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Oral History Conversation with David Bruemmer

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DAVID BRUEMMER (ADAPTIVE MOTION GROUP)

Conducted by Brandon Chung, Constance Olmert, Roberto Rodriguez, and Alec Weber

00:00:02.230 --> 00:00:06.520
I'm going to start by saying that this is an oral
history conversation on Social Enterprise.

00:00:06.520 --> 00:00:08.640
We are all enrolled in Business Ethics

00:00:08.650 --> 00:00:11.640
here at the University of San Diego

00:00:11.640 --> 00:00:13.920
We are here with Mr. David Bruemmer,

00:00:13.920 --> 00:00:16.400
founder and CEO of Adaptive Motion Group.

00:00:16.400 --> 00:00:19.340
David, once again we want to thank you for taking

00:00:19.340 --> 00:00:21.810
the time to come in. We really appreciate you being here

00:00:21.820 --> 00:00:23.340
with us to talk with us.

00:00:23.340 --> 00:00:25.560
To start things off, I want to get an idea

00:00:25.560 --> 00:00:29.140
of what Adaptive Motion Group actually does.

00:00:29.140 --> 00:00:33.660

Sure so, Adaptive Motion Group is a company focused on

00:00:33.660 --> 00:00:38.110
creating intelligent
motion through autonomy and through

00:00:38.110 --> 00:00:45.500
software for safety. The underlying premise, one of the things that

00:00:45.500 --> 00:00:51.090
makes it unique is that we really believe
positioning is the key to both safety and

00:00:51.090 --> 00:00:54.570
autonomy. So whereas a lot of the

00:00:54.580 --> 00:00:57.580
past work that I've done
has been focused on more traditional

00:00:57.590 --> 00:01:03.260
artificial intelligence looking at using
cameras and lasers to build maps and

00:01:03.270 --> 00:01:07.850
drive around. We've come to believe that
we need to create an ecosystem where the

00:01:07.860 --> 00:01:14.770
human and manned vehicles, like cars
and buses and trucks and forklifts, as

00:01:14.780 --> 00:01:19.050
well as robots, can all sort of work together
and I think the best way to do that

00:01:19.060 --> 00:01:19.880
is by having

00:01:20.310 --> 00:01:24.900

a common, peer to peer positioning
framework and so what we're doing is we're

00:01:24.910 --> 00:01:31.200
creating a means to embed
positioning into the environment in

00:01:31.210 --> 00:01:37.240
a very different way than has ever been
done before so by embedding into lampposts

00:01:37.240 --> 00:01:42.530
and automotive shark fins and
many others different devices,

00:01:42.530 --> 00:01:45.800
we can create this sort of framework

00:01:45.800 --> 00:01:50.100
of intelligent distributed positioning.

00:01:50.100 --> 00:01:53.860
So whether it's preventing a collision
around a blind corner in

00:01:53.870 --> 00:01:58.180
a forklift environment or preventing
collisions in New York City,

00:01:58.190 --> 00:02:00.710
these are things that we've actually
demonstrated as

00:02:00.720 --> 00:02:04.310
being incredibly effective for safety.

00:02:04.310 --> 00:02:05.490
Then on top of that,

00:02:05.490 --> 00:02:08.490

we can we can find ways to

00:02:08.490 --> 00:02:13.490
support what is generally called connected
vehicle strategies, which allow for the

00:02:13.500 --> 00:02:15.680
highway to really be transformed from
what it is today,

00:02:15.680 --> 00:02:18.680
where it's either a human driven car

00:02:18.680 --> 00:02:23.180
or an individual autonomous car,
both of which are really very limited

00:02:23.190 --> 00:02:26.100
actually in their knowledge of the
environment.

00:02:26.100 --> 00:02:29.100
Imagine if we give both the human

00:02:29.100 --> 00:02:31.560
and the AI system

00:02:31.580 --> 00:02:36.300
a whole lot more information and allow the
vehicle to essentially be caught within

00:02:36.310 --> 00:02:40.830
a web of distributed motion, so that
the cars essentially become like

00:02:40.840 --> 00:02:42.500
a big train, right.

00:02:42.500 --> 00:02:45.500
Because at the end of the day,

the problem that we have right

00:02:45.500 --> 00:02:46.530
now isn't that we don't have enough
intelligence in the cars,

00:02:46.530 --> 00:02:49.530
we have human brain in the car,

00:02:49.530 --> 00:02:54.560
and that's very intelligent.
The problem is that you can't solve the

00:02:54.570 --> 00:02:59.970
issues of congestion with intelligence. It's
not possible. One of the things I like

00:02:59.980 --> 00:03:01.550
to say is if I could think my way out of

00:03:01.560 --> 00:03:07.220
a traffic jam I would do it, but you
can't. So for both safety and autonomous

00:03:07.230 --> 00:03:13.050
driving the most important thing is
positioning. We found a way using

00:03:13.060 --> 00:03:19.560
a really innovative strategy to allow
every element of the environment to know

00:03:19.570 --> 00:03:23.780
the exact position of its peers to

00:03:23.790 --> 00:03:29.690
a centimeter. This allows for a
much more intelligent environment and it's

00:03:29.700 --> 00:03:36.050

not just about robotics, it's about
coordinating a more efficient world.

00:03:36.820 --> 00:03:40.410
One of the big things I try
to get across to people is

00:03:40.420 --> 00:03:42.740
even if all I'm trying to do is direct

00:03:43.120 --> 00:03:47.610
a manned bus to pick people up in New York
City, I can do that much better if I know

00:03:47.620 --> 00:03:50.330
where everyone is. Taking an example of

00:03:50.340 --> 00:03:56.920
Uber and Lyft in San Francisco for instance,
the problem is currently with GPS,

00:03:56.930 --> 00:04:02.210
which are way worse than most people realize
because of the tall buildings actually

00:04:02.210 --> 00:04:08.390
add many minutes on to the average Uber ride because
essentially if if the Uber app directs

00:04:08.650 --> 00:04:14.560
a car to the wrong corner of the intersection,
you would think conceptually like oh

00:04:14.570 --> 00:04:15.390
that's not that big of

00:04:15.400 --> 00:04:20.500
a deal. Well, it is because then that driver
has to go around in a huge circle that

00:04:20.510 --> 00:04:24.790
can easily take ten minutes. So then
multiply that by the number of Uber

00:04:24.800 --> 00:04:30.120
drivers and the number of times that's
happening per minute and it ends up

00:04:30.130 --> 00:04:34.940
being an astonishingly large amount of wasted time.
If you look at the United States, four billion hours,

00:04:34.950 --> 00:04:37.690
or it's actually worse I think,

00:04:37.700 --> 00:04:42.190
so several billion hours are wasted stuck
in traffic not moving. And my trip here

00:04:42.200 --> 00:04:49.150
today to talk to you is no different.
It has to stop. It is ridiculous.

00:04:49.160 --> 00:04:53.500
My daughter when I was driving to a
Chargers game said "Dad just take

00:04:53.510 --> 00:04:59.470
a deep breath. You have to understand there's
just nothing you can do." And it really

00:04:59.480 --> 00:05:03.480
hit me I was like wow this is
the problem. The problem isn't

00:05:03.490 --> 00:05:07.400
a technological problem, the problem
is that we just all are like

00:05:07.410 --> 00:05:11.850

a frog being slowly boiled in water, where
you just raise the temperature just

00:05:11.860 --> 00:05:16.860
a little bit. I went and studied traffic
in Delhi in India and it is

00:05:16.870 --> 00:05:19.670
incredible because there you have actually

00:05:19.680 --> 00:05:24.100
a situation where the pollution is so
bad from the cars, that it has actually

00:05:24.110 --> 00:05:29.060
dramatically reduced the lifespan of the
inhabitants by almost ten years and you have

00:05:29.070 --> 00:05:32.400
a situation where people can't let their
kids go out and play and it's really

00:05:32.410 --> 00:05:38.180
linked to an inability to stem the tide
early on and say, you know what we've got to

00:05:38.190 --> 00:05:44.550
change something. So AMG is really about
two things. One is about perfect

00:05:45.940 --> 00:05:52.090
positioning, the other thing is about
showing people demonstrably that there is

00:05:52.100 --> 00:05:58.010
a better way to do this, that we don't
have to keep suffering for hours

00:05:58.020 --> 00:06:02.710
in traffic, that we really can I

mean to get to be clear, if you have

00:06:02.720 --> 00:06:07.270
a centimeter accuracy, you can get rid of stop signs and traffic lights completely

00:06:07.280 --> 00:06:12.410
You should never have to stop. Every car should just be able to pass

00:06:12.420 --> 00:06:15.680
and enter through an intersection without any fear of being in

00:06:15.690 --> 00:06:21.990
a collision. Every pedestrian should be trackable based on their cell phone so the

00:06:21.100 --> 00:06:26.340
difference of whether they're standing on the curb or off the curb should be

00:06:26.350 --> 00:06:29.390
perfectly clear to the system. So a big part of

00:06:29.400 --> 00:06:35.370
AMG is saying look this isn't just about the individual brain in your cellphone

00:06:35.380 --> 00:06:39.880
or in your car this is about the system and it's about creating essentially

00:06:39.890 --> 00:06:49.560
a city wide brain which knows how to orchestrate and move things

00:06:49.600 --> 00:06:51.610
Alright, so could you take us back to what

00:06:51.610 --> 00:06:55.150
your childhood was like. Were there any specific childhood experiences

00:06:55.150 --> 00:06:58.570
that you might be able to connect

00:06:58.570 --> 00:07:01.465
to the kind of work you are doing with AMG?

00:07:01.465 --> 00:07:03.780
We already talked about the biking,

00:07:03.780 --> 00:07:06.800
that that's where you get some of your ideas from

00:07:06.840 --> 00:07:11.970
But are there any other specific instances

00:07:11.970 --> 00:07:13.330
or any particular relationships that you have built

00:07:13.350 --> 00:07:15.433
that got you where you are?

00:07:15.433 --> 00:07:16.806
Yeah, boy I could talk for a long time.

00:07:16.806 --> 00:07:19.600
So I actually grew up, I was
born in Texas, grew up in Scotland and I

00:07:19.610 --> 00:07:23.870
grew up pretty close to Edinburgh and the
Scottish mentality is great. You've

00:07:23.880 --> 00:07:28.440
got a lot of inventors who
came from Scotland,

00:07:28.540 --> 00:07:33.140
a lot of entrepreneurs as well. So, Adam Smith, for instance is

00:07:33.150 --> 00:07:37.840
a famous Scot who gave us sort of the underpinnings
of our current capitalist system

00:07:37.850 --> 00:07:43.100
and really kind of, you know, one of
my big heroes was Andrew Carnegie

00:07:43.120 --> 00:07:47.930
who is actually a very complicated figure but an
incredible entrepreneur in many ways. So I

00:07:47.940 --> 00:07:52.160
actually grew up not far from his birthplace
in the house that he lived in and

00:07:52.170 --> 00:07:58.050
actually played in the same park called the
Glen which was, at the time that he was

00:07:58.060 --> 00:08:03.690
a boy, off limits to him so he was always getting
caught and beaten. So the first thing he did

00:08:03.690 --> 00:08:10.180
when he made a lot of money was he came back to his
hometown, which is Dunfermline, where I grew up,

00:08:10.180 --> 00:08:12.270
and bought that and basically turned it into

00:08:12.280 --> 00:08:14.430
a park where I got to play. So Andrew Carnegie

00:08:14.440 --> 00:08:19.180
was a fascinating figure and much later
when I

00:08:19.360 --> 00:08:27.000
actually moved back to the United States.
I ended up getting this and NSF grant

00:08:27.000 --> 00:08:27.770
which is

00:08:27.780 --> 00:08:31.450
a National Science Foundation when I was
in high school, which is pretty unusual.

00:08:31.600 --> 00:08:32.590
got a nose and

00:08:32.630 --> 00:08:39.220
a sophomore and it was this crazy you
know fortunate man and really large one

00:08:39.230 --> 00:08:43.030
thousand me having some really smart teachers
as well that I worked with but I was

00:08:43.039 --> 00:08:49.200
programming all the time and really had
this opportunity and probably unique not

00:08:49.210 --> 00:08:54.860
only did they put tons of these really
advanced Silicon Graphics machines in to the

00:08:54.870 --> 00:08:58.700
school for us to use but they gave me
access to what was at the time the fastest

00:08:58.770 --> 00:09:00.910
supercomputer in the world
and the Cray I.M.P.

00:09:00.920 --> 00:09:04.450

Which was actually at Carnegie
Mellon which of course was

00:09:04.730 --> 00:09:09.350
a university largely founded by the guy
who had grown up in the small town there

00:09:09.440 --> 00:09:14.400
where I'd also ground zero is very interesting
connections. And also strange and so

00:09:14.410 --> 00:09:15.150
I grew up in

00:09:15.160 --> 00:09:20.650
a pretty. Interesting way so my parents
were missionaries in Scotland and we lived

00:09:20.660 --> 00:09:24.940
in you know starting out in what was called
council housing so you would think that

00:09:24.950 --> 00:09:26.950
there were a lot of opportunities
but I actually was

00:09:26.960 --> 00:09:31.000
a fantastic way to grow up so it's constantly
contacting people from other cultures

00:09:31.010 --> 00:09:36.370
in other places who are working with my
parents and and because most of their

00:09:36.380 --> 00:09:38.630
ministry work was with
kids I really had actually

00:09:38.640 --> 00:09:44.040
a very wonderful childhood I also was very

lucky because somehow the school that I

00:09:44.050 --> 00:09:49.880
was going to. In Scotland really had the
sort of like hands on attitude about

00:09:50.350 --> 00:09:55.230
education which is just wonderful so you
really got to own your own education right

00:09:55.240 --> 00:09:58.470
I could do my work whenever I wanted to I
could do projects it was fantastic and

00:09:58.480 --> 00:10:03.260
one of the things that I did was somehow
they had this robot which was kind of

00:10:03.270 --> 00:10:08.920
crazy because it was very early which was
provided and I ended up just sort of you

00:10:08.930 --> 00:10:10.380
know working with it and having

00:10:10.390 --> 00:10:13.930
a lot of fun with it so even from the time
I was really young like you know six or

00:10:13.940 --> 00:10:15.550
seven years old I was
literally programming

00:10:15.560 --> 00:10:20.570
a robot which is very very. Same Shit You
know to look back on and the fact that I

00:10:20.580 --> 00:10:21.690
got as N.S.F. Grant as

00:10:21.700 --> 00:10:26.590
a sophomore in high school and then was
like flying around the you know to all

00:10:26.600 --> 00:10:30.790
these different locations Corning work
and it was really at that time as

00:10:30.800 --> 00:10:36.230
a sophomore in high school taught me so
much about how to write proposals about how

00:10:36.240 --> 00:10:37.100
to tell

00:10:37.110 --> 00:10:41.380
a story like I would stand in front of these
large auditoriums and spin this whole

00:10:41.390 --> 00:10:46.570
story about like the need to study chaos
theory and the importance of harnessing

00:10:46.580 --> 00:10:51.280
randomness for creativity and imagination
and and I was just sort of making it all

00:10:51.290 --> 00:10:56.960
up but it was also true and I realize
that like everything in technology and

00:10:56.970 --> 00:11:00.630
everything and science really comes
down to story time so even as

00:11:00.640 --> 00:11:06.550
a young kid like I got money and was
listened to and bizarrely was able to get

00:11:06.560 --> 00:11:13.240

a ton of my fellow students and and teachers
to basically do my ideas he because I

00:11:13.250 --> 00:11:13.430
was

00:11:13.440 --> 00:11:17.380
a good storyteller and so growing up like
my my grandfather especially was like the

00:11:17.390 --> 00:11:21.880
best storyteller in the world
and you know that was very much

00:11:21.890 --> 00:11:25.950
a part of my upbringing was just sitting
around the dinner table and listening to

00:11:26.360 --> 00:11:29.300
my family tell stories and so
everything whether it's writing

00:11:29.310 --> 00:11:33.240
a proposal to DARPA or to the military
or to the part of energy or trying to

00:11:33.250 --> 00:11:37.810
transportation it's always the same
thing I would say if you can put into

00:11:38.130 --> 00:11:44.450
a single paragraph what I like to call the
Tom Clancy vignette how this technology

00:11:44.460 --> 00:11:49.010
is going to impact someone's daily life
like if you can't write it into your novel

00:11:49.020 --> 00:11:54.650
so to speak then you have you haven't

really invented anything. Right in other

00:11:54.660 --> 00:12:00.650
words the ability to sort of embed into
someone's life or into the function of

00:12:00.660 --> 00:12:03.170
a factory or into the daily life of

00:12:03.180 --> 00:12:08.340
a Kayu us to go out into the minefield and
find landmines that that story telling

00:12:08.380 --> 00:12:14.900
isn't just about marketing it's about
conceiving the connections between your idea

00:12:14.910 --> 00:12:16.030
and your technology and

00:12:16.040 --> 00:12:22.750
a million other things and that's so
important so so I certainly love that and

00:12:22.760 --> 00:12:28.220
then when I was an undergrad a swath
more college I also got another N.S.F.

00:12:28.230 --> 00:12:33.410
Track as a junior which was
really fun and not. That involved

00:12:33.630 --> 00:12:37.050
a really fun robot project
where I again kind of enlisted

00:12:37.060 --> 00:12:42.520
a bunch of my peers ten of my peers there
at the college and to build this robot

00:12:42.530 --> 00:12:46.560
vacuum that was anonymous and I actually
vacuumed entire office building which back

00:12:46.570 --> 00:12:47.850
in one thousand nine
hundred six was kind of

00:12:47.860 --> 00:12:54.190
a big deal I mean it's ninety seven.
And then again got super duper lucky

00:12:54.200 --> 00:12:59.020
because. I sent you four days
after I graduated from saw from

00:12:59.030 --> 00:13:04.680
a college I got married to my wife
who's. Wonderful It was also appears not

00:13:04.690 --> 00:13:07.010
interest. We then took

00:13:07.020 --> 00:13:10.440
a job kind of audibly teaching which was
wonderful because it really again taught

00:13:10.450 --> 00:13:12.990
me how to think on my
feet and it was it was

00:13:13.000 --> 00:13:16.810
a lot of fun but I had this sort of like
drive to get back to robotics is even

00:13:16.820 --> 00:13:20.290
though I was like coaching track and cross
country and teaching all the stuff I was

00:13:20.300 --> 00:13:24.210

just managed I feel like I've got it you
know I've got like I know how to make

00:13:24.220 --> 00:13:28.650
robots do what I want you know and I actually
view that as storytelling to us like

00:13:28.660 --> 00:13:32.470
literally like I want this is how I want
their whole body to work this is the story

00:13:32.480 --> 00:13:38.390
of how this thing is going to go into the
world and do its job and I did in very

00:13:38.400 --> 00:13:39.920
different ways whoever
else was trying to build

00:13:39.930 --> 00:13:44.480
a map to try to keep exact you know.
Mission the math is perfect whatever I was

00:13:44.490 --> 00:13:48.630
like in town that's not how I vacuum you
know I mean I don't do that if you told me

00:13:48.640 --> 00:13:51.490
to mow the lawn or vacuum
go like spend like you know

00:13:51.500 --> 00:13:55.770
a lot of time building the perfect model
and then run pathfinding algorithms to for

00:13:55.780 --> 00:13:59.430
Greg Zaki the theoretically optimal way to
you know I would do I'd just like go out

00:13:59.440 --> 00:14:03.870

there and I roughly just sort of like you
know stick to vacuum into the various

00:14:03.880 --> 00:14:05.430
corners and just sort of keep

00:14:05.440 --> 00:14:09.420
a very loose mental model and this drove
people in computer science crazed or at

00:14:09.430 --> 00:14:12.320
all that's ridiculous I mean obviously
we're not going to get robot like that as

00:14:12.330 --> 00:14:17.230
equal why not like why not because that I
can absolutely guarantee you will never

00:14:17.240 --> 00:14:22.060
screw up. Right the robot can absolutely
see corners it can recognize features it

00:14:22.070 --> 00:14:25.990
can see doorways and Soma literally
like my strategy was again

00:14:26.300 --> 00:14:30.040
a different story right he said Boggo in
the office building I'll keep track of the

00:14:30.050 --> 00:14:33.200
number of doors I know I can always go
back to them in the hallway if I get

00:14:33.210 --> 00:14:36.210
confused and I can literally count
know it well that's ridiculous I mean

00:14:36.540 --> 00:14:41.170
a robot that would have to count the

number of doors I'm like why. Why is that

00:14:41.180 --> 00:14:44.980
ridiculous because it scalable to work for
any office building in the world and the

00:14:44.990 --> 00:14:48.340
Times says we didn't have sophisticated
you know indoor positioning and all that

00:14:48.350 --> 00:14:52.770
kind of stuff it but the point is it
worked right and it never failed and never

00:14:52.780 --> 00:14:54.900
felt so so so even though it was kind of

00:14:54.910 --> 00:15:00.260
a strange story it worked and I ended up
using very similar strategies then for my

00:15:00.270 --> 00:15:01.270
next job which I got

00:15:01.280 --> 00:15:04.580
a call out of the blue which was hey do you
want to come work at DARPA which is the

00:15:04.590 --> 00:15:08.740
Defense Advanced Research Projects Agency
that if you don't know did many important

00:15:08.750 --> 00:15:12.920
things like invent the Internet right so
so then I showed up and lo and behold the

00:15:12.930 --> 00:15:16.000
guy who was the chief
roboticists for the U.S.

00:15:16.010 --> 00:15:22.830
Army. A fantastic guy Colonel Swanson
basically you know took me under his

00:15:22.840 --> 00:15:28.400
wing and gave me essentially. An unparalleled
opportunity to to help coordinate

00:15:28.410 --> 00:15:32.540
a whole bunch of these different robotics
programs which really gave rise to the

00:15:32.550 --> 00:15:36.980
Pack Bot in the town if you feel familiar
with it i Robot Company the Pack Bot of

00:15:36.990 --> 00:15:40.590
sort of the robot that came out of that
and then as the our program which is

00:15:40.600 --> 00:15:44.770
software for to see would robotics
essentially did the first one hundred robot

00:15:44.780 --> 00:15:49.270
swarms which was really a big deal
and a lot of fun and then also to

00:15:49.280 --> 00:15:53.330
a large extent kind of produced what we now
know is the Roomba right which was also

00:15:53.340 --> 00:15:55.570
came out of that work because it's
essentially what it was supposed to be

00:15:55.580 --> 00:15:56.060
originally was

00:15:56.070 --> 00:16:02.560

a little smarm bot. So that was sort of
my early you know that basically takes us

00:16:02.570 --> 00:16:07.270
through nine hundred ninety nine and looking
back at that trajectory you know it's

00:16:07.280 --> 00:16:11.110
impossible to think of any of that stuff
as coincidence right I mean each one of

00:16:11.120 --> 00:16:15.100
those opportunities had no business
happening right I mean it they're just

00:16:15.610 --> 00:16:20.980
completely bizarre actually but in each
case I would say my willingness to bluff my

00:16:20.990 --> 00:16:25.790
way through was pretty important because
I remember the DARPA being like there is

00:16:25.800 --> 00:16:29.970
no way these guys are to give me money to
go build like at the mining robot like I

00:16:29.980 --> 00:16:34.790
have no credentials I mean I really only
had an undergrad degree at the time and

00:16:35.440 --> 00:16:39.570
then the other was incredibly obstinate
and willful too so I would stand in front

00:16:39.580 --> 00:16:42.990
of these guys in the Pentagon like no
that's not going to work like you're crazy

00:16:43.000 --> 00:16:43.190

that's

00:16:43.200 --> 00:16:47.470
a stupid idea we're going to do that and
it will who are you your son like you know

00:16:47.510 --> 00:16:51.120
twenty four year olds he doesn't have any
credentials and why would I listen to and

00:16:51.130 --> 00:16:53.660
I won't I mean because I actually not

00:16:53.670 --> 00:16:58.370
a program robots and I'm just telling us
not to work and so these big programs like

00:16:58.410 --> 00:17:02.230
for instance future combat systems like an
eighteen billion dollar you know program

00:17:02.270 --> 00:17:05.160
just for the U.S. Army and it is part of

00:17:05.170 --> 00:17:09.000
a thing that most people don't know about
but Congress actually mandated the house

00:17:09.010 --> 00:17:13.020
of the army was going to be on manned by
the year two thousand and twenty which you

00:17:13.030 --> 00:17:15.060
know obviously isn't going
to happen but it was

00:17:15.069 --> 00:17:17.700
a law it was passed and so they
funded it with billions of U.S.

00:17:17.710 --> 00:17:21.579
Taxpayer dollars and it didn't work and
it didn't work for reasons that were

00:17:21.589 --> 00:17:25.069
abundantly clear to me back in one thousand
nine hundred nine which was he know

00:17:25.380 --> 00:17:31.000
that assume that all the Eagles knew exactly
where they were which they didn't and

00:17:31.010 --> 00:17:35.810
weren't going to sack and only
that they had somehow magically

00:17:35.850 --> 00:17:42.430
a teen and terrain data for the entire
world right so there's sort of had us

00:17:42.790 --> 00:17:43.940
up to date you know

00:17:43.950 --> 00:17:50.870
a perfect model of everything
which they didn't. And also that

00:17:50.880 --> 00:17:55.100
there is this massive connectivity between
everything to descend all this raw data

00:17:55.110 --> 00:17:58.510
back and forth which was not
only not possible but also just

00:17:58.520 --> 00:18:03.610
a really bad idea Ray and my point I guess
is that what these guys lacked although

00:18:03.620 --> 00:18:09.720

many of them are extremely bright and
extremely well qualified. Was actually

00:18:09.760 --> 00:18:13.390
philosophy they didn't understand
the way the world works like at

00:18:13.400 --> 00:18:16.950
a deep level and Strangely
I feel like I learned

00:18:16.960 --> 00:18:22.790
a lot of the bizarrely from my religion
classes so i would you know I studied I

00:18:22.800 --> 00:18:24.740
have a degree in computer science but also

00:18:24.750 --> 00:18:28.610
a degree in religion and which was really
philosophy for the most part studying

00:18:28.620 --> 00:18:31.970
sort of. This college is

00:18:32.010 --> 00:18:36.370
a big part of sort of the you know
if you look at like Guston and

00:18:36.800 --> 00:18:43.510
a lot of the early. Philosophical thinkers
and not only in the Christian tradition

00:18:43.520 --> 00:18:47.100
but in many traditions you realize that
these people really understood the nature

00:18:47.110 --> 00:18:52.970
of knowledge and intelligence. Level which
strangely we seem to have forgotten to

00:18:52.980 --> 00:18:56.870
a large degree so if you look at how many
companies right now are approaching self

00:18:56.880 --> 00:19:02.420
driving or approaching these problems of.
Structuring the smart city or sharing

00:19:02.430 --> 00:19:05.030
data or whatever you know
like wow this is just

00:19:05.040 --> 00:19:11.550
a terrible concept so so to me being
able to come at these issues from not

00:19:11.560 --> 00:19:15.570
only a technological
perspective but also from

00:19:15.610 --> 00:19:19.490
a philosophical perspective is stream really
important and let me give you another

00:19:19.500 --> 00:19:24.370
example so that so when the departed
transportation started looking at creating

00:19:24.380 --> 00:19:29.080
intelligent highways they did what all
bureaucrats do they said well nothing could

00:19:29.090 --> 00:19:35.300
be better than having you know again
perfect control when you have control of

00:19:35.310 --> 00:19:40.290
everything. And so we'll have a
centralized system in Washington D.C.

00:19:40.520 --> 00:19:43.720
Everything will be run based
on satellites and space G.P.S.

00:19:43.730 --> 00:19:47.870
The same story that I dealt with back under
the Future Combat Systems program right

00:19:47.870 --> 00:19:52.530
. And nothing really changed who's made
the even though we failed to do that

00:19:52.540 --> 00:19:56.390
properly in the military and eventually
had to fall back on this more sort of.

00:19:57.610 --> 00:19:58.380
Again what I'm calling

00:19:58.390 --> 00:20:04.940
a peer to peer system. We we then went
through the same sort of strangely

00:20:05.390 --> 00:20:10.390
identical process in transportation where
the idea had been well we'll just tell

00:20:10.400 --> 00:20:13.860
every single car where to go and what to
do and it'll all be great right and we'll

00:20:13.870 --> 00:20:14.620
run the simulation

00:20:14.630 --> 00:20:18.940
a lot in the simulation turns out we're
right you know because as one of my

00:20:18.950 --> 00:20:23.590

colleagues you know likes to say simulations
are always doomed to succeed they

00:20:23.600 --> 00:20:27.390
always work out exactly like you program
into but in reality they don't work so

00:20:27.400 --> 00:20:30.430
this big project we just did recently
in New York City where we you know

00:20:30.870 --> 00:20:31.610
essentially that is

00:20:31.620 --> 00:20:34.490
a part of transportation wanted to show
that all this connected vehicle stuff could

00:20:34.500 --> 00:20:37.830
work they brought all these different
companies there and lo and behold over the

00:20:37.840 --> 00:20:40.770
course of the year many millions of dollars
and none of them didn't work and the

00:20:40.780 --> 00:20:43.210
reason they didn't work wasn't the
problem with the software was

00:20:43.220 --> 00:20:47.720
a problem with connectivity the satellites
right so it turns out if you have this

00:20:47.730 --> 00:20:53.400
big sort of fifty meter error bound around
your car you can't really do much right

00:20:54.180 --> 00:20:58.380
because if if you don't know whether you're

headed behind of the other car I mean

00:20:58.390 --> 00:21:01.920
how how would you orchestrate things you
need to know if that car is truly in the

00:21:01.930 --> 00:21:06.320
left hand turn lane or not because if it's
not the left hand how you have to slow

00:21:06.330 --> 00:21:07.870
down and come to a stop if it isn't

00:21:07.880 --> 00:21:11.710
a left hand turn away you can go right by
the sitting so again it turns out that

00:21:11.720 --> 00:21:17.750
this position is really important the
dependence though of this entire program on

00:21:17.760 --> 00:21:18.250
G.P.S.

00:21:18.260 --> 00:21:24.680
Was staggering and the words it really ends
are wasting massive amounts of time and

00:21:24.680 --> 00:21:29.700
money again and and the way that I ended
up communicating to them was it was more

00:21:29.710 --> 00:21:29.930
of like

00:21:29.950 --> 00:21:36.990
a conceptual argument which is say
look. If you guys get we want

00:21:37.530 --> 00:21:38.350

less a G.P.S.

00:21:38.360 --> 00:21:41.780
Doesn't magically work the way that you
think it should right which is never going

00:21:41.790 --> 00:21:46.600
to happen but let's say for the sake of
argument that it dead you would then have

00:21:46.610 --> 00:21:53.560
a system hold of these vehicles could be
hacked. Or jammed and there'd be nothing

00:21:53.570 --> 00:21:59.500
you could do about it so you literally
create this perfectly optimal system that

00:21:59.510 --> 00:22:03.790
then with tremendous optimality allowed
about actor to take control of the system

00:22:03.800 --> 00:22:09.170
and that's what that would be the worst
thing ever and and so again telling

00:22:09.180 --> 00:22:13.390
a story which I literally in some cases did
by showing them movies right so imagine

00:22:13.400 --> 00:22:17.200
like the Star Wars movie where you shoot
down the drone control ship and all the

00:22:17.240 --> 00:22:23.080
Droid stopped working like dots the problem
is centralized control so learning the

00:22:23.090 --> 00:22:24.830
difference philosophically between

00:22:24.840 --> 00:22:31.180
a system which is structured around the
promise of you know sort of democratic

00:22:31.270 --> 00:22:38.160
distributed swarm based principles versus
centralized control on the other hand is

00:22:38.160 --> 00:22:43.190
really important and is once you understand
the fundamental difference between

00:22:43.190 --> 00:22:48.650
those two mindsets it completely changes
the way you think about everything

00:22:50.380 --> 00:22:56.830
but if you don't have that underpinning
then you go for the theoretically optimal

00:22:56.840 --> 00:22:59.210
and you don't run on really comes as

00:22:59.220 --> 00:23:05.970
a massive shock that issues like
latency and. Connectivity and

00:23:05.980 --> 00:23:11.580
imprecision and problems with the world
model and countless other things come in

00:23:11.820 --> 00:23:17.580
and essentially destroy this perfect system
that you had in your mind right and so

00:23:17.590 --> 00:23:23.350
it's like the difference between like the
you know the hood the in and one hand you

00:23:23.360 --> 00:23:23.590
build

00:23:23.600 --> 00:23:30.360
a system to grapple with all the mass in
us and the other you say oh no it's going

00:23:30.370 --> 00:23:32.800
to be just like my simulation
everything will be perfect.

00:23:38.780 --> 00:23:40.240
As he.

00:23:48.200 --> 00:23:52.340
Was asked. It's

00:23:52.350 --> 00:23:56.420
a great question so basically if I look
back at the last twenty years of my life it

00:23:56.430 --> 00:24:03.190
to me they all seem very.
Very much like layers which

00:24:03.200 --> 00:24:08.400
are essential and so it you know I think
there's this myth that you can just sort

00:24:08.410 --> 00:24:11.950
of like come up with a great new you know
concept and immediately sell it make

00:24:11.960 --> 00:24:15.090
a ton of money and you know no doubt
some people have done not but but my

00:24:15.100 --> 00:24:18.120
experience has been that it's a hell of

00:24:18.130 --> 00:24:23.430
a lot of work and that I really can't count
on anyone to catch the technology my

00:24:23.440 --> 00:24:29.690
throat over the fence. At each level I've
had to tune it out so you know several

00:24:29.700 --> 00:24:32.090
years of doing and of suffering and
work that you would say was out of

00:24:32.100 --> 00:24:36.470
a very basic research level
moving to DARPA did work for

00:24:36.480 --> 00:24:42.340
a couple of years that was more athletic.
Starting to prototype some of it and

00:24:42.350 --> 00:24:45.230
demonstrate the principles and I'm using
the national lab system which I didn't

00:24:45.240 --> 00:24:48.240
talk about but I was there for nine years
where essentially I built you know they

00:24:48.250 --> 00:24:52.590
built me this huge runway and we had this
huge area to run robots It was amazing

00:24:52.870 --> 00:24:53.350
and we applied

00:24:53.360 --> 00:24:57.230
a lot of the technology to energy but that
you would call applied research and in

00:24:57.240 --> 00:25:01.420

terms of the NASA what they call technology
readiness levels it was like six three

00:25:01.430 --> 00:25:04.860
to six for. It's basic research is

00:25:04.870 --> 00:25:09.780
a six one six two right and then
when I found it five D. Five D.

00:25:09.790 --> 00:25:16.240
Then took it from two thousand and nine
to basically you know just being acquired

00:25:17.110 --> 00:25:19.700
about you know three months
ago so you taught me at

00:25:19.710 --> 00:25:24.860
a very interesting times that basically
then led. In one way or another the

00:25:24.870 --> 00:25:30.080
development of the technology through what
you might call that an ocelot of zero

00:25:30.760 --> 00:25:36.240
six five two six eight And so now it's
deployed you know and you know in Canada for

00:25:36.250 --> 00:25:41.580
rail and it's going into the New York subway
system and there is just big New York

00:25:41.590 --> 00:25:46.250
Times article about having last week so
it's really starting to kind of pick up but

00:25:46.900 --> 00:25:49.670
but that technology that

came out of five D.

00:25:50.330 --> 00:25:55.350
Really kind of ended up giving us very
accurate positioning and sort of.

00:25:58.080 --> 00:26:03.670
Demolished will state that I'm very proud
of that and the technology especially

00:26:03.680 --> 00:26:03.980
like

00:26:04.020 --> 00:26:08.650
a great example was the fact that by putting
on every fourth lamp post in an area

00:26:08.660 --> 00:26:14.520
of Manhattan we really could direct the
motion of these heterogeneous cars with

00:26:14.560 --> 00:26:21.010
with incredible precision right. But
what is now doing is saying Great

00:26:21.450 --> 00:26:27.930
so now that the fundamental chip technology
is there that allows for this peer to

00:26:27.940 --> 00:26:30.880
peer radio pulse think
of it is century it's

00:26:30.890 --> 00:26:37.870
a pico second wide pulse and credible
precision that that then allows us to

00:26:37.880 --> 00:26:43.390
range between different devices with
centimeter level accuracy right. So think of

00:26:43.400 --> 00:26:47.220
that almost by analogy like when
when Qualcomm came out with C.D.M.A.

00:26:47.260 --> 00:26:53.300
Re the sort of like core technology that
is in pretty much all cell phones out of

00:26:53.310 --> 00:26:58.910
Qualcomm it went to. You know individuals
or really to anyone at that point and

00:26:58.920 --> 00:27:02.040
said like hey this is going to be great
and explain all the benefits of the cell

00:27:02.050 --> 00:27:06.880
phone and then asked you to buy this little
chip you know one hundred percent of

00:27:06.890 --> 00:27:10.430
people do like I don't know what to do
with that I'm like that that's not solving

00:27:10.440 --> 00:27:15.250
my problem you know and the early folks
like want to say nor believe me this is

00:27:15.260 --> 00:27:19.590
actually really important like this this
little thing here is really really what no

00:27:19.600 --> 00:27:23.680
one would have understood I should say
no I didn't meet one out of ten thousand

00:27:23.690 --> 00:27:27.660
people would have understood the value and
really that's the predicament for of the

00:27:27.670 --> 00:27:33.480
entrepreneur in general it really is I
mean imagine if you've been there watching

00:27:33.490 --> 00:27:37.110
the Wright Brothers first flight and no
one understood what the impact of flight

00:27:37.120 --> 00:27:38.980
was really going to be and they watched as

00:27:38.990 --> 00:27:44.460
a little wooden thing barely get off the
ground I can absolutely guarantee you know

00:27:44.610 --> 00:27:49.610
that the investor sitting there like so
tell me again how much free Can I put on

00:27:49.620 --> 00:27:53.530
not airplane because it doesn't look like
it's really going to be the useful for me

00:27:53.570 --> 00:28:00.350
you know and those investors would been
both completely correct and also incredibly

00:28:00.360 --> 00:28:05.730
short sighted it. Right
but that's it that's in

00:28:05.740 --> 00:28:10.490
a nutshell. They would have gotten other
little spreadsheets and been like well you

00:28:10.500 --> 00:28:15.050
know. You know I just even when the
police little bigger or just don't think

00:28:15.060 --> 00:28:18.490
there's enough infrastructure in general
because we've decided that you're going to

00:28:18.500 --> 00:28:23.120
need these these places for these things
to take off and land and I just we don't

00:28:23.130 --> 00:28:26.690
control there is no we don't have there's
airfields like I and I don't see you know

00:28:26.700 --> 00:28:30.660
that we have and I don't I can't it's going
to be too long for me to ever make any

00:28:30.670 --> 00:28:37.230
money off of it so therefore I'm not
interested. And and that is the predicament I

00:28:37.240 --> 00:28:41.520
mean the issue is how do you take

00:28:41.950 --> 00:28:45.130
a technology through all these
reference stages and it's

00:28:45.140 --> 00:28:51.660
a labor of love it's incredibly hard it's
incredibly hard and Mikey's yes it's

00:28:51.670 --> 00:28:56.110
taken twenty years and each one of those
steps there's been an incredibly big

00:28:56.960 --> 00:29:02.830
capacity or capability to demonstrate so
it's not like and any point I've said to

00:29:02.840 --> 00:29:07.620

anyone Hey just have faith you know you
mean it's you know this we we deployed this

00:29:07.630 --> 00:29:11.260
stuff for the military we used it for Law
month actually used it to map out tunnels

00:29:11.270 --> 00:29:16.020
and bunkers that no one else could do over
and over again we did world record type

00:29:16.030 --> 00:29:18.030
things I had a robot follow a person

00:29:18.040 --> 00:29:23.350
a soldier for an entire day or we did the
first swarms of us that went out and and

00:29:23.360 --> 00:29:27.050
worked together in the sky so
it was never about sort of

00:29:27.090 --> 00:29:32.440
a just trust us you know someday we'll
make this stuff work but at the same time

00:29:32.560 --> 00:29:33.500
like for five D.

00:29:33.510 --> 00:29:40.470
The company. That has spent the last
nine years. It really came down

00:29:40.480 --> 00:29:47.090
to adoption and there was people saying you
know we'll definitely invest mean once

00:29:47.100 --> 00:29:52.290
you have twenty million of these things
out there you know and you're like right

00:29:52.300 --> 00:29:57.010
but I mean we have to start somewhere so
we started working industrial sites and

00:29:57.020 --> 00:30:01.860
and it is taking off and on very very
excited about the ability for that to scale

00:30:01.870 --> 00:30:08.090
but one of the big things I realized
adopted motion group is that. You have to

00:30:08.100 --> 00:30:13.720
create middleware you know I mean my
middleware MIT the idea of middleware is that

00:30:13.730 --> 00:30:17.390
you're not going to control every component
and you're not going to build every

00:30:17.400 --> 00:30:22.280
component and if you really want your
component to take off you actually have to

00:30:22.290 --> 00:30:22.640
figure out

00:30:22.650 --> 00:30:26.290
a way to make it in or operate with all
these existing components you know I'm

00:30:26.300 --> 00:30:31.560
saying so now I'm trying to localize not
only using alter wideband which was the

00:30:31.570 --> 00:30:34.500
core capability of the
you know the five D.

00:30:34.510 --> 00:30:40.560
Chip but also by using other ranges
so we are modelling with G.P.S.

00:30:40.570 --> 00:30:44.220
We are melding with Bluetooth localization
we are melding with other things that

00:30:44.230 --> 00:30:50.680
exist in your cell phone and. Not works
and whatever because really the value at

00:30:50.690 --> 00:30:51.090
least for

00:30:51.100 --> 00:30:55.960
a long time is going to be in that inner
operability So that's really the next

00:30:56.010 --> 00:31:01.780
level is saying OK now that we have this
core capability we've demonstrated the

00:31:01.820 --> 00:31:06.710
incredible value of being able to have
accurate super accurate positioning how do

00:31:06.720 --> 00:31:10.810
we scale it how do we get it out into all
these things I used to think that I could

00:31:10.820 --> 00:31:15.180
just show people how well it worked and
then the entire cell phone industry has

00:31:15.190 --> 00:31:19.930
been like hey you know we we want to put
it in but that's not the way it works you

00:31:19.940 --> 00:31:24.870

know it's the opposite of large corporations
view ideas like like the one I've been

00:31:24.880 --> 00:31:29.990
describing as destruction they for
the large you know I was a cook

00:31:30.000 --> 00:31:32.350
a large corporations by
their very nature with

00:31:32.390 --> 00:31:37.870
a few exceptions will always say they want
to have Asian and they do they want to

00:31:37.910 --> 00:31:42.550
enter it of innovation that they control
so if your idea is actually disruptive

00:31:42.590 --> 00:31:47.210
they absolutely do not want right because
they can't control it that's pretty much

00:31:47.220 --> 00:31:52.170
what they were disrupt that means is that
even so trying to figure out how to take

00:31:52.210 --> 00:31:59.000
a new idea and sort of slip it in
where we can build an ecosystem of

00:31:59.110 --> 00:32:05.670
business benefit. Is really hard in fact
of you know I've come to say and pretty

00:32:05.680 --> 00:32:12.450
much every respect that the process
of. Essentially orchestrating the

00:32:12.460 --> 00:32:17.600

business side of this is at least as complex
maybe more complex than the technology

00:32:17.600 --> 00:32:23.580
. And unfortunately you need both Ray.

00:32:24.800 --> 00:32:28.110
To really succeed so M.G.

00:32:28.120 --> 00:32:30.690
Right now is very exciting
as well working with

00:32:30.700 --> 00:32:34.330
a ton of automotive companies lighting
companies utilities municipalities and it's

00:32:34.340 --> 00:32:39.780
about building exactly what scares everybody
in those vaster going even really big

00:32:39.790 --> 00:32:44.810
companies like Google and Apple and
they're of trade of using infrastructure

00:32:44.820 --> 00:32:49.640
because they don't control and they don't
own it so either become very focused and

00:32:49.640 --> 00:32:51.040
say well we're going to do everything with

00:32:51.050 --> 00:32:55.800
a cellphone and one hundred percent of
our business model be linked to the cell

00:32:55.800 --> 00:33:00.230
phone ecosystem because we control that
although even there no one company controls

00:33:00.250 --> 00:33:06.280
it the alternative is to say we're going
to be com essentially public like the

00:33:06.300 --> 00:33:11.840
Internet right we're not going to naturally
control in the traditional sense which

00:33:11.840 --> 00:33:15.910
brings me back to this whole fundamental
concept of distributed control which is

00:33:15.930 --> 00:33:19.630
behind all the work I did was swarming
robotics it's behind everything I'm doing

00:33:19.650 --> 00:33:20.750
with how to coordinate

00:33:20.760 --> 00:33:24.340
a highway and it's beyond literally how
I'm trying to create this business

00:33:24.360 --> 00:33:30.630
ecosystem to to get this technology out
there to the world and it requires

00:33:30.660 --> 00:33:36.910
a very humble attitude of
saying hey. I can't control

00:33:37.380 --> 00:33:41.340
anything I can't control of the cities
do I can't control what the large

00:33:41.340 --> 00:33:47.900
corporations do I can't control. Hardly
anything about this but it brings me all

00:33:47.910 --> 00:33:53.610

the way back to where I started which is
story time if you if you tell the story

00:33:53.650 --> 00:33:59.390
the right way. You can really see is control
of people's hearts and minds and not

00:33:59.400 --> 00:34:03.450
is the most important thing. I
was talking with the C.T.O.

00:34:03.460 --> 00:34:07.190
Of one of the largest corporations in the
world and his sponsor of ours with name

00:34:07.800 --> 00:34:08.500
and if I don't as

00:34:08.510 --> 00:34:13.949
a this really just comes down you know
it works you absolutely know that that's

00:34:13.960 --> 00:34:17.670
where she know that if we get into all
these cars we can absolutely fundamentally

00:34:17.679 --> 00:34:21.949
transform the nature of transportation in
one fell swoop it really just comes down

00:34:21.960 --> 00:34:28.699
to whether or not you believe that this
can be done and whether you want it

00:34:31.550 --> 00:34:37.880
and again to be fair also whether you
believe that this adoption strategy is

00:34:37.889 --> 00:34:43.179
practical right because it isn't just

about you know as as has been said to me

00:34:43.179 --> 00:34:46.449
before you know rainbows and
unicorns right it can't just be

00:34:46.449 --> 00:34:47.480
a good story it's got to be

00:34:47.489 --> 00:34:54.380
a story Bill and many many small
layers right and so each represented

00:34:54.389 --> 00:34:57.950
environment that we go do whether it's
the United rentals industrial yard or

00:34:57.950 --> 00:34:59.000
a forklift environment or

00:34:59.020 --> 00:35:05.430
a factory you know those are the
real demonstrators. But it's

00:35:05.450 --> 00:35:11.910
a process of sort of inching the story
along with the demand and the actual real

00:35:11.920 --> 00:35:16.180
world demonstration so so
you're never quite requiring

00:35:16.220 --> 00:35:18.220
a leap of faith you're just requiring

00:35:18.240 --> 00:35:24.070
a step of faith he know. And

00:35:24.610 --> 00:35:26.550
yes I'm going.

00:35:31.580 --> 00:35:38.380
Through part of creativity is. An.

00:35:42.550 --> 00:35:48.970
Appropriate. Question is you
have the city moments where.

00:35:50.250 --> 00:35:56.880
You. Had. A situation. How those of

00:35:56.890 --> 00:36:01.340
you worked. Relations.

00:36:06.640 --> 00:36:11.320
You know this is going to sound silly but
like over and over again in my life oh

00:36:11.330 --> 00:36:17.710
Tom itself like well maybe you're just
overstating things maybe maybe we really can

00:36:17.720 --> 00:36:18.790
just make G.P.S.

00:36:18.800 --> 00:36:23.170
Good enough every time we go on in
the field and most recently with

00:36:23.180 --> 00:36:29.960
a M G We're deploying the Thomas bus in
Hong Kong and I told him over I never even

00:36:29.970 --> 00:36:33.200
been to Hong Kong but I you know I looked
and seen all the tall buildings and you

00:36:33.210 --> 00:36:36.660
know it's guys it's not nice don't think
it's going to work you know it's not

00:36:36.670 --> 00:36:42.020
anywhere and they just like every time you
know they just don't listen to me and

00:36:42.030 --> 00:36:47.970
like woah I mean. David and everyone
says going to work you're Qana just

00:36:48.240 --> 00:36:54.180
a big dampen you know dampening force on
our progress here. So my Garri Well you

00:36:54.190 --> 00:36:58.090
know do you want me to comment like yeah
you know we we do we want you to common

00:36:58.530 --> 00:37:05.400
and you know so I show up and it's
like you know. Hour after hour after

00:37:05.410 --> 00:37:10.400
hour of of like Hey just give us another
five minutes you know I think we just

00:37:10.410 --> 00:37:16.460
don't have good satellite writ reception
right now in your local. How is that going

00:37:16.460 --> 00:37:21.960
to be effects like by waiting more time you
know now but it was so well and we got

00:37:21.960 --> 00:37:27.570
where well when we did it in Portland like
out in the open I mean like right right

00:37:27.630 --> 00:37:31.520
it's completely different kind of environment
so so how did this experience over

00:37:31.530 --> 00:37:35.210
and over again it is like every time it's
like an epiphany for these people right

00:37:35.230 --> 00:37:40.980
every time it's like. OK maybe

00:37:42.030 --> 00:37:45.830
maybe we'll just refer to this as an edge
case because people will once they've

00:37:45.840 --> 00:37:49.140
once they believe something it's hard to
get them to shift so it would depend on

00:37:49.150 --> 00:37:53.610
transportation it was again they get was
the funniest thing is like well you know

00:37:53.620 --> 00:37:57.680
David I think ninety nine percent of the
world is going to be fine with G.P.S.

00:37:57.690 --> 00:38:02.340
I mean but what we will grant you this
there may be education. There may be edge

00:38:02.350 --> 00:38:06.820
cases where your technology to be really
useful right like under bridges or in

00:38:06.830 --> 00:38:13.020
tunnels absolutely meant me will give you
up and then of course it turned out that

00:38:13.030 --> 00:38:15.470
one hundred percent of Manhattan was

00:38:15.680 --> 00:38:21.700

a top right it is all it on up. And they
still refer to that either so I guess the

00:38:21.740 --> 00:38:26.040
G.P.S. Tonight aerial strike right
but to be clear the city is a G.P.S.

00:38:26.050 --> 00:38:32.280
Night area. Does it in then and Leah in
new we we have that down we would advise

00:38:32.290 --> 00:38:38.840
a G.P.S. In areas like. So to
be clear what your calling

00:38:38.880 --> 00:38:45.160
a small educates is like ninety percent of
what we care about we never had traffic

00:38:45.170 --> 00:38:52.040
problems in Kansas cornfields the traffic
problems are all in the cities but

00:38:52.050 --> 00:38:58.430
the perception is really important so for
me it's like reliving that appear for me

00:38:58.440 --> 00:39:01.600
over and over again if you really mean

00:39:01.950 --> 00:39:07.410
a leg right the reason you can't
track the soldiers is because G.P.S.

00:39:07.420 --> 00:39:11.710
Doesn't work through the buildings you
know and eventually like you know God It

00:39:11.720 --> 00:39:17.760
doesn't work indoors but it does work

outdoors I know that you know. Not not kind

00:39:17.770 --> 00:39:21.640
of the way you think like I got all the
requirements say in our thing we spent

00:39:21.650 --> 00:39:24.670
seven years of these requirements Dave
they say that we're going to mark G.P.S.

00:39:25.260 --> 00:39:26.930
You know we're going to
mark landmines with G.P.S.

00:39:26.970 --> 00:39:30.660
So we have to do it it's it's it's doctrine
like that's what we said we're going to

00:39:30.670 --> 00:39:35.240
do you know. So you're telling
me you want to walk through

00:39:35.250 --> 00:39:38.620
a minefield with a G.P.S.

00:39:38.630 --> 00:39:44.560
Device telling you where to stuff like no
that's not going what has to work it has

00:39:44.570 --> 00:39:48.730
to work because otherwise we have to wait
another seven years ago your car Mr so

00:39:48.740 --> 00:39:54.030
then surely what I learned to do is to
essentially say you're right you're correct

00:39:54.070 --> 00:39:59.600
we will absolutely do that and so then
you build a box. You do indeed put

00:39:59.610 --> 00:40:00.350
a little G.P.S.

00:40:00.360 --> 00:40:04.540
Receiver in it but you also put all this
other stuff inside of it and then you say

00:40:04.550 --> 00:40:05.800
to them Here is your G.P.S.

00:40:05.810 --> 00:40:11.110
Solution and the like we knew it made now
then even though they are on even using

00:40:11.120 --> 00:40:11.920
the G.P.S.

00:40:13.030 --> 00:40:17.100
So generally it's in there technically of
met the requirement but it's not actually

00:40:17.110 --> 00:40:22.420
doing what they think it's doing it's
just that you can't actually succeed in

00:40:22.430 --> 00:40:28.440
persuading large peer bureaucracies
to admit that their plans are

00:40:29.970 --> 00:40:36.480
incorrect so it's much better to
sort of say well. Yes we will make

00:40:36.490 --> 00:40:38.620
G.P.S. Work in tunnels Di's

00:40:38.630 --> 00:40:44.520
a great idea and we will do it if you
know you know it's fantastic here's some

00:40:44.530 --> 00:40:50.480
money. So that again is sort of like what
one of the difficult lessons learned is I

00:40:50.490 --> 00:40:54.470
think one of the biggest mistakes I've
made as an entrepreneur is is is over

00:40:54.480 --> 00:40:59.660
honesty right it's sort of saying look let
me explain to you the problem with how

00:40:59.670 --> 00:41:03.060
you're thinking about this you know which
to me I'm like doing them this massive

00:41:03.070 --> 00:41:08.300
favor like in my little mind right like how
fortunate they are that I'm here to set

00:41:08.310 --> 00:41:14.180
them straight and and then finally. We will
pay to not listen to this crowd because

00:41:14.760 --> 00:41:15.920
he know it's

00:41:15.930 --> 00:41:21.710
a really worry me what your say is so
figuring out sort of how to tell the story in

00:41:21.720 --> 00:41:27.980
a way that is one hundred percent truthful
but also is not. My phrase overly honest

00:41:27.980 --> 00:41:34.840
. Is really trivial and many many companies
we'll look at what just happened with

00:41:34.850 --> 00:41:39.520
their own straight where it's actually so
telling so sternness is the blood testing

00:41:39.530 --> 00:41:41.330
company where they essentially exaggerate

00:41:41.340 --> 00:41:45.280
a lot of their capabilities and are
usually sort of lied about some of their

00:41:45.290 --> 00:41:50.030
capabilities and you know that it's
hilarious to me actually that the Silicon

00:41:50.040 --> 00:41:54.430
Valley mindset is like oh yeah no absolutely
ever I mean everyone knew that that

00:41:54.440 --> 00:41:56.640
was complete rubbish
but you know she tells

00:41:56.650 --> 00:42:01.650
a good story so you know
as they were right like on

00:42:01.660 --> 00:42:06.080
a spectrum from like incredibly honest
and truthful about everything to making

00:42:06.090 --> 00:42:10.480
everything up you know I think Silicon
Valley kind of wants people to be like right

00:42:10.490 --> 00:42:16.830
here you know I kind of want to be right
here which is also really problematic

00:42:17.230 --> 00:42:24.070

and so I think you know the the issue
is like how to how do you. How do you

00:42:24.080 --> 00:42:24.460
tell

00:42:24.600 --> 00:42:31.400
a story which has the right amount
of forward looking. Promise but

00:42:31.410 --> 00:42:38.040
also the right amount of veracity.
And and that that is again

00:42:38.050 --> 00:42:44.810
that's that's the art of the right story.
And so the way again the way I like to do

00:42:44.820 --> 00:42:48.960
it is to say look I'm going
to demonstrate to you in

00:42:48.970 --> 00:42:54.270
a put up or shut up real world way exactly
how this operates today so there is no

00:42:54.280 --> 00:42:57.180
uncertainty about that and
then I'm going to verbal E.

00:42:57.190 --> 00:43:03.740
Or sometimes with with movie making.
Illustrate how it can be although

00:43:04.120 --> 00:43:05.570
it's interesting I've become sort of

00:43:05.580 --> 00:43:11.690
a bit obsessed with not making movies
that are what I would call it alive live

00:43:11.700 --> 00:43:17.480
action you know cinematography because
it's crazy if people see it in

00:43:17.490 --> 00:43:22.680
a sort of cinema grout a flick like
that it won't see it works. That was

00:43:22.690 --> 00:43:26.830
a concept but here OK so I've insisted
that when we are showing the future we

00:43:26.840 --> 00:43:31.700
literally use like animations you see even
because then like no one no one reads

00:43:32.380 --> 00:43:33.120
they know and it's

00:43:33.290 --> 00:43:36.940
a lot harder for people to read it in the
animation what has happened over and over

00:43:36.950 --> 00:43:43.860
again is that companies tend
to. Film The for their future

00:43:43.870 --> 00:43:45.480
vision but in

00:43:45.490 --> 00:43:49.890
a way where it all too easily can be perceived
as like what they're actually trying

00:43:49.900 --> 00:43:54.460
to say here to being so there is
this really kind of famous case of

00:43:54.470 --> 00:43:58.360

a drone company that emerged in Silicon Valley misuse the software raise like

00:43:58.370 --> 00:44:03.340
twenty million. But literally just off of this You Tube video Reza they made this

00:44:03.350 --> 00:44:07.770
beautiful You Tube video where the drone came in it followed to the boat and you

00:44:07.780 --> 00:44:11.820
know follow the wedding for Diana and I was like I want to you know dot dot

00:44:11.830 --> 00:44:17.430
scraping and so the words literally throwing money at them and my own board of

00:44:17.440 --> 00:44:21.010
directors at the Thomas like you know what can you be more like them you know that

00:44:21.020 --> 00:44:26.880
company is amazing you know or right except that they can't do it and like you know

00:44:26.930 --> 00:44:31.270
well I mean take Trey's lots of money I mean that's they can't be just making it up

00:44:31.280 --> 00:44:38.270
you know no actually they are they are making it up like it's hero and eventually

00:44:38.280 --> 00:44:41.160
they got me went bankrupt it took them like to have years because it literally for

00:44:41.170 --> 00:44:45.110

a while they just kept raising more money
if you like well I care I'll be so busy

00:44:45.980 --> 00:44:52.880
the you know the trick is. How do you
how do you create that how do you

00:44:52.890 --> 00:44:58.730
stimulate people's imagination so they can
really understand the potential of the

00:44:58.740 --> 00:45:05.530
technology without bamboozling them so that
they are really misled about the state

00:45:05.540 --> 00:45:09.340
of the technology.

00:45:06.990 --> 00:45:08.760
So going off what you were just saying

00:45:08.780 --> 00:45:12.600
about misleading people about limitations
there is this one interview that we read

00:45:12.600 --> 00:45:17.350
about you talking about how a lot of
people / entrepreneurs have their ego and

00:45:17.370 --> 00:45:24.270
and basically make the public perceive as
if their technology can do

00:45:24.270 --> 00:45:27.720
something, but then they would not
communicate the actual limitations of

00:45:27.730 --> 00:45:29.250
their product.
Right.

00:45:29.260 --> 00:45:34.000
So in that interview you mentioned the
importance of contact sensitive shared

00:45:34.000 --> 00:45:37.990
control with regards to AI technologies,
you also mentioned that you always try

00:45:38.000 --> 00:45:41.580
to emphasize that robotics should never
be about the robots but rather

00:45:41.580 --> 00:45:45.990
about the people they work with. So the
question is, could you provide specific

00:45:45.990 --> 00:45:48.070
examples from your own product development
process that

00:45:48.080 --> 00:45:48.860
illustrates the ideas you

00:45:48.860 --> 00:45:50.550
are emphasizing?

00:45:50.560 --> 00:45:57.730
Yea, yea absolutely. So one of the ways
that I said it recently, that was maybe a

00:45:57.730 --> 00:46:03.350
a little bit overly provocative, but I
said that robot strategies that are

00:46:03.350 --> 00:46:09.910
focused on 100% autonomy, fail 100% of the
time. And I really mean that. I think

00:46:09.910 --> 00:46:16.710
there is always a lot of appeal both from

a spreadsheet business model perspective

00:46:16.710 --> 00:46:22.700
also just from like a "that going to be
cool" perspective to this concept that you

00:46:22.700 --> 00:46:26.850
can eliminate the human. And over and
over again these robotics programs are

00:46:26.850 --> 00:46:31.480
sold based on this reduction of labor
concept. Whether it was future combat

00:46:31.480 --> 00:46:35.370
systems: "Well we are paying a lot on
soldiers paychecks what if we just didn't

00:46:35.370 --> 00:46:39.900
do that anymore?" Or Amazon saying, "Hey
when we put these little Kiva robots in

00:46:39.900 --> 00:46:44.180
our factories we can fire like half of our
employees". And it never really actually

00:46:44.180 --> 00:46:49.060
fortunately, in my mind, works out that
way.

00:46:49.060 --> 00:46:55.400
So, so let me give you an example, when
we worked on bringing robotics into the

00:46:55.400 --> 00:47:02.280
military, they actually ran cost models
that showed the only real benefit that

00:47:02.280 --> 00:47:07.650
they seemed at that time to care about

was reducing paychecks. They just wanted

00:47:07.650 --> 00:47:14.570
to pay fewer soldiers because paychecks
were the largest amount of money that

00:47:14.570 --> 00:47:22.250
they were shelling out and it just seemed
like the thing to do. And as it turned out

00:47:22.250 --> 00:47:26.690
we didn't get rid of a single soldier by
introducing all these many robots we

00:47:26.690 --> 00:47:30.490
deployed, and when I say "we" I don't mean
that these were all deployed by me

00:47:30.490 --> 00:47:34.320
personally, but the U.S. military deployed
the technology that would come out of

00:47:34.320 --> 00:47:39.690
these programs. Like the P.A.C. bot, the
Warrior, the Sub V, which was a small

00:47:39.690 --> 00:47:46.170
ground vehicle. The Talon, you know about
4,000 of those were produced, and these

00:47:46.170 --> 00:47:50.630
were robots that you would see in movies
like, The Hurt Locker, and even, "Mr. and

00:47:50.630 --> 00:47:56.880
Mrs. Smith". Anyway, the point is that we
deployed thousands of these robots

00:47:56.880 --> 00:48:03.500
and if anything, I would say that is may

have even increased work load.

00:48:03.500 --> 00:48:09.420
The value wasn't in reducing human labor,
the value was in keeping soldiers out of

00:48:09.420 --> 00:48:13.630
harms way. Which actually does have a
tremendous economic benefit. Each soldier

00:48:13.630 --> 00:48:20.300
costs a million dollars to train and the
effects of a bomb essentially rattling

00:48:20.300 --> 00:48:26.110
your brain, even if you don't die, is in
many cases tragically year after year

00:48:26.110 --> 00:48:31.550
after year of medical treatment for PTSD
and traumatic brain injury, these things

00:48:31.550 --> 00:48:38.030
actually again are both tragic and also
economically very serious, and we are

00:48:38.030 --> 00:48:44.610
going to spend way more than we spent on
the war to address PTSD over time. So

00:48:44.610 --> 00:48:51.560
keeping humans out of mine fields was
fantastic and we did a really good job

00:48:51.560 --> 00:48:55.880
of saving lives by having these robotic
technologies out there, but it actually

00:48:55.880 --> 00:49:01.750
didn't align at all with the business

model. In other words, the U.S. Congress

00:49:01.750 --> 00:49:07.830
had this business model, which indicated
this big benefit regarding reduction of

00:49:07.830 --> 00:49:14.260
labor, and my point all along was like,
"Stop saying that. Stop thinking that.

00:49:14.260 --> 00:49:18.330
The human is still going to be an
important part of the system. You know,

00:49:18.330 --> 00:49:24.605
the problem is that you can't just shoehorn
the human back in.

00:49:24.605 --> 00:49:29.355
If the strategy in the programs in these projects
were also based on the notion that

00:49:29.362 --> 00:49:31.740
these things were going to be super
intelligent and autonomous,

00:49:31.740 --> 00:49:34.740
you literally build

00:49:34.740 --> 00:49:38.260
a completely different system
than if your goal was to have

00:49:38.290 --> 00:49:44.980
the human play a major role.
And and so what I found

00:49:45.020 --> 00:49:49.020
in the research that we did was that
when you have the human as an integral part

00:49:49.030 --> 00:49:55.250
of the system, the performance was so much
better which doesn't mean that you require

00:49:55.260 --> 00:50:00.390
the imminent joystick It doesn't mean that the
human has to be responsible for all the actions

00:50:00.670 --> 00:50:05.380
of the robot right, for us the scanning of
the mine sensor over the ground and the advancement

00:50:05.390 --> 00:50:08.340
of the robot and ability or
office all that is being done by

00:50:08.350 --> 00:50:14.070
a robot. But you still needed the human
there and part of the reason was that there

00:50:14.080 --> 00:50:16.800
were really difficult decisions in many cases
that had to be made like is this

00:50:16.810 --> 00:50:19.130
a weapon of mass destruction or is it just

00:50:19.140 --> 00:50:25.340
a simple bomb is it an ID that has the ability
to take out a huge area or is it just

00:50:25.650 --> 00:50:28.000
a small problem that is going to threaten
a single vehicle

00:50:28.010 --> 00:50:34.130
because how will you go about
addressing the threat is something that
00:50:34.140 --> 00:50:40.190

we really want to human to decide, right. The
the robot is not really equipped to make

00:50:40.200 --> 00:50:45.070
decisions about weapons of mass
destruction, you know is there

00:50:45.080 --> 00:50:49.050
a dirty bomb is there or is there
radiological contaminants that are

00:50:49.060 --> 00:50:54.810
linked to this on all of these kinds of
issues are, to be clear, above the pay grade of

00:50:54.820 --> 00:51:00.480
any of my robots right, so
that was a great example of

00:51:00.490 --> 00:51:05.890
a situation where no matter how much of
the robotics intelligence we batted into

00:51:05.900 --> 00:51:12.870
that particular robot it still wasn't going
to get rid of the soldier and as far as

00:51:12.880 --> 00:51:13.760
I can tell, that's

00:51:13.770 --> 00:51:19.680
a good thing so and so my goal was never
to eliminate humans. My goal is to

00:51:19.920 --> 00:51:24.380
keep them safe and allow the operation
to be much faster so in our case with

00:51:24.390 --> 00:51:27.850
a lot of the robotics stuff that we did in

minefields were four times faster than a

00:51:27.860 --> 00:51:33.710
training human and of course you're keeping
the human out so those are very laudable

00:51:33.720 --> 00:51:39.690
benefits they just want the benefits that
hadn't been originally promised and this is

00:51:39.700 --> 00:51:44.120
somehow, get back to the fundamentals, this
is something that drives me crazy about

00:51:44.180 --> 00:51:50.370
entrepreneurial processes in general, is in
my experience I'm always been asked.

00:51:51.380 --> 00:51:52.260
To accomplish

00:51:52.270 --> 00:51:58.410
a goal that I didn't set and then
it seems my job is to subtly

00:51:58.630 --> 00:52:04.750
readjust those goals over the course of
the period time, you know, and say,

00:52:05.340 --> 00:52:11.220
"Um, I know you want to eliminate
the human soldier

00:52:11.230 --> 00:52:17.960
but what if we had one
human who could operate three robots"

00:52:18.890 --> 00:52:22.910
and there was a little more the
supervisor would look OK I guess I guess

00:52:23.040 --> 00:52:28.030
that seems like a reasonable next step right here
you're not moving the needle but okay,

00:52:28.040 --> 00:52:34.000
we're all on board with the concept that one human is
going to work with three robots great. So you see,

00:52:34.440 --> 00:52:39.030
because now at least I have an excuse
to keep the human in the loop right

00:52:39.040 --> 00:52:43.850
and I can build the system I want but again,
it's an ongoing negotiation always

00:52:44.100 --> 00:52:48.430
and the other thing I used to always
joke about is to say that the customer is

00:52:48.440 --> 00:52:55.010
always correct but the requirements are
dreadfully mislead so so but

00:52:55.020 --> 00:52:59.250
again the trick is you can't just come
in and tell them like hey, number three seven

00:52:59.260 --> 00:53:03.960
nine twelve fifteen yet we're
not going to do those so you have to

00:53:03.970 --> 00:53:10.790
basically go in there and say right, so we're
we're going to address this I have some

00:53:10.800 --> 00:53:16.470
concerns and I'm going to develop some
contingencies for numbers one blah (x3). And then

00:53:16.480 --> 00:53:22.660
over time and again, you sort of get
sign off to readjust. You say, right so

00:53:23.750 --> 00:53:29.940
we're going to involve if it's OK
with you. A homeland air vehicle to

00:53:29.940 --> 00:53:36.470
notice that there's been some anomalies and
then only then are we going to have the

00:53:36.480 --> 00:53:40.540
robot come in because the robot has
to cover this massive area it's just going to take

00:53:40.560 --> 00:53:46.910
a really long time and they're like, well it's not in
our requirements and you're like right but

00:53:46.980 --> 00:53:52.670
But what if I can dramatically reduce the cost
of the system and they're like, well I do like the

00:53:52.680 --> 00:53:57.830
sound of that right so what if I did an excursion
here pragmatic excursion where

00:53:57.840 --> 00:54:02.420
we tested this. So this is the sort of
ongoing negotiation with the customer is

00:54:02.430 --> 00:54:07.680
really critical so that if you do it well,
by the end of it they will claim that

00:54:07.690 --> 00:54:13.160
you met every single requirement but
God forbid you get out the old dossier

00:54:13.200 --> 00:54:18.550
you know that that was there at the
beginning of the program like oh yeah you

00:54:18.560 --> 00:54:23.750
met maybe at most fifty percent of the
requirements but that, thankfully if you've done

00:54:23.760 --> 00:54:29.060
your job well, that dossier doesn't exist
anymore. So the new one exists that has

00:54:29.060 --> 00:54:34.870
the requirements that are now agreed
to that. You know ends up being

00:54:34.880 --> 00:54:38.790
a very different list than the one
from two years ago so that again

00:54:38.800 --> 00:54:42.900
is part of the storytelling right,
and you're literally building the story

00:54:43.320 --> 00:54:49.940
and part of it by the way isn't, in other words,
that the reason for this isn't just that I

00:54:49.950 --> 00:54:53.430
knew in the beginning everything but I have
to cajole the customer. It's actually,

00:54:53.470 --> 00:54:59.490
that's not the case fifty percent of
those changes are because I failed

00:55:00.530 --> 00:55:05.130
in other words I may have failed to meet technical
requirements that I thought I could

00:55:05.140 --> 00:55:10.110
meet and so I'm actually going
to prevail on them to allow

00:55:10.120 --> 00:55:15.240
a different tactical solution because I
screwed up I couldn't make it work and part of

00:55:15.250 --> 00:55:21.060
the whole deal here in being a good
entrepreneur and good storyteller and

00:55:21.070 --> 00:55:25.620
a good technologist is that adaptation the
ability to actually recognize very early

00:55:25.630 --> 00:55:32.550
on where you haven't achieved part of
the goal and adapt and just be honest

00:55:32.560 --> 00:55:38.700
about it. Be like, yeah, you know
what, we can't do

00:55:39.400 --> 00:55:42.260
all of this with a camera in front
we're going to have to add

00:55:42.270 --> 00:55:46.700
a lighter or I thought it was going to work
but the problem is when there's dust it

00:55:46.710 --> 00:55:52.550
just doesn't work. I can't see when there
is dust I wish I could but I can't.

00:55:52.560 --> 00:55:57.040
I didn't think about that when I wrote
this original technical

00:55:57.050 --> 00:56:03.300
plan I just hadn't been thinking about dust
so, sorry you know and but because the

00:56:03.310 --> 00:56:10.240
problem is it's so easy for
technologists to say the canonical thing of

00:56:10.650 --> 00:56:15.540
you know what, give me six more months
and another ten million and I will make

00:56:15.550 --> 00:56:20.220
that camera work in the dust

00:56:20.240 --> 00:56:25.540
and maybe it will be a little bit better but maybe
after six more months of ten million more dollars it will

00:56:25.550 --> 00:56:30.630
work insufficiently. So another big...

00:56:32.330 --> 00:56:37.330
Thing that has been very humbling for
me is to realize that it's not just about

00:56:37.510 --> 00:56:43.150
steering my customer because
of their lack of knowledge it's

00:56:43.160 --> 00:56:50.040
also steering the ship largely because
of my own failings. So that's

00:56:50.050 --> 00:56:56.240
a big part of it but throughout all of this
work I really believe that if you view
00:56:56.250 --> 00:57:02.680
the human as part of the system, there's

lot more flexibility in how you address

00:57:02.720 --> 00:57:07.280
those failings and so if your premise is
like everything has to be completely

00:57:07.290 --> 00:57:11.600
autonomous then when you fail
at a particular component or

00:57:11.610 --> 00:57:13.400
a particular capability

00:57:13.410 --> 00:57:18.040
it's a big deal because now the whole
system is not going to work, whereas

00:57:18.050 --> 00:57:21.440
if the human's part of the system, then
you say, hey, the robot can phone

00:57:21.450 --> 00:57:28.140
a friend right. The robot could basically
say, hey buddy, mister human, I'd like

00:57:28.150 --> 00:57:35.110
a little help here and that hopefully
isn't a problem. In other words

00:57:35.120 --> 00:57:41.360
if you structured the mindset
correctly from the beginning you know that

00:57:41.370 --> 00:57:45.310
is not the problem right
the challenges for

00:57:45.320 --> 00:57:50.490
a lot of the self-driving stuff that you read about
in the news because they sort of stake

00:57:50.550 --> 00:57:56.440
their name and their reputation on one
hundred percent autonomous when the vehicle

00:57:56.450 --> 00:58:00.940
makes a mistake or if the vehicle is
struggling in a particular situation it's

00:58:00.980 --> 00:58:07.700
a big problem and so another way
to say this is is ninety nine

00:58:07.710 --> 00:58:09.710
percent of the work for

00:58:09.720 --> 00:58:13.610
a critical application like self-driving
is that last percent of reliability.

00:58:13.620 --> 00:58:18.380
So getting to ninety nine
percent is like rate for demos

00:58:18.390 --> 00:58:23.370
where you control the whole environment
but unfortunately ninety nine

00:58:23.370 --> 00:58:30.300
percent reliability is nonstop death and
dismemberment on the highway. So until

00:58:30.310 --> 00:58:31.420
you really get

00:58:31.460 --> 00:58:37.910
a fully functional fully rival system
it's very hard to get any value.

— End of Transcription —