AND LET'S JUST SAY

776

00:34:36,766 --> 00:34:39,833  
IT'S RIGHT IN THE MIDDLE  
OF THE NORTH ATLANTIC HERE.

777

00:34:39,833 --> 00:34:41,366  
ALL RIGHT?

778

00:34:41,366 --> 00:34:44,200  
NOW, IF YOU MAKE THE--  
IF WE GO UP AND DEFLECT IT

779

00:34:44,200 --> 00:34:47,133  
AND WE MAKE IT ARRIVE  
A LITTLE BIT EARLY--

780

00:34:48,700 --> 00:34:50,233  
HELLO, THERE WE GO.

781

00:34:50,233 --> 00:34:53,000

LET'S SAY WE MADE IT ARRIVE  
TWO MINUTES EARLIER,

782

00:34:53,000 --> 00:34:55,800  
OKAY, THEN IT WOULD HIT HERE.

783

00:34:55,800 --> 00:34:58,100  
OR IF WE MAKE IT ARRIVE  
FOUR MINUTES EARLY,

784

00:34:58,100 --> 00:34:59,666  
IT'S GONNA BE THERE.

785

00:34:59,666 --> 00:35:02,433  
OF COURSE, IF WE MAKE IT  
EIGHT MINUTES EARLY,

786

00:35:02,433 --> 00:35:05,133  
IT'S OVER THERE.  
THAT'S WHAT WE WANT, OKAY?

787

00:35:05,133 --> 00:35:08,000  
BUT IF SOMETHING GOES WRONG,  
OF COURSE,

788

00:35:08,000 --> 00:35:09,766  
IT'S GONNA HIT IN THOSE PLACES,

789

00:35:09,766 --> 00:35:12,566  
OR WE COULD MAKE IT ARRIVE  
TWO MINUTES LATE

790

00:35:12,566 --> 00:35:14,766  
OR MAYBE FOUR MINUTES LATE,

791

00:35:14,766 --> 00:35:17,800  
OR IF WE WANT IT TO MISS  
THE EARTH, EIGHT MINUTES LATE,

792

00:35:17,800 --> 00:35:20,666  
AND IT WOULD GO  
BEHIND THE EARTH.

793  
00:35:20,666 --> 00:35:22,833  
ALL RIGHT?

794  
00:35:22,833 --> 00:35:24,800  
IF YOU'RE A FRENCHMAN,

795  
00:35:24,800 --> 00:35:27,400  
WHAT DO YOU SAY?  
OKAY?

796  
00:35:27,400 --> 00:35:29,500  
"OH, WELL, LET'S MAKE IT GO  
TO THE LEFT," RIGHT?

797  
00:35:29,500 --> 00:35:31,166  
AND IF YOU'RE AN AMERICAN,  
YOU SAY,

798  
00:35:31,166 --> 00:35:33,233  
"WELL, NO, NO.  
LET'S TAKE IT OVER--

799  
00:35:33,233 --> 00:35:35,233  
YOU KNOW, LET'S TAKE IT OVER  
TO THE RIGHT."

800  
00:35:35,233 --> 00:35:38,400  
IN OTHER WORDS, IN ORDER  
TO SUCCESSFULLY ACCOMPLISH

801  
00:35:38,400 --> 00:35:40,366  
A DEFLECTION,

802  
00:35:40,366 --> 00:35:43,400  
WE'RE GOING TO BE DRAGGING--  
EFFECTIVELY DRAGGING

803

00:35:43,400 --> 00:35:47,366

THE IMPACT POINT ALONG  
THE SURFACE OF THE EARTH,

804

00:35:47,366 --> 00:35:50,400

ALONG THAT LINE  
UNTIL WE GET IT OUT HERE

805

00:35:50,400 --> 00:35:52,766

SO THAT IT'S NO LONGER  
GONNA HIT THE EARTH.

806

00:35:52,766 --> 00:35:55,066

BUT OF COURSE,  
IF SOMETHING GOES WRONG,

807

00:35:55,066 --> 00:35:57,833

THESE PEOPLE COULD BE  
IN REAL DANGER.

808

00:35:57,833 --> 00:35:59,766

SO THERE IS RISK.

809

00:35:59,766 --> 00:36:01,966

ANY TIME YOU'RE TALKING ABOUT  
A DEFLECTION,

810

00:36:01,966 --> 00:36:05,033

YOU'RE TALKING ABOUT  
SHIFTING RISK

811

00:36:05,033 --> 00:36:08,200

AND PUTTING PEOPLE AT RISK  
WHO WERE NOT INITIALLY

812

00:36:08,200 --> 00:36:12,266

IN ORDER TO ELIMINATE THE RISK  
FOR EVERYBODY.

813

00:36:12,266 --> 00:36:16,333

AND YOU,  
AS THE PRESIDENT OF FRANCE

814

00:36:16,333 --> 00:36:19,000

AND COMING UP FOR AN ELECTION,

815

00:36:19,000 --> 00:36:22,333

ARE GOING TO HAVE TO SAY,  
"WELL, DO I ACCEPT THAT?"

816

00:36:22,333 --> 00:36:24,600

YOU KNOW?  
"DO WE HAVE A REFERENDUM?"

817

00:36:24,600 --> 00:36:26,433

"WELL, WE GOTTA DECIDE  
BY NEXT WEEK.

818

00:36:26,433 --> 00:36:27,933

WHAT DO WE DO?"

819

00:36:27,933 --> 00:36:31,266

OKAY, AND SO THIS IS  
THE GEOPOLITICAL CHALLENGE

820

00:36:31,266 --> 00:36:33,000

OF DEFLECTION.

821

00:36:33,000 --> 00:36:35,066

HOW DO YOU MAKE A DECISION?

822

00:36:35,066 --> 00:36:37,466

AND FOR THAT MATTER,  
SUPPOSE WE DECIDE

823

00:36:37,466 --> 00:36:40,100

TO DRAG IT THIS WAY,

824

00:36:40,100 --> 00:36:42,200

DO WE LET RUSSIA DO THAT?

825

00:36:42,200 --> 00:36:44,866

OR DOES THE UNITED STATES  
DO THAT?

826

00:36:44,866 --> 00:36:47,966

OR MAYBE INDIA, OR MAYBE  
IF IT'S 100 YEARS FROM NOW,

827

00:36:47,966 --> 00:36:50,633

ZAMBIA  
WITH THEIR SPACE PROGRAM.

828

00:36:50,633 --> 00:36:52,300

WHO KNOWS?  
OKAY?

829

00:36:52,300 --> 00:36:53,900

NO MATTER WHAT YOU DO,

830

00:36:53,900 --> 00:36:55,900

IN ORDER TO HAVE A DEFLECTION,

831

00:36:55,900 --> 00:36:59,566

YOU HAVE TO DRAG AN IMPACT  
POINT, WHEREVER IT IS ON EARTH,

832

00:36:59,566 --> 00:37:02,500

ACROSS PARTS OF THE EARTH  
THAT WEREN'T AT RISK

833

00:37:02,500 --> 00:37:06,033

IN ORDER TO GET IT OFF THE EARTH  
AND EVERYBODY SAFE.

834

00:37:06,033 --> 00:37:10,333

THAT IS A HUGE

GEOPOLITICAL CHALLENGE.

835

00:37:10,333 --> 00:37:13,566

OBVIOUSLY, THOSE ARE BAD.

836

00:37:13,566 --> 00:37:15,866

THAT'S GOOD.

837

00:37:15,866 --> 00:37:18,233

THOSE ARE THE ONES WE WANT.

838

00:37:18,233 --> 00:37:21,566

OKAY, THERE IS

THE BACK OF MY HEAD

839

00:37:21,566 --> 00:37:23,433

BEFORE I HAD A BALD SPOT

840

00:37:23,433 --> 00:37:27,000

SPEAKING AT THE UNITED NATIONS  
IN VIENNA

841

00:37:27,000 --> 00:37:29,466

AT THE COMMITTEE ON THE PEACEFUL  
USES OF OUTER SPACE,

842

00:37:29,466 --> 00:37:31,433

OR AS PETE SAID, COPUOS.

843

00:37:31,433 --> 00:37:34,666

AND WE TOOK THIS ISSUE  
TO THE UNITED NATIONS

844

00:37:34,666 --> 00:37:37,200

AND BASICALLY SAID,  
"LOOK, GUYS,

845

00:37:37,200 --> 00:37:39,666

"YOU KNOW, WE--THIS IS

A COLLECTIVE DECISION.

846

00:37:39,666 --> 00:37:42,133

"THE PLANET IS AT RISK HERE.

847

00:37:42,133 --> 00:37:44,533

"EVEN THOUGH THERE IS  
ONE IMPACT POINT,

848

00:37:44,533 --> 00:37:46,566

"EVERYBODY ON THE PLANET--  
THAT--THAT LINE

849

00:37:46,566 --> 00:37:48,500

"COULD BE ACROSS ANY COUNTRY,

850

00:37:48,500 --> 00:37:50,866

"AND TYPICALLY THERE ARE  
GONNA BE 10 OR 20 COUNTRIES

851

00:37:50,866 --> 00:37:53,033

"ALONG THAT LINE.

852

00:37:53,033 --> 00:37:57,100

"THIS HAS GOT TO BE  
A COOPERATIVE PLANETARY EFFORT,

853

00:37:57,100 --> 00:37:59,600

"AND YOU'VE  
GOT TO GET TOGETHER.

854

00:37:59,600 --> 00:38:02,433

SO, UNITED NATIONS,  
GET ORGANIZED."

855

00:38:02,433 --> 00:38:04,400

OKAY, SO I'M GONNA  
COME TO THE END HERE.

856

00:38:04,400 --> 00:38:06,433  
I'M GONNA GIVE A SCORECARD  
OF WHERE WE STAND

857  
00:38:06,433 --> 00:38:07,833  
ON THESE THREE THINGS.

858  
00:38:07,833 --> 00:38:10,166  
EARLY WARNING, OKAY?

859  
00:38:12,233 --> 00:38:14,833  
EARLY WARNING I'M GONNA GIVE  
A B-MINUS.

860  
00:38:14,833 --> 00:38:17,000  
NASA HAS DONE  
A PRETTY GOOD JOB

861  
00:38:17,000 --> 00:38:20,133  
UP UNTIL  
A COUPLE OF YEARS AGO

862  
00:38:20,133 --> 00:38:22,100  
WHEN THE LIMIT  
ON THEIR TELESCOPES

863  
00:38:22,100 --> 00:38:24,100  
WAS ESSENTIALLY REACHED

864  
00:38:24,100 --> 00:38:26,633  
AND THE CURVE DROPPED OFF  
VERY DRAMATICALLY.

865  
00:38:26,633 --> 00:38:28,900  
THE DISCOVERY RATE IS ALMOST,  
NOT QUITE,

866  
00:38:28,900 --> 00:38:31,100  
BUT ALMOST DOWN TO ZERO.

867

00:38:31,100 --> 00:38:33,500

AND OF COURSE, WE'RE NOWHERE  
NEAR FINDING, YOU KNOW,

868

00:38:33,500 --> 00:38:35,566

THE MILLION OBJECTS  
WE GOTTA FIND.

869

00:38:35,566 --> 00:38:37,700

BUT WE KNOW HOW TO DO IT.  
WE'VE BEEN DOING IT.

870

00:38:37,700 --> 00:38:40,900

IT'S JUST THAT NASA ISN'T  
GETTING THE MONEY THAT'S NEEDED

871

00:38:40,900 --> 00:38:43,066

IN ORDER TO GET THIS DONE,

872

00:38:43,066 --> 00:38:47,333

AND SO B612 FOUNDATION HAS SAID,  
"OKAY, JUST DO IT.

873

00:38:47,333 --> 00:38:50,166

WE'LL DO IT. FINE."  
SO WE'RE DOING IT PRIVATELY.

874

00:38:52,266 --> 00:38:54,833

AND AGAIN, IT'S A B-MINUS.

875

00:38:54,833 --> 00:38:57,066

WE GOT A LOT OF WORK TO DO,  
BUT WE KNOW WHAT WE'RE DOING.

876

00:38:57,066 --> 00:39:00,066

DEFLECTION--WE KNOW  
HOW TO DO A DEFLECTION.

877

00:39:00,066 --> 00:39:01,933

WE KNOW IT CAN BE DONE.

878

00:39:01,933 --> 00:39:03,733  
THE TECHNOLOGY IS NOT THE ISSUE,

879

00:39:03,733 --> 00:39:05,833  
BUT IT'S GOTTA BE DEMONSTRATED.

880

00:39:05,833 --> 00:39:08,500  
AND WE'VE NEVER BEEN ABLE  
TO GET NASA OFF THE DIME

881

00:39:08,500 --> 00:39:11,166  
TO ACTUALLY ORGANIZE

882

00:39:11,166 --> 00:39:14,600  
AND SET UP A DEMONSTRATION  
OF A DEFLECTION.

883

00:39:14,600 --> 00:39:18,566  
ACTUALLY CHANGE THE ORBIT OF  
A, YOU KNOW, A RANDOM ASTEROID

884

00:39:18,566 --> 00:39:20,166  
THAT'S GOING BY.

885

00:39:20,166 --> 00:39:21,833  
BUT IT HASN'T BEEN DONE.

886

00:39:21,833 --> 00:39:23,666  
BUT ON THE OTHER HAND,  
IT'S STILL PRETTY EARLY.

887

00:39:23,666 --> 00:39:25,633  
SO LET'S JUST SAY D-MINUS,

888

00:39:25,633 --> 00:39:27,933  
BUT WE'RE NOT GONNA WORRY  
ABOUT IT TOO MUCH.

889

00:39:27,933 --> 00:39:31,100

OKAY, THE GEOPOLITICAL--

890

00:39:31,100 --> 00:39:33,466

THAT'S--THAT'S THE TOUGHEST ONE.

891

00:39:33,466 --> 00:39:35,433

I'M GONNA GIVE AN INCOMPLETE.

892

00:39:37,666 --> 00:39:40,400

YOU KNOW, THIS IS REALLY  
THE MOST IMPORTANT ISSUE

893

00:39:40,400 --> 00:39:42,300

OF THE THREE--  
EARLY WARNING.

894

00:39:42,300 --> 00:39:43,833

YOU CAN'T DO ANYTHING

895

00:39:43,833 --> 00:39:46,933

UNLESS YOU KNOW WHAT'S OUT THERE  
AND COMING AT YOU.

896

00:39:46,933 --> 00:39:48,766

DEFLECTION YOU DON'T  
REALLY NEED

897

00:39:48,766 --> 00:39:50,800

UNTIL YOU HAVE SOMETHING  
THAT'S COMING AT YOU,

898

00:39:50,800 --> 00:39:52,366

BUT YOU BETTER BE READY.

899

00:39:52,366 --> 00:39:53,766

BUT ON THE OTHER HAND,  
THIS ONE,

900

00:39:53,766 --> 00:39:55,833

THAT'S THE HARDEST ONE.

901

00:39:55,833 --> 00:39:58,033

YOU CAN IMAGINE TRYING TO GET  
THE NATIONS OF THE WORLD

902

00:39:58,033 --> 00:39:59,566

TO AGREE.

903

00:39:59,566 --> 00:40:02,000

WHERE DIFFERENT NATIONS  
ARE GONNA BE ACCEPTING RISK

904

00:40:02,000 --> 00:40:04,433

AND SOMEBODY ELSE IS GONNA  
HAVE IT ELIMINATED

905

00:40:04,433 --> 00:40:06,600

AND WHOSE TAXPAYERS ARE--

906

00:40:06,600 --> 00:40:08,800

ARE GONNA PAY,  
ET CETERA, ET CETERA.

907

00:40:08,800 --> 00:40:11,466

THAT'S A REALLY, REALLY TOUGH  
CHALLENGE.

908

00:40:11,466 --> 00:40:14,400

NOW, SO THAT'S MY SCORECARD.

909

00:40:17,400 --> 00:40:20,200

LET ME SAY IN RESPONSE  
TO PEOPLE WHO SAY,

910

00:40:20,200 --> 00:40:22,166

"WHY THE UNITED NATIONS?"

911

00:40:22,166 --> 00:40:25,133

WELL, THE UNITED NATIONS  
IS THE ONLY ORGANIZATION

912

00:40:25,133 --> 00:40:27,500

THAT REALLY REPRESENTS  
EVERYBODY ON THE PLANET,

913

00:40:27,500 --> 00:40:29,533

OR JUST ABOUT EVERYBODY.

914

00:40:29,533 --> 00:40:32,466

SO, YOU KNOW,  
THEY GOT A BIG HAT.

915

00:40:32,466 --> 00:40:33,833

YOU KNOW,  
NO CATTLE, BUT A BIG HAT.

916

00:40:33,833 --> 00:40:36,533

BUT MY GOD, WHAT A HAT,  
YOU KNOW?

917

00:40:36,533 --> 00:40:41,366

OKAY, SO COMING TO THE END  
OF THE TALK HERE,

918

00:40:41,366 --> 00:40:44,333

LET ME JUST STAND BACK  
FROM ALL OF THIS

919

00:40:44,333 --> 00:40:48,600

AND--AND BE  
A BIT PHILOSOPHICAL.

920

00:40:48,600 --> 00:40:50,866

EVERYBODY IN THIS AUDIENCE

921

00:40:50,866 --> 00:40:53,133  
AND MOST PEOPLE IN THE WORLD

922  
00:40:53,133 --> 00:40:55,133  
WHO THINK ABOUT THESE THINGS

923  
00:40:55,133 --> 00:40:57,400  
HAVE THOUGHT ABOUT,

924  
00:40:57,400 --> 00:40:59,900  
IS THERE LIFE OUT THERE  
IN THE UNIVERSE?

925  
00:40:59,900 --> 00:41:04,100  
THERE MUST BE IN ALL  
OF THE BILLIONS OF GALAXIES--

926  
00:41:04,100 --> 00:41:06,300  
AND THESE ARE ALL GALAXIES,  
THERE ARE NO STAR--

927  
00:41:06,300 --> 00:41:09,266  
INDIVIDUAL STARS  
IN THAT IMAGE.

928  
00:41:09,266 --> 00:41:11,100  
THEY'RE ALL GALAXIES,  
AND EACH OF THEM

929  
00:41:11,100 --> 00:41:15,600  
HAS HUNDREDS OF BILLIONS  
OF--OF--OF STARS

930  
00:41:15,600 --> 00:41:17,400  
IN EACH OF THOSE GALAXIES.

931  
00:41:17,400 --> 00:41:19,300  
AND OF COURSE, WE KNOW THERE ARE  
PLANETS AROUND,

932

00:41:19,300 --> 00:41:21,566

APPARENTLY, MOST STARS NOW

933

00:41:21,566 --> 00:41:24,000

THAT WE SEEM TO HAVE DISCOVERED.

934

00:41:24,000 --> 00:41:27,333

SO THERE IS LOTS AND LOTS  
OF PLANETS OUT THERE

935

00:41:27,333 --> 00:41:30,300

IS IT IMAGINABLE  
THAT THERE'S NOT LIFE?

936

00:41:30,300 --> 00:41:31,966

I DON'T THINK SO.

937

00:41:31,966 --> 00:41:34,166

WE DON'T HAVE ANY PROOF OF IT,  
BUT IT CERTAINLY IS,

938

00:41:34,166 --> 00:41:37,900

TO ME, NOT--IT'S NOT EVEN  
A STRETCH TO IMAGINE,

939

00:41:37,900 --> 00:41:40,400

YOU KNOW, THAT THERE IS  
INTELLIGENT LIFE OUT THERE.

940

00:41:40,400 --> 00:41:43,733

AND IN ALL LIKELIHOOD,  
IN MY VIEW, PERSONALLY,

941

00:41:43,733 --> 00:41:45,933

THERE PROBABLY ARE PEOPLE

942

00:41:45,933 --> 00:41:49,200

WHO HAVE FORMED A COMMUNITY  
FROM DIFFERENT PLANETS.

943

00:41:49,200 --> 00:41:51,366

WHO KNOWS?

944

00:41:51,366 --> 00:41:53,866

BUT ALL OF THEM--OH, I KEEP  
HITTING THAT. PARDON ME.

945

00:41:53,866 --> 00:41:57,266

ALL OF THEM LIVE  
IN A SOLAR SYSTEM,

946

00:41:57,266 --> 00:41:59,933

CAME FROM A SOLAR SYSTEM  
LIKE OURS.

947

00:41:59,933 --> 00:42:02,333

AND WE KNOW THAT DIFFERENT  
STELLAR SYSTEMS

948

00:42:02,333 --> 00:42:04,433

HAVE ASTEROIDS AND COMETS.

949

00:42:04,433 --> 00:42:06,666

YOU KNOW, WE'RE NOT UNIQUE.

950

00:42:06,666 --> 00:42:08,766

SO EVERYONE HAS FACED THIS.

951

00:42:08,766 --> 00:42:11,633

AND MY THOUGHT HERE  
IS THAT THIS IS--

952

00:42:11,633 --> 00:42:14,633

YOU KNOW,  
I LOOK AT MYSELF.

953

00:42:14,633 --> 00:42:17,333

45 YEARS AGO

I FLEW ON APOLLO.

954

00:42:17,333 --> 00:42:19,766

I HAD THE GREAT PRIVILEGE

955

00:42:19,766 --> 00:42:22,233

OF DEALING

WITH THAT CHALLENGE

956

00:42:22,233 --> 00:42:24,066

OF HUMAN BEINGS

FIRST LEAVING THE EARTH

957

00:42:24,066 --> 00:42:27,566

AND LANDING ON ANOTHER BODY

IN--IN THE COSMOS.

958

00:42:27,566 --> 00:42:31,133

AND TODAY,

I SAY THAT YOU HAVE--

959

00:42:31,133 --> 00:42:33,700

THIS GENERATION, THE KIDS

OUT HERE IN THE AUDIENCE,

960

00:42:33,700 --> 00:42:35,733

IN PARTICULAR THE STUDENTS,

THE INTERNS--

961

00:42:35,733 --> 00:42:39,133

IT'S YOUR GENERATION THAT HAS

THIS INCREDIBLE PRIVILEGE

962

00:42:39,133 --> 00:42:41,733

TO DEAL WITH THE CHALLENGE

963

00:42:41,733 --> 00:42:43,800

OF PREVENTING EXTINCTION,

964

00:42:43,800 --> 00:42:47,633  
PREVENTING THE--THIS--  
THESE ASTEROID IMPACTS,

965  
00:42:47,633 --> 00:42:50,066  
WHICH ULTIMATELY  
CAN LEAD TO EXTINCTION

966  
00:42:50,066 --> 00:42:53,333  
AND PREVENTING US FROM  
MOVING OUT INTO THE UNIVERSE.

967  
00:42:53,333 --> 00:42:57,900  
SO I ALWAYS LIKE TO SHOW  
THIS STATEMENT

968  
00:42:57,900 --> 00:42:59,466  
AT THE END, OKAY?

969  
00:42:59,466 --> 00:43:02,000  
IT'S LIKELY THAT IF--  
AND I UNDERLINE "IF"--

970  
00:43:02,000 --> 00:43:04,266  
THERE IS A COMMUNITY  
OF SENTIENT LIFE

971  
00:43:04,266 --> 00:43:06,233  
OUT THERE IN THE UNIVERSE

972  
00:43:06,233 --> 00:43:09,200  
THAT ITS MEMBERS HAVE EACH FACED  
THIS CHALLENGE--

973  
00:43:09,200 --> 00:43:12,200  
THAT IS THE CHALLENGE OF  
PREVENTING ASTEROID IMPACTS

974  
00:43:12,200 --> 00:43:14,400  
ON THEIR HOME PLANET.

975

00:43:14,400 --> 00:43:17,066

OTHERWISE THEY WOULDN'T  
HAVE MADE IT, OKAY?

976

00:43:17,066 --> 00:43:19,233

THEY PASSED THAT CHALLENGE.

977

00:43:19,233 --> 00:43:22,900

WE HUMANS NOW FACE  
THIS GREAT TEST OF ADMISSION

978

00:43:22,900 --> 00:43:25,333

INTO THE LIFE OF THE COSMOS.

979

00:43:25,333 --> 00:43:28,633

THIS IS YOUR CHALLENGE.  
WE DID APOLLO.

980

00:43:28,633 --> 00:43:31,633

YOU DO THIS, PLEASE.  
THANKS.

981

00:43:31,633 --> 00:43:34,633

[applause]

982

00:43:43,900 --> 00:43:45,766

- SO WE HAVE A--  
TIME FOR A FEW QUESTIONS.

983

00:43:45,766 --> 00:43:47,800

IF YOU HAVE A QUESTION,  
PLEASE RAISE YOUR HAND,

984

00:43:47,800 --> 00:43:49,433

WAIT FOR THE MICROPHONE,

985

00:43:49,433 --> 00:43:51,633

AND STAND UP

AND ASK YOUR QUESTION.

986

00:43:54,300 --> 00:43:57,733  
- SO TODAY'S JULY 17, 2014.

987

00:43:57,733 --> 00:43:59,833  
WE LOOK UP ON OUR TEL--  
[microphone feedback]

988

00:43:59,833 --> 00:44:03,766  
AT OUR TELESCOPE AND WE SEE  
SOMETHING COMING AT US.

989

00:44:03,766 --> 00:44:05,600  
HOW MUCH TIME  
DO WE HAVE TO REACT,

990

00:44:05,600 --> 00:44:08,933  
ACTUALLY GO THROUGH STEPS TWO  
AND THREE ON YOUR LIST?

991

00:44:14,200 --> 00:44:16,533  
- IF YOU LOOK UP--

992

00:44:16,533 --> 00:44:18,366  
NUMBER ONE,

993

00:44:18,366 --> 00:44:21,566  
YOU'RE NOT GONNA LOOK UP  
AND KNOW RIGHT AWAY

994

00:44:21,566 --> 00:44:25,066  
WHETHER SOMETHING IS  
QUOTE: "COMING AT US."

995

00:44:25,066 --> 00:44:28,333  
THERE IS A VERY SLIGHT  
POSSIBILITY,

996

00:44:28,333 --> 00:44:31,366  
VERY LOW PROBABILITY  
THAT YOU CAN LOOK AND SEE ONE

997  
00:44:31,366 --> 00:44:33,233  
THAT'S JUST ABOUT TO HIT,

998  
00:44:33,233 --> 00:44:37,000  
BUT THAT WOULD BE  
A TOTAL MIRACLE TO DO THAT.

999  
00:44:37,000 --> 00:44:39,800  
YOU--YOU LOOK UP  
AND YOU FIND THINGS MOVING

1000  
00:44:39,800 --> 00:44:41,333  
IN THE SKY--

1001  
00:44:41,333 --> 00:44:44,566  
ASTEROIDS MOVING AGAINST  
THE STAR BACKGROUND.

1002  
00:44:44,566 --> 00:44:46,400  
YOU--YOU TRACK THEM.

1003  
00:44:46,400 --> 00:44:50,366  
YOU PLOT THEIR ORBIT, AND YOU  
PROJECT 100 YEARS AHEAD OF TIME,

1004  
00:44:50,366 --> 00:44:52,933  
AND YOU SAY,  
"IN THAT 100 YEARS,

1005  
00:44:52,933 --> 00:44:55,666  
IS THERE GOING TO BE  
AN INTERSECTION?"

1006  
00:44:55,666 --> 00:44:57,200  
YOU DON'T--

1007

00:44:57,200 --> 00:44:59,666

THERE--THERE'S NO SENSE THAT,  
"IT'S COMING, DUCK."

1008

00:44:59,666 --> 00:45:01,500

I MEAN, THAT'S NOT THE DEAL.

1009

00:45:01,500 --> 00:45:03,666

WE'RE TALKING ABOUT  
BEING ABLE--

1010

00:45:03,666 --> 00:45:06,466

THE NICE THING ABOUT ASTEROIDS  
OR ANYTHING IN SPACE,

1011

00:45:06,466 --> 00:45:09,600

AS ALL OF YOU KNOW HERE,  
IS THAT THEY'RE PREDICTABLE.

1012

00:45:09,600 --> 00:45:13,100

THEY BEHAVE IN ORDERLY WAYS,  
NEWTON'S LAWS AND ALL OF THAT.

1013

00:45:13,100 --> 00:45:15,766

A FEW OTHER THINGS,  
LIKE RELATIVITY,

1014

00:45:15,766 --> 00:45:17,533

BUT YOU KNOW,  
WE CAN PREDICT

1015

00:45:17,533 --> 00:45:20,400

WHERE SOMETHING IS GOING TO BE  
IN SPACE

1016

00:45:20,400 --> 00:45:22,366

MANY, MANY YEARS  
AHEAD OF TIME.

1017

00:45:22,366 --> 00:45:23,400  
AND TO DO OUR DEFLECTION,

1018  
00:45:23,400 --> 00:45:26,700  
WE NEED SOMETHING LIKE  
15 OR 20 YEARS.

1019  
00:45:26,700 --> 00:45:28,800  
SO GENERALLY SPEAKING,  
YOU'RE NOT TALKING ABOUT

1020  
00:45:28,800 --> 00:45:30,766  
FINDING SOMETHING  
AT THE LAST MINUTE.

1021  
00:45:30,766 --> 00:45:34,600  
ALTHOUGH,  
THAT IS A VERY--

1022  
00:45:34,600 --> 00:45:37,966  
THERE IS A POSSIBILITY OF  
DOING THAT AT FAIRLY LOW COST,

1023  
00:45:37,966 --> 00:45:40,833  
BUT YOU'RE NOT--YOU'RE NOT GONNA  
BE DOING ANYTHING THERE

1024  
00:45:40,833 --> 00:45:43,700  
OTHER THAN, IN FACT,  
SAYING, "DUCK."

1025  
00:45:43,700 --> 00:45:47,633  
IF YOU SEE SOMETHING  
LITERALLY COMING AT YOU

1026  
00:45:47,633 --> 00:45:50,233  
ON FINAL APPROACH,  
WHAT I CALL FINAL APPROACH,

1027  
00:45:50,233 --> 00:45:53,966

OR WHAT OTHER NON-FRIENDS CALL  
THE DEATH PLUNGE...

1028

00:45:53,966 --> 00:45:56,933

[laughter]

1029

00:45:56,933 --> 00:46:00,366

GENERALLY SPEAKING,  
YOU HAVE SOMEWHERE BETWEEN

1030

00:46:00,366 --> 00:46:02,900

TWO DAYS AND MAYBE A MONTH

1031

00:46:02,900 --> 00:46:05,433

TO EVACUATE, THE SAME WAY  
YOU WOULD WITH A HURRICANE.

1032

00:46:05,433 --> 00:46:07,200

BUT WHAT WE WANT TO DO

1033

00:46:07,200 --> 00:46:10,266

IS TO BE ABLE TO DEFLECT  
AND PREVENT IMPACTS,

1034

00:46:10,266 --> 00:46:12,433

AND TO DO THAT,  
WE FIND THESE THINGS,

1035

00:46:12,433 --> 00:46:14,133

UNDERSTAND WHERE THEY--

1036

00:46:14,133 --> 00:46:16,666

WE INVENTORY  
THIS WHOLE ARRAY OF THINGS

1037

00:46:16,666 --> 00:46:19,966

KNOW THEIR ORBITS, AND WE KNOW  
20 YEARS AHEAD OF TIME

1038

00:46:19,966 --> 00:46:21,966

WHETHER SOMETHING  
IS GOING TO HIT.

1039

00:46:21,966 --> 00:46:23,466

BUT WE HAVE TO FIND IT FIRST.

1040

00:46:23,466 --> 00:46:26,166

THAT'S WHY THE EARLY WARNING  
IS SO IMPORTANT.

1041

00:46:29,700 --> 00:46:31,566

I CAN SEE HANDS GOING UP  
BUT I DON'T KNOW WHO--

1042

00:46:31,566 --> 00:46:33,566

THERE'S THE MIC. OKAY.  
- HELLO.

1043

00:46:33,566 --> 00:46:36,633

YOU SHOWED US THAT IF YOU WERE  
ABLE TO DEFLECT AN ASTEROID

1044

00:46:36,633 --> 00:46:39,900

IT WOULD COME EITHER BEFORE  
OR AFTER EARTH BUT PRETTY CLOSE.

1045

00:46:39,900 --> 00:46:42,366

IS THERE A CONCERN  
OF IT COMING BACK AROUND AGAIN

1046

00:46:42,366 --> 00:46:44,800

AS IT MAKES ANOTHER ORBIT  
AROUND THE MOON IN THE FUTURE?

1047

00:46:44,800 --> 00:46:47,566

AND WOULD YOU HAVE TO DEFLECT IT  
EVERY SINGLE TIME AGAIN?

1048

00:46:47,566 --> 00:46:50,966

- YES.

1049

00:46:50,966 --> 00:46:52,400

I DON'T KNOW.

1050

00:46:52,400 --> 00:46:54,666

WE GOT THE LAPEL MIC ON?

OKAY, THERE WE GO.

1051

00:46:54,666 --> 00:46:56,800

THE ANSWER IS YES.

1052

00:46:56,800 --> 00:46:59,800

WE MAKE A VERY,  
VERY SMALL CHANGE

1053

00:46:59,800 --> 00:47:02,100

IN THE SPEED--IN THE ORBIT  
OF THESE ASTEROIDS

1054

00:47:02,100 --> 00:47:04,033

IN ORDER TO MAKE THEM MISS  
THE EARTH.

1055

00:47:04,033 --> 00:47:10,066

SO THAT ASTEROID WILL STILL BE  
IN APPROXIMATELY THE SAME ORBIT,

1056

00:47:10,066 --> 00:47:14,300

AND IT MAY, 20, 50 YEARS,  
100 YEARS, COME BACK.

1057

00:47:14,300 --> 00:47:17,433

THAT'S THE REASON WE WANT TO  
HAVE A PRECISE

1058

00:47:17,433 --> 00:47:19,033

END DEFLECTION CAPABILITY.

1059

00:47:19,033 --> 00:47:21,700  
NOT JUST HIT IT  
AND MAKE IT MISS THE EARTH

1060  
00:47:21,700 --> 00:47:23,033  
BUT NOT KNOW  
WHERE IT'S GONNA GO.

1061  
00:47:23,033 --> 00:47:25,366  
WE WANT TO TRY TO PUT IT  
IN AN ORBIT,

1062  
00:47:25,366 --> 00:47:27,933  
A PRECISE ORBIT,  
THAT WE'LL SAY,

1063  
00:47:27,933 --> 00:47:30,633  
"IT'S NOT GONNA BE A PROBLEM FOR  
ANOTHER 100 YEARS OR SOMETHING."

1064  
00:47:30,633 --> 00:47:32,466  
AND THERE WILL BE  
DIFFERENT TECHNOLOGY,

1065  
00:47:32,466 --> 00:47:34,633  
BETTER TECHNOLOGY.

1066  
00:47:34,633 --> 00:47:38,300  
IN THE END, WE WOULD BE ABLE TO,  
IN MY VIEW,

1067  
00:47:38,300 --> 00:47:40,333  
WE WILL BE ABLE TO, IN FACT,

1068  
00:47:40,333 --> 00:47:42,666  
SET UP A DEFLECTION  
IN SUCH A WAY

1069  
00:47:42,666 --> 00:47:46,166  
THAT, IN FACT, IT WILL GO

SOMEWHERE NEAR VENUS--

1070

00:47:46,166 --> 00:47:48,900  
CLOSE ENOUGH TO, SAY,  
VENUS OR MARS

1071

00:47:48,900 --> 00:47:51,300  
ON ITS TRAJECTORY THAT

1072

00:47:51,300 --> 00:47:54,366  
THAT PLANET WILL AFFECT IT  
GRAVITATIONALLY

1073

00:47:54,366 --> 00:47:56,300  
AND IT WILL NO LONGER  
BE A PROBLEM.

1074

00:47:56,300 --> 00:47:58,266  
IN OTHER WORDS,  
THERE IS A POSSIBILITY

1075

00:47:58,266 --> 00:48:00,666  
OVER A LONG PERIOD OF TIME

1076

00:48:00,666 --> 00:48:04,066  
OF GETTING RID OF ASTEROIDS.

1077

00:48:04,066 --> 00:48:06,066  
AND IN FACT, I WOULD SUGGEST  
THAT ONE WAY

1078

00:48:06,066 --> 00:48:08,866  
WE'RE GOING TO BE ABLE TO TELL,  
ULTIMATELY,

1079

00:48:08,866 --> 00:48:11,233  
IF WE GET THE RIGHT KIND  
OF TELESCOPES AND THINGS,

1080

00:48:11,233 --> 00:48:13,566  
WHETHER A PLANET MIGHT BE  
INHABITED IS TO SAY,

1081  
00:48:13,566 --> 00:48:16,166  
"ARE ALL THE ASTEROIDS  
IN THAT SOLAR SYSTEM

1082  
00:48:16,166 --> 00:48:18,900  
CLEARED OUT  
OF THAT PLANET'S PATH?"

1083  
00:48:18,900 --> 00:48:21,566  
YOU KNOW, WHO--THAT DIDN'T  
HAPPEN BY ACCIDENT, YOU KNOW?

1084  
00:48:21,566 --> 00:48:25,533  
THAT MAY BE A GOOD INDICATOR  
OF LIFE, INTELLIGENT LIFE.

1085  
00:48:25,533 --> 00:48:27,966  
RESPONSIBLE LIFE.  
[laughter]

1086  
00:48:29,766 --> 00:48:31,566  
- SO WHEN YOU TALKED ABOUT  
DEFLECTION,

1087  
00:48:31,566 --> 00:48:33,466  
YOU ONLY MENTIONED DEFLECTION  
MAKING IT FASTER

1088  
00:48:33,466 --> 00:48:35,133  
OR MAKING IT SLOWER.

1089  
00:48:35,133 --> 00:48:37,000  
BUT COULD YOU POSSIBLY DEFLECT  
IT IN OTHER WAYS,

1090  
00:48:37,000 --> 00:48:41,000

LIKE, I DON'T KNOW, ANY OF  
THE SPATIAL DIRECTIONS REALLY?

1091  
00:48:41,000 --> 00:48:45,366  
- THE ANSWER TO THAT  
IS YES, YOU CAN DO THAT,

1092  
00:48:45,366 --> 00:48:49,333  
BUT IT'S INCREDIBLY  
INEFFECTIVE.

1093  
00:48:49,333 --> 00:48:51,600  
IF--WE CAN TALK  
ABOUT THAT LATER--

1094  
00:48:51,600 --> 00:48:55,166  
BUT IF YOU DRAW THE VECTOR--I'M  
SURE YOU'RE A VECTOR PERSON--

1095  
00:48:55,166 --> 00:48:57,333  
SO IF YOU DRAW  
THE VELOCITY VECTOR

1096  
00:48:57,333 --> 00:48:59,000  
OF ONE OF THESE THINGS,

1097  
00:48:59,000 --> 00:49:01,500  
AND YOU CHANGE ITS LENGTH,

1098  
00:49:01,500 --> 00:49:03,633  
IN OTHER WORDS,  
CHANGE THE VELOCITY,

1099  
00:49:03,633 --> 00:49:05,433  
THE MAGNITUDE OF THE VELOCITY,

1100  
00:49:05,433 --> 00:49:08,266  
YOU'RE GOING TO HAVE  
A CUMULATIVE EFFECT.

1101

00:49:08,266 --> 00:49:11,700

IT'S GONNA MAKE THE--THE ORBIT  
A LITTLE BIT LARGER

1102

00:49:11,700 --> 00:49:13,533

AND IT TAKES THE--  
OR SMALLER--

1103

00:49:13,533 --> 00:49:16,366

AND IT TAKES THE ASTEROID LONGER  
TO GET AROUND

1104

00:49:16,366 --> 00:49:19,000

OR A LITTLE BIT LESS TIME  
TO GET AROUND.

1105

00:49:19,000 --> 00:49:20,400

IT MAY CHANGE  
THE ORBITAL PERIOD

1106

00:49:20,400 --> 00:49:23,233

BY ONLY A MATTER  
OF A COUPLE OF MINUTES, OKAY?

1107

00:49:23,233 --> 00:49:26,366

BUT EACH TIME IT GOES AROUND,  
THAT ADDS UP--

1108

00:49:26,366 --> 00:49:28,800

TWO MINUTES, FOUR MINUTES,  
SIX, EIGHT, TEN, ET CETERA.

1109

00:49:28,800 --> 00:49:32,866

SO YOU MAKE A BIG CHANGE  
IN THE ARRIVAL TIME.

1110

00:49:32,866 --> 00:49:36,100

IF YOU CHANGE THE POINT--  
THE DIRECTION OF THE VELOCITY--

1111  
00:49:36,100 --> 00:49:39,733  
OF THE VECTOR, YOU DO NOTHING  
TO THE ARRIVAL TIME.

1112  
00:49:39,733 --> 00:49:43,166  
IT'S GONNA HIT 5 MILES  
FROM WHERE IT WOULD HAVE HIT

1113  
00:49:43,166 --> 00:49:44,733  
BEFORE YOU DID THAT.

1114  
00:49:44,733 --> 00:49:48,900  
SO CHANGING THE DIRECTION  
OF THE VECTOR--

1115  
00:49:48,900 --> 00:49:51,833  
THE VELOCITY VECTOR  
IS NOT USEFUL.

1116  
00:49:51,833 --> 00:49:54,200  
YOU CAN ONLY AFFECT  
A DEFLECTION

1117  
00:49:54,200 --> 00:49:57,066  
BY CHANGING THE LENGTH  
OF THE VECTOR.

1118  
00:49:57,066 --> 00:49:59,133  
OKAY, YES.

1119  
00:50:02,200 --> 00:50:04,400  
- HELLO.

1120  
00:50:04,400 --> 00:50:06,200  
HELLO.  
- THERE WE GO.

1121  
00:50:06,200 --> 00:50:08,000  
- [indistinct]

1122

00:50:08,000 --> 00:50:10,100

[laughter]

- I THINK YOU SWITCHED IT OFF.

1123

00:50:10,100 --> 00:50:12,200

- ANYWAY, THERE WE GO.

1124

00:50:12,200 --> 00:50:14,733

HI, MY NAME'S GREG MORRISSEY,  
AND I JUST TRANSITIONED

1125

00:50:14,733 --> 00:50:17,066

FROM MARSHALL SPACE FLIGHT  
CENTER HERE TO AMES

1126

00:50:17,066 --> 00:50:19,600

AND HAD A CHANCE  
TO HEAR YOU TESTIFY

1127

00:50:19,600 --> 00:50:22,233

TWO OR THREE YEARS AGO  
BEFORE CONGRESS

1128

00:50:22,233 --> 00:50:25,333

ON SUPPORT OF THE PRESIDENT'S  
PLAN FOR COMMERCIAL SPACE

1129

00:50:25,333 --> 00:50:28,200

AS NEIL ARMSTRONG  
OPPOSED THAT PLAN,

1130

00:50:28,200 --> 00:50:30,666

AND I WAS HONORED TO BE IN THAT  
HEARING ROOM AT THAT TIME.

1131

00:50:30,666 --> 00:50:32,666

THAT TO SAY,

1132

00:50:32,666 --> 00:50:35,333  
AS YOU'VE OBSERVED NASA FUNDING  
OVER THE YEARS,

1133  
00:50:35,333 --> 00:50:38,666  
AND AS YOU'VE HAD A CHANCE  
TO SPEAK TO OUR LEGISLATORS

1134  
00:50:38,666 --> 00:50:40,500  
AND LEADERS,

1135  
00:50:40,500 --> 00:50:43,333  
HOW DO YOU SEE NASA'S BUDGET NOW  
AND GOING FORWARD

1136  
00:50:43,333 --> 00:50:45,500  
TO FUND THE THINGS THAT YOU SEE

1137  
00:50:45,500 --> 00:50:48,500  
AND YOU'VE CONVINCINGLY  
PORTRAYED AS VERY IMPORTANT

1138  
00:50:48,500 --> 00:50:50,200  
TO US AS A NATION

1139  
00:50:50,200 --> 00:50:53,066  
AND AS A WORLDWIDE CONCERN?

1140  
00:50:55,100 --> 00:50:57,633  
- ALL RIGHT, WELL, I'M GOING TO  
EXTRAPOLATE A LITTLE BIT

1141  
00:50:57,633 --> 00:50:59,400  
ON YOUR QUESTION.

1142  
00:50:59,400 --> 00:51:01,700  
I'M GOING TO ASSUME THAT  
WHAT YOU'RE REALLY ASKING

1143

00:51:01,700 --> 00:51:04,866  
IS HOW DO I SEE FUNDING  
FOR SOMETHING--

1144  
00:51:04,866 --> 00:51:08,733  
FOR PLANETARY DEFENSE IN  
COMPARISON WITH OTHER THINGS...

1145  
00:51:08,733 --> 00:51:12,500  
- YES.  
- IN THE FUTURE?

1146  
00:51:12,500 --> 00:51:16,766  
YOU KNOW, WE--WE HAVE--  
ED AND I AND PETE AND OTHERS

1147  
00:51:16,766 --> 00:51:18,900  
HAVE WORKED ON THIS ISSUE

1148  
00:51:18,900 --> 00:51:20,866  
ON NASA AND ON THE CONGRESS

1149  
00:51:20,866 --> 00:51:24,566  
FOR A DECADE AND A HALF,  
TWO DECADES.

1150  
00:51:24,566 --> 00:51:29,233  
AND WHILE PEOPLE ALWAYS,  
ONCE THEY UNDERSTAND IT...

1151  
00:51:29,233 --> 00:51:32,866  
UNDERSTAND THERE'S  
A REALITY TO IT

1152  
00:51:32,866 --> 00:51:35,500  
AND THEY'RE CONCERNED ABOUT IT,

1153  
00:51:35,500 --> 00:51:38,966  
MOST OF THE CONGRESS  
HAS NO CLUE

1154

00:51:38,966 --> 00:51:41,900

OF WHAT AN ASTEROID IS  
OR THAT THEY IMPACT.

1155

00:51:41,900 --> 00:51:45,733

THEY GOT EXCITED ABOUT THE ONE  
THAT HIT IN RUSSIA.

1156

00:51:45,733 --> 00:51:49,133

AND IT LASTED FOR ABOUT A WEEK  
OR SOMETHING,

1157

00:51:49,133 --> 00:51:50,900

TWO WEEKS.

1158

00:51:50,900 --> 00:51:53,866

COMPARED WITH THE POTHOLES  
IN THE ROAD,

1159

00:51:53,866 --> 00:51:57,700

ASTEROIDS IMPACTING  
20 OR 30 OR 40 YEARS FROM NOW

1160

00:51:57,700 --> 00:51:59,666

DON'T AMOUNT  
TO A HILL OF BEANS

1161

00:51:59,666 --> 00:52:02,600

AS FAR AS MOST PEOPLE  
ARE CONCERNED.

1162

00:52:02,600 --> 00:52:08,300

AND SO WHILE EVERYBODY WHO  
REALLY UNDERSTANDS THIS ISSUE

1163

00:52:08,300 --> 00:52:11,500

UNDERSTANDS IT IS, NUMBER ONE,  
A HUGE ISSUE,

1164

00:52:11,500 --> 00:52:14,066

BECAUSE ULTIMATELY,  
VERY SELDOM,

1165

00:52:14,066 --> 00:52:16,533

BUT AT THE LARGEST END,  
YOU'RE TALKING ABOUT EXTINCTION,

1166

00:52:16,533 --> 00:52:19,466

THE END OF THE WHOLE  
EVOLUTIONARY PROCESS

1167

00:52:19,466 --> 00:52:21,000

HERE ON THIS PLANET.

1168

00:52:21,000 --> 00:52:23,300

AND IT DOESN'T COST MUCH  
TO DO IT.

1169

00:52:23,300 --> 00:52:25,666

NEVERTHELESS,  
THE POTHOLES IN THE ROAD--

1170

00:52:25,666 --> 00:52:28,333

I'M GONNA GET LETTERS  
FROM MY CONSTITUENTS NEXT WEEK

1171

00:52:28,333 --> 00:52:30,466

ABOUT THIS, THAT,  
AND THE OTHER THING--

1172

00:52:30,466 --> 00:52:32,500

IMMIGRATION, YOU NAME IT.

1173

00:52:32,500 --> 00:52:35,466

SO THIS HAS NEVER BEEN  
A HIGH PRIORITY

1174

00:52:35,466 --> 00:52:37,866

FOR THE CONGRESS,  
AND FRANKLY,

1175

00:52:37,866 --> 00:52:41,800  
IT HAS NOT BEEN A HIGH PRIORITY  
FOR NASA EITHER,

1176

00:52:41,800 --> 00:52:45,000  
PARTLY BECAUSE NASA  
DOES NOT,

1177

00:52:45,000 --> 00:52:48,200  
AND HAS NEVER GOTTEN  
CLEAR RESPONSIBILITY

1178

00:52:48,200 --> 00:52:51,033  
FROM THE CONGRESS  
OR THE PRESIDENT

1179

00:52:51,033 --> 00:52:54,366  
FOR THIS ISSUE,  
FOR PLANETARY--

1180

00:52:54,366 --> 00:52:57,533  
FOR PROTECTING THE EARTH  
FROM ASTEROID IMPACTS.

1181

00:52:57,533 --> 00:53:00,266  
AND BECAUSE THAT AUTHORITY,

1182

00:53:00,266 --> 00:53:03,533  
THAT RESPONSIBILITY  
HAS NEVER BEEN NASA'S,

1183

00:53:03,533 --> 00:53:06,633  
THEY DON'T HAVE THE AUTHORITY  
TO ASK FOR THE MONEY TO DO IT.

1184

00:53:06,633 --> 00:53:10,300  
SO NASA IS RESPONSIBLE

FOR SPACE SCIENCE

1185

00:53:10,300 --> 00:53:12,233

AND FOR EXPLORATION.

1186

00:53:12,233 --> 00:53:15,833

AND ANY MONEY THAT GOES  
OUT OF NASA'S BUDGET FOR THIS

1187

00:53:15,833 --> 00:53:18,533

COMES OUT OF THE POCKET  
OF GRADUATE STUDENTS

1188

00:53:18,533 --> 00:53:20,966

WHO ARE DOING RESEARCH  
ON SPACE SCIENCE

1189

00:53:20,966 --> 00:53:22,633

OR WHATEVER.

1190

00:53:22,633 --> 00:53:25,633

SO THE IRONY IS THAT  
THIS IS ONLY SURVIVAL.

1191

00:53:25,633 --> 00:53:27,433

WHO CARES, RIGHT?

1192

00:53:27,433 --> 00:53:29,600

[laughter]

- WELL, WE CARE.

1193

00:53:29,600 --> 00:53:32,133

WE FEEL THAT YOU CARE,

1194

00:53:32,133 --> 00:53:36,366

BECAUSE THE TIME HORIZON  
ON YOUR CONCERNS

1195

00:53:36,366 --> 00:53:40,166

IS PERHAPS YOUR CHILDREN  
OR YOUR GRANDCHILDREN'S LIVES.

1196  
00:53:40,166 --> 00:53:42,966  
THE TIME HORIZON  
FOR CORPORATE WORLD

1197  
00:53:42,966 --> 00:53:45,200  
IS MAYBE THE NEXT QUARTER.

1198  
00:53:45,200 --> 00:53:47,500  
FOR THE GOVERNMENT WORLD,  
IT MAY BE THE NEXT ELECTION.

1199  
00:53:47,500 --> 00:53:51,066  
YOU KNOW, WE'RE TALKING  
2, 4, 6, 12 YEARS.

1200  
00:53:51,066 --> 00:53:53,566  
THIS IS A LONG TIME.  
THIS IS SURVIVAL.

1201  
00:53:53,566 --> 00:53:56,633  
SO WE HAVE GONE TO THE PUBLIC  
WITH B612

1202  
00:53:56,633 --> 00:54:01,666  
AND SAYING, "OKAY, THIS MEETS  
YOUR TIME HORIZON FOR VALUES.

1203  
00:54:01,666 --> 00:54:04,433  
"THIS IS WHAT YOU CARE ABOUT--  
SURVIVAL,

1204  
00:54:04,433 --> 00:54:06,733  
"THE CONTINUATION OF EVOLUTION.

1205  
00:54:06,733 --> 00:54:09,366  
AND YOUR OWN FAMILIES,  
FOR THAT MATTER."

1206

00:54:09,366 --> 00:54:11,300

OKAY.

1207

00:54:11,300 --> 00:54:13,200

LAST ONE, YEAH.

1208

00:54:13,200 --> 00:54:16,300

- IT'S BEEN 45 YEARS  
SINCE YOU FLEW IN SPACE.

1209

00:54:16,300 --> 00:54:20,566

LOOKING TO THE FUTURE  
OF HUMAN SPACE TRAVEL,

1210

00:54:20,566 --> 00:54:22,500

IN THOSE 45 YEARS,  
HAVE YOU NOTICED

1211

00:54:22,500 --> 00:54:26,200

ANY PHYSIOLOGICAL EFFECTS  
ON YOURSELF

1212

00:54:26,200 --> 00:54:28,966

AS A RESULT OF THAT..

- OH, YEAH

1213

00:54:28,966 --> 00:54:30,833

I'VE GOTTEN A LOT WISER.

- SPACE?

1214

00:54:30,833 --> 00:54:32,833

[laughter]

1215

00:54:32,833 --> 00:54:34,400

- [laughs]

1216

00:54:34,400 --> 00:54:38,200

[applause]

1217

00:54:38,200 --> 00:54:40,466

NO. NO.

1218

00:54:40,466 --> 00:54:42,933

BUT, YOU KNOW,

AT SOME LEVEL OF DETAIL,

1219

00:54:42,933 --> 00:54:45,066

I'M SURE THAT THERE ARE  
SOME EFFECTS.

1220

00:54:45,066 --> 00:54:47,266

AND OP--

THE EFFECT ON VISION

1221

00:54:47,266 --> 00:54:49,433

APPEARS TO BE SOMETHING REAL

1222

00:54:49,433 --> 00:54:52,700

AND SYSTEMIC

IN SPACE FLIGHT.

1223

00:54:52,700 --> 00:54:56,533

YOU KNOW, YOU HAVE BONE LOSS,  
CALCIUM LOSS,

1224

00:54:56,533 --> 00:55:00,666

AND REDUCES THE DENSITY OF YOUR  
BONES, BUT IT COMES BACK.

1225

00:55:00,666 --> 00:55:02,766

YOU KNOW, THERE ARE  
SOME LONG-TERM EFFECTS

1226

00:55:02,766 --> 00:55:06,066

BUT NONE OF THEM  
THAT REALLY ARE SIGNIFICANT

1227

00:55:06,066 --> 00:55:09,133  
COMPARED WITH THE DRINK  
YOU'LL HAVE THIS AFTERNOON.

1228  
00:55:09,133 --> 00:55:11,466  
[laughter]  
I THINK.

1229  
00:55:11,466 --> 00:55:13,666  
OKAY, THANK YOU VERY MUCH.

1230  
00:55:13,666 --> 00:55:15,266  
[applause]

1231  
00:55:15,266 --> 00:55:16,933  
- AND AGAIN,  
THANK YOU VERY MUCH.

1232  
00:55:16,933 --> 00:55:19,433  
- THANK YOU.