



1  
00:00:01,220 --> 00:00:05,850

\h Announcer: Please welcome Philip Metzger, research, physicist and scientist engineer of

2  
00:00:05,850 --> 00:00:08,740

\h the year for the NASA Kennedy Space Center. [ APPLAUSE ]

3  
00:00:08,740 --> 00:00:14,790

\h Philip Metzger: I thank you very much. I'm going to talk to you today about the energy barrier at the end

4  
00:00:14,790 --> 00:00:20,910

\h Some processes in nature are continuous, like walking up a hill would be a continuous process, but if th

5  
00:00:20,910 --> 00:00:28,620

\h are a series of ravines that cut across the hillside, then you'd have to stop and leap over those barriers

6  
00:00:28,620 --> 00:00:31,340

\h every so often and that would be a discontinue use process.

7  
00:00:31,340 --> 00:00:35,970

\h I want to make the claim that the growth of civilization is like a discontinue use process.

8  
00:00:35,970 --> 00:00:42,660

\h Mostly it grows continuously but certain barriers we run into, we've had the barriers in the past and when

9  
00:00:42,660 --> 00:00:48,160

\h you get to one of these barriers it takes the bravest of us, the most creative and most innovative to get

10  
00:00:48,160 --> 00:00:51,670

\h civilization over that hump to the next level.

11  
00:00:51,670 --> 00:01:00,240

\h The Russian astronomer Kardishov was looking at how do we find signals from outer space as evidence

12  
00:01:00,240 --> 00:01:04,460

\h civilizations and he wisely noted that we shouldn't make the assumption

13  
00:01:04,460 --> 00:01:07,650

\h that every civilization is at the same level that we are.

14

00:01:07,650 --> 00:01:10,460

\h Some civilizations could possibly be vastly older than us and

15

00:01:10,460 --> 00:01:14,270

\h far ahead and so he came one this classification scheme.

16

00:01:14,270 --> 00:01:18,310

\h He said a type one civilization is one that is sort of like us, basically like us.

17

00:01:18,310 --> 00:01:26,490

\h It's grown to spread across the planet and utilizes essentially all the resources of its planet,

18

00:01:26,490 --> 00:01:32,750

\h whereas a type two would be a civilization that has gone beyond its home planet and it's using vastly more

19

00:01:32,750 --> 00:01:40,190

\h energy up to the energy of an entire star, a type three civilization would be one that has gone into

20

00:01:40,190 --> 00:01:46,620

\h interstellar space beyond a single star and it's using the energy of an entire galaxy, and he noted that if

21

00:01:46,620 --> 00:01:53,150

\h there are any type two or type three civilizations out there, their signals might not look the same as our own

22

00:01:53,150 --> 00:01:56,510

\h Well, what I want to say is what about earlier categories?

23

00:01:56,510 --> 00:02:01,420

\h Let's think about where we've been already and what does that tell us about the growth of civilization.

24

00:02:01,420 --> 00:02:05,790

\h We could continue the numbering scheme backwards, so maybe a type zero would

25

00:02:05,790 --> 00:02:09,230

\h be a civilization that encompassed an entire continent.

26

00:02:09,230 --> 00:02:15,250

\h It hasn't yet developed the technology or the social structures to span the oceans,

27

00:02:15,250 --> 00:02:18,010

\h and to become a type one civilization.

28

00:02:18,010 --> 00:02:20,310

\h Spanning the oceans was quite a feat.

29

00:02:20,310 --> 00:02:25,610

\h It was only done about 500 years ago, and we often create the analogy to space flight.

30

00:02:25,610 --> 00:02:27,250

\h It's a good analogy.

31

00:02:27,250 --> 00:02:32,750

\h Going back even further we could say a type minus one would be a civilization that encompasses an en

32

00:02:32,750 --> 00:02:40,460

\h river valley, the birthplace of civilization in four river valleys, the Nile, the Mesopotamia,

33

00:02:40,460 --> 00:02:43,410

\h the Indus River Valley and the Yellow River.

34

00:02:43,410 --> 00:02:53,320

\h When people figured out there was a vast quantity of energy that could be had in river valleys by using h

35

00:02:53,320 --> 00:02:59,450

\h to grow crops in the rich soil from the flood plains you could have such a concentration of food energy th

36

00:02:59,450 --> 00:03:02,830

\h you could support a larger population than we've ever had in

37

00:03:02,830 --> 00:03:06,610

\h one place before and that was the birth of cities, of civilization.

38

00:03:06,610 --> 00:03:12,170

\h It was a big leap forward, but going back even further, let answer say a type minus two with the isolated

39

00:03:12,170 --> 00:03:19,260

\h enclaves when humans were pre-agricultural, doing hunting and gathering, find safe places to live.

40

00:03:19,260 --> 00:03:26,170

\h If you think about it, going from one type to the next is always involves a leap, first you have to leap

41

00:03:26,170 --> 00:03:30,930

\h beyond the limited energy in one area, and the safety of your enclave,

42

00:03:30,930 --> 00:03:34,580

\h set-up social institutions to enable large scale agricultural.

43

00:03:34,580 --> 00:03:39,470

\h Once they got the large scaling agriculture the cities rapidly filled out the flood plains,

44

00:03:39,470 --> 00:03:45,360

\h they didn't go beyond that because they didn't have the logistics, transportation or the armies to protect

45

00:03:45,360 --> 00:03:49,500

\h the logistics to send large quantities of food outside the river

46

00:03:49,500 --> 00:03:53,870

\h networks to support cities in the mountains or across the deserts, for example.

47

00:03:53,870 --> 00:04:02,350

\h Once they got global or continental size empires, then we could fill out the continents, but it was another

48

00:04:02,350 --> 00:04:06,340

\h leap to go to an entirely planetary global civilization.

49

00:04:06,340 --> 00:04:12,430

\h We've reached another one of these points now, where we are starting to feel the barrier, the next limit

50

00:04:12,430 --> 00:04:15,200

\h that we're pushing up against. We're already feeling it.

51

00:04:15,200 --> 00:04:21,450

\h I just want to point out that all of the global challenges we're facing are really symptoms of one problem,

52

00:04:21,450 --> 00:04:28,490

\h we've reached toward the limit of a type one civilization and hitting the barrier we've got to leap across.

53

00:04:28,490 --> 00:04:31,260

\h Here's some predictions, we are essentially type one right now.

54

00:04:31,260 --> 00:04:34,650

\h I don't think we'll get any closer to the technical definition of type

55

00:04:34,650 --> 00:04:38,220

\h one than we are today unless we can go beyond the planet.

56

00:04:38,220 --> 00:04:45,690

\h If we do go outside a single planet, it was within 50 to 100 years we would reach type two already or if w

57

00:04:45,690 --> 00:04:52,570

\h don't go outside the planet we might never achieve it ever because achieving sustainability where we do

58

00:04:52,570 --> 00:04:56,330

\h use non-renewable resources anymore, people predicted the earth might support only

59

00:04:56,330 --> 00:04:59,700

\h 2 billion people and we're already way beyond that.

60

00:04:59,700 --> 00:05:08,220

\h If we can't replace the non-renewables, then going backwards is really painful, and I think the only ethica

61

00:05:08,220 --> 00:05:11,650

\h thing is to go forward, beyond a single planet towards type two.

62

00:05:11,650 --> 00:05:17,750

\h If we do achieve type two, the technologies indicate that leaping on to type three is no problem at all.

63

00:05:17,750 --> 00:05:23,520

\h The reason I say we're running up on to a barrier and I call it an energy barrier is because energy is

64

00:05:23,520 --> 00:05:29,310

\h really the key to everything, if you've got abundant energy, you can recycle and you can use resources t

65

00:05:29,310 --> 00:05:32,970

\h are not as valuable, it's really not a problem if you've got all the energy you want.

66

00:05:32,970 --> 00:05:38,870

\h All the indications are the nonrenewable energies, even with fracking can't possibly last another century

67

00:05:38,870 --> 00:05:42,910

\h They say we have enough natural gas from fracking to last 100 years.

68

00:05:42,910 --> 00:05:48,110

\h It doesn't account for the fact that china is industrializing, now the number one energy user in the world,

69

00:05:48,110 --> 00:05:51,560

\h still one-fourth per capita of our energy usage.

70

00:05:51,560 --> 00:05:53,580

\h India is industrializing.

71

00:05:53,580 --> 00:06:01,030

\h If the entire world spends energy at the level of the U.S., we can't just replace the non-renewables.

72

00:06:01,030 --> 00:06:07,210

\h We need to replace them ten times over, even if we can reduce our energy usage by a factor of three, w

73

00:06:07,210 --> 00:06:12,110

\h fracking we only have 30 years' worth of energy if the world achieves a level,

74

00:06:12,110 --> 00:06:14,550

\h a standard of living that the west has.

75

00:06:14,550 --> 00:06:22,190

\h So the sense that we're starting to reach the limits of our planet it's being felt by everybody,

76

00:06:22,190 --> 00:06:27,630

\h even when you go to donate clothes you'll notice it doesn't say goodwill. It says planet aid.

77

00:06:27,630 --> 00:06:30,130

\h You donate your socks to save the planet.

78

00:06:30,130 --> 00:06:35,330

\h And there's a growing feeling, a growing sense that we really are at a point where everything we do is

79

00:06:35,330 --> 00:06:40,280

\h planetary, it's global, because we've reached the limit of a type one civilization.

80

00:06:40,280 --> 00:06:43,730

\h I want to say we really don't have a resource problem.

81

00:06:43,730 --> 00:06:49,780

\h What we have is an imagination problem. We live in a hugely rich part of the galaxy.

82

00:06:49,780 --> 00:06:54,200

\h We have a billion times more of everything in the solar system than what we have on earth.

83

00:06:54,200 --> 00:06:57,300

\h I didn't just say a billion because I made it up.

84

00:06:57,300 --> 00:07:00,490

\h We really have a billion times more accessible metal in the asteroid belt,

85

00:07:00,490 --> 00:07:03,980

\h 2 billion times more energy leaves the sun than what falls on the earth.

86

00:07:03,980 --> 00:07:10,920

\h There's a billion times more water in the moons of Jupiter than in the earth so the order of magnitude is

87

00:07:10,920 --> 00:07:13,130

\h So there's really no resource problem.

88

00:07:13,130 --> 00:07:20,160

\h We just need to know how to go beyond this to type two. People say think globally, act locally.

89

00:07:20,160 --> 00:07:25,850

\h Thinking globally is the new way of thinking too small. That's the problem, not the solution.

90

00:07:25,850 --> 00:07:31,950

\h We have to think extra globally and people also say let's think outside the box, that's good but we can

91

00:07:31,950 --> 00:07:37,780

\h improve on it because it's not really a box that's our problem, it's the limitations of the sphere that we live

92

00:07:37,780 --> 00:07:42,960

\h We need to think outside the sphere and when you've expanded your civilization all around the two-

93

00:07:42,960 --> 00:07:47,800

\h dimensional surfaces of the globe and you've filled it out, there's no other dimension you can travel in

94

00:07:47,800 --> 00:07:52,370

\h except perpendicularly outward towards space.

95

00:07:52,370 --> 00:07:57,620

\h A lot of people think this is not really feasible, because it's such a paradigm shift to imagine

96

00:07:57,620 --> 00:08:01,660

\h transporting resources across the vastness of the solar system.

97

00:08:01,660 --> 00:08:07,290

\h Think what a paradigm shift it was for the people living in the pacific, when the European ships showed

98

00:08:07,290 --> 00:08:14,250

\h The people in Tahiti and Hawaii they could actually cross the ocean without any significant source of

99

00:08:14,250 --> 00:08:19,540

\h metals, which limited their technology capabilities, because they didn't have the resources that were

100

00:08:19,540 --> 00:08:26,350

\h available on some of the continents, but it was a heroic task to cross an ocean.

101

00:08:26,350 --> 00:08:29,060

\h Think about this little device here, this clicker.

102

00:08:29,060 --> 00:08:34,040

\h The materials that went into this include metal and plastic, metals came from Africa,

103

00:08:34,040 --> 00:08:37,110

\h the plastic came from petroleum from Arabia.

104

00:08:37,110 --> 00:08:40,160

\h The materials were processed in America, chips were made in America,

105

00:08:40,160 --> 00:08:44,490

\h it was assembled in china and it was shipped back here and sold in the U.S.

106

00:08:44,490 --> 00:08:50,250

\h There was at least four ocean crossings that went into little device that probably cost \$15.

107

00:08:50,250 --> 00:08:56,530

\h The people in Tahiti just a few hundred years ago would not have believed you if you said those ships

108

00:08:56,530 --> 00:09:01,750

\h carrying resources were possible and economical, but here we're doing it.

109

00:09:01,750 --> 00:09:06,700

\h There's no reason we can't take the next leap to go to a type two civilization.

110

00:09:06,700 --> 00:09:10,660

\h We are a species that has a history of leaping over those barriers.

111

00:09:10,660 --> 00:09:14,360

\h We've done it so many times before. We can do the next one.

112

00:09:14,360 --> 00:09:21,230

\h So people have started to envision what it might be like to have industry in space, in the '60s through

113

00:09:21,230 --> 00:09:27,480

\h '90s, Gerard K. O'Neill led the charge talking about manufacturing outposts in space.

114

00:09:27,480 --> 00:09:33,430

\h In his scenario you would need 10,000 people living and working in habitats like this before it became

115

00:09:33,430 --> 00:09:39,280

\h economical, which unfortunately was a little too expensive for congress to fund so we didn't do it.

116

00:09:39,280 --> 00:09:49,870

\h In the 1980s, in 1980, the Ames Research Center hosted a summer study for self-replicating lunar facto

117

00:09:49,870 --> 00:09:55,370

\h and this was an advancement forward and they showed with just 100 tons of hardware on the moon you

118

00:09:55,370 --> 00:10:00,800

\h up one self-replicating node which would grow and produce this gigantic industrial power in space.

119

00:10:00,800 --> 00:10:07,340

\h It was an idea before its time. The technologies weren't ready yet and 100 tons is a lot to put on the mo

120

00:10:07,340 --> 00:10:13,240

\h an expensive thing to pay for but there's been game changers recently.

121

00:10:13,240 --> 00:10:21,660

\h First of all, robotics has been leaping forward, and just go to YouTube and search for "learning robots" a

122

00:10:21,660 --> 00:10:25,420

\h see some of the things that are going on with robots nowadays.

123

00:10:25,420 --> 00:10:31,180

\h Computing speed, you need computers to have robots that can build things in space,

124

00:10:31,180 --> 00:10:35,020

\h Mohr's law continued without any signs of stopping.

125

00:10:35,020 --> 00:10:39,670

\h We're getting to the point where you could have a really smart robot on a small platform now.

126

00:10:39,670 --> 00:10:44,840

\h Manufacturing technology, a revolution going on right now 3-d printing.

127

00:10:44,840 --> 00:10:50,040

\h We have one of our collaborators here from the University of Southern California, Brock Kashenevitz,

128

00:10:50,040 --> 00:10:57,820

\h the inventor of 3-d printing of entire buildings so these are things that are made with 3-D printing.

129

00:10:57,820 --> 00:11:05,090

\h Another game changer is the discovery of ice on the moon, our co-worker, Tony muscatel said now there

130

00:11:05,090 --> 00:11:10,860

\h nothing that can't be made on the moon because now we know the ice has nitrogen compounds and ca

131

00:11:10,860 --> 00:11:17,340

\h compounds and carbon, nitrogen are fully abundant and everything we need for a fully healthy industry

132

00:11:17,340 --> 00:11:23,200

\h moon in earth orbit and we during constellation we used the funding to

133

00:11:23,200 --> 00:11:26,570

\h develop these technologies to test them and we've shown they work.

134

00:11:26,570 --> 00:11:28,260

\h We can use space resources.

135

00:11:28,260 --> 00:11:33,850

\h We can mine in space and build things in space and we've tested these things and reduced gravity light

136

00:11:33,850 --> 00:11:41,970

\h Van Townsend and Adam Ducese testing and removing soil out of the processes, lunar soil.

137

00:11:41,970 --> 00:11:48,390

\h We proposed a new approach. I also want to mention this is a part of my charts, the international space

138

00:11:48,390 --> 00:11:55,480

\h university just completed their 2012 study and they've come up with a concept called oasis, which shows

139

00:11:55,480 --> 00:12:04,410

\h you can economically, every step of the way is economical to mining water in space, to producing propellant

140

00:12:04,410 --> 00:12:10,840

\h into selling them, to a low earth orbit space tug business that will carry satellites the rest of the way,

141

00:12:10,840 --> 00:12:15,090

\h the high earth orbit, and it will vastly reduce launch costs.

142

00:12:15,090 --> 00:12:18,410

\h They've shown the business cases there. You can make money doing this.

143

00:12:18,410 --> 00:12:23,040

\h There is a business case for people right now to mine the moon and begin doing

144

00:12:23,040 --> 00:12:26,900

\h industry and space economically without congress having to pay for it.

145

00:12:26,900 --> 00:12:30,680

\h The key idea is taking the next step beyond oasis,

146

00:12:30,680 --> 00:12:36,120

\h and we want to put industry on the moon so don't launch it, evolve it.

147

00:12:36,120 --> 00:12:42,280

\h When the colonists came to America from Europe they didn't put entire cities on ships and launch the cities

148

00:12:42,280 --> 00:12:45,750

\h They just brought the tools. They brought its first generation of tools.

149

00:12:45,750 --> 00:12:50,200

\h The colonists had to build the second generation of tools which are typically more crude than the first

150

00:12:50,200 --> 00:12:53,810

\h generation and then they started working back upward from there.

151

00:12:53,810 --> 00:12:57,100

\h You use appropriate technology. It doesn't need to be high tech.

152

00:12:57,100 --> 00:13:02,350

\h It needs to be easy to make in space and we don't have to pay for all the technology.

153

00:13:02,350 --> 00:13:07,230

\h It's being paid for by this humongous technology engine that we have in our economy.

154

00:13:07,230 --> 00:13:12,670

\h We need to find them and spin them in, and finally, let's not forget that technologies are advancing

155

00:13:12,670 --> 00:13:16,700

\h exponentially, so let's answer not underpredict what's possible.

156

00:13:16,700 --> 00:13:21,960

\h An idea, a concept of appropriate technology look at housing in America

157

00:13:21,960 --> 00:13:26,600

\h in 1620 versus what the Europeans were living in, in 1620.

158

00:13:26,600 --> 00:13:32,490

\h We need to be prepared to build things on the moon with inferior materials, but make them so that they

159

00:13:32,490 --> 00:13:36,850

\h work with those inferior materials. That's the way we need to be thinking.

160

00:13:36,850 --> 00:13:42,060

\h Appropriate technology water pumps, people found that if you deliver a high-tech water pump to an

161

00:13:42,060 --> 00:13:48,530

\h underdeveloped area, they can't maintain it, because they need to maintain it with local processes and I

162

00:13:48,530 --> 00:13:54,560

\h So with these things in mind, we've laid out a strategy, one possible strategy of six generations of

163

00:13:54,560 --> 00:14:00,870

\h spiraling technology upward on the moon, and we've shown that for as little as 60 tons of hardware or e

164

00:14:00,870 --> 00:14:06,330

\h getting it down to 12 tons of hardware, you can get self-sustaining industry eventually within six

165

00:14:06,330 --> 00:14:12,070

\h generations to where you don't need to launch anything anymore, and then all you need to launch are th

166

00:14:12,070 --> 00:14:18,270

\h people to go out and enjoy what you're making, and utilize what you're making, so the industry can grow

167

00:14:18,270 --> 00:14:22,970

\h exponentially by the end of six generations, you could have 100,000 robots on

168

00:14:22,970 --> 00:14:27,860

\h the moon and 100,000 tons of manufactured hardware.

169

00:14:27,860 --> 00:14:31,340

\h This is detailed modeling where we've shown this is feasible using

170

00:14:31,340 --> 00:14:35,210

\h technologies not too advanced beyond what we can do right now.

171

00:14:35,210 --> 00:14:40,490

\h There needs to be technology advancement but it's not unbelievable technology advancement.

172

00:14:40,490 --> 00:14:48,460

\h Another 20 years beyond this you'll have a million times the industrial output of the entire united states,

173

00:14:48,460 --> 00:14:53,840

\h and by the way, the next step beyond the moon is the asteroid belt, that's where you really want industry

174

00:14:53,840 --> 00:14:58,230

\h be, and then ten years beyond that, you've got a billion times

175

00:14:58,230 --> 00:15:01,350

\h the industrial capability of the entire united states.

176

00:15:01,350 --> 00:15:05,920

\h What could you do with a billion times the industrial capacity?

177

00:15:05,920 --> 00:15:11,110

\h Well the question is really what can't you do with a billion times the industrial capacity?

178

00:15:11,110 --> 00:15:17,250

\h You could have a global relief effort. You could land manufactured goods, land resources.

179

00:15:17,250 --> 00:15:23,770

\h You can bring, beam energy down. You don't have to launch the energy generators.

180

00:15:23,770 --> 00:15:34,400

\h You can terraform planets and people can migrate to space, you can have a backup to civilization, the s

181

00:15:34,400 --> 00:15:40,650

\h endowment would fund things people do in space, there's also the negative side, if we don't do this,

182

00:15:40,650 --> 00:15:47,510

\h somebody is going to and we need to do it right, so in conclusion, we are near the limits of a type one

183

00:15:47,510 --> 00:15:52,830

\h world, and there is a barrier at the end of type one, and we're starting to feel it, and it's going to hurt

184

00:15:52,830 --> 00:15:57,950

\h and it's going to hurt worse if we don't jump over it, going to hurt worse if we try to move back and so we

185

00:15:57,950 --> 00:16:03,570

\h need to leap over that barrier, and it's going to take the creative innovators to do that, and we need you