

## DARPA Challenge webcast – part 1 (before the break)

Good morning everybody. I guess it's almost mid-day. Good afternoon. For those people on the webcast I guess it's good morning, good afternoon, good evening, depending on where in the world you're watching this from. And just so you know this is a live webcast and we know that we have a lot of folks from around the world tuning in to watch this event. Welcome, I see a lot of great faces but you didn't get the memo about jacket and tie. (laughter) Oh well. We have a great program for you today and I know you have all seen that. Seven months ago we were in the desert, a lot of us, for the Grand Challenge asking 'what next?'. Well today is the first chapter of what next. I would like to introduce Dr. Tony Tether. Many of you know him. He is the Director of DARPA and he pretty much is the brainchild behind the Grand Challenge series and even leading to the Urban Challenge over here. It's his ideas that started this whole endeavor and without a doubt has brought a community of people together. So without further ado I would like to welcome Dr. Tony Tether to the stage please. (applause)

Dr. Tether: Well, welcome back. It doesn't seem like it was that long ago, actually. I see a lot of familiar faces here. We had a hard time, actually, trying to decide what to do next for the next Grand Challenge. The obvious case was, now that everyone could travel through the desert, is to move it to the cities because in order for these vehicles to really do what we want them to do – while there will be long stretches like you had last time in the desert – eventually you will have to go through a city. And that was actually easy to think up. And the question was how do you do that and that really took us a long length of time. So I am going to just go over the highlights of that. You are going to hear a lot of the details after on the rules, what to expect. We'll try not to change them, too often. (laughter) We think we've got them all down now. This is our third time but, you know, that chief judge, you can never count on him to go along with anything. Next slide. This is DARPA, I think you all know that. Next slide. Well, as you know, we've had these three challenges. One was Barstow to Primm. That's where we really learned about how hard this really was and quite frankly I still believe that was a great success even though the distance would not show it but to have a vehicle go by itself that distance was really a great success. And, of course, that's where we also learned about things like the desert Tortoise and a few other things. (laughter) And, of course the last one that you were all at, 132 miles, 10 hours, \$2 million, with a great success. And here we go for the third, the Urban Challenge, which will be on November 3, 2007. Why November 3? Well, it's about 18 months from now and that seems to be what it takes for everybody to get going, to get their teams going. And, in fact, as was mentioned earlier, that has caused us a problem, but that's how we picked that date. There will roughly be 60 miles, six hours. This time we are

proposing three prize levels – a first prize of two million dollars, a second prize of \$500,000, a third prize of \$250,000. You might ask why we are doing the second and third prizes this time when we didn't do it before. I want to make sure there is an interest there. I want to make sure that somebody doesn't feel that there is somebody who is such a front runner, and I don't know who that front runner is, that there is no need to be out there trying. And so by having these other two levels we are hoping to keep the momentum going. Next slide. I don't know if this is an old slide. As of at least Friday, I guess, we have people here from 29 states. I'm sure we have more than that on the webcast where people are, but there is quite a few here from all over the country, which is really gratifying. Next slide. Now, why, again? You know, before we were looking at basically city to city kind of driving. The distances we picked were the typical distances you would find in a place like Baghdad as convoys would travel between major cities. And as difficult as that was, that really is still not where we have to be. Next slide. Because we now, sooner or later, will go through Baghdad itself. And going through Baghdad itself as a city, this kind of gives you a feel for how one might make itself through Baghdad with traffic. And it's roughly about 60 miles, which is where we came up with 60 miles. And again, about six hours because you have to do it in less than that for this to really be tactically interesting. Just trying to give you some motivation for these numbers, they will probably, no need to do that ever again, but just so you understand we didn't really pick them up out of the air. We tried to have some rational for what they were. Next slide. You are going to have to obey traffic laws. Safe entry into traffic flow. Safe passage through busy intersections. Safe following or passage of moving vehicles; safe passage of a stopped vehicle. I mean, if you thought passing somebody out in the desert last time was scary well that is just one part of what you are going to have to do here. Find an alternative route if the primary one happens to be blocked. And, a safe U-turn, because you might want to turn around and go back from where you came. So these are all the things that your vehicles are going to have to do. You're going to have to demonstrate that you can do it to get to the main event. And in the main event we will simulate this activity to the extent that we can. I mean, there will be clutter, there will be moving vehicles. There will be professional drivers driving those moving vehicles. We will make sure that each vehicle experiences the same experience to the extent that we can. In other words that your vehicle does not experience some traffic that another vehicle did not. So it is going to take coordination on our part a lot harder. But we will do what we can. Next slide. Okay, you probably have notices that we have two tracks. The first track is kind of the normal DARPA process. And the first track is basically that we let contracts with what is called a Broad Agency Announcement, where we basically say "hey, we want to have a vehicle to come and do exactly what I just talked about." And people put in a proposal. These

are not lengthy proposals, this process is meant to be friendly, you know, and so forth and so on. We will evaluate those proposals. You really are not so much evaluated against each other. In fact, you aren't evaluated against each other but we basically try to evaluate the person with the best proposal for achieving the ultimate objective of getting to the finals and doing six hours, 60 miles in less than six hours. The difference here is that we're going to pay up to \$1 million in technology development funds for the people in track A. The program does -- now, this program will have all the regular stages. It will have an NQE that you have to go through in order to get to the main event. The program actually ends at the end QE, the qualifying event. It is possible that just because you're in this track that you don't get to go to the main event. In other words, you can flunk the NQE and not get to go to the main event. So vehicles even on track A still have to pass all of the gates. Track B is more the normal one that you've been used to in the past. Here you submit an application, you send a video, you get selected for a DARPA site visit. Those of you who have had those before you know what those are like. Now, this site visit will be different than the last one. We're going to have a very tough site visit. Very, very tough to get through this site visit. The reason is, is that if you get through it, you get to participate in the national qualifying event and we are proposing to pay whoever shows up at the NQE \$50,000. If you get through the NQE which again you can flunk along with the other side, the track A and make it to the main event, you're given another \$100,000 to participate in the final event, which would be the three prizes. So this really -- I mean, hopefully as we go through it the rest of the day this will become clearer. This is really straight forward. Not complicated your most complicated thing is trying to decide which way to go, quite frankly. Next slide. Now, the DARPA prize authority. This is the way it states in the legislation. Actually the prize authority is not given to DARPA. The prize authority is really always given to the Secretary of Defense. And this is the way the bill reads. The Secretary of Defense may carry out a program but it also says the Secretary of Defense acting through the director of the advanced research project agency may carry out a program. Now, this always irks Secretary Rumsfeld, quite frankly, that Congress gives him this authority but then tells him how to run his business. But that's the way it reads that he's given the authority and then he's told how to carry it out. Now, what happened is that it expired -- is expiring on September 30th. We could have made the event in September to comply with where we are. In retrospect maybe we should have done that. But we didn't so we went for new legislation to kind of extend this authority past the end of FY 2007 and it caused a few problems. Next slide. Here is the situation. (laughter) Well, the house Armed Services Committee, as you go through this for those familiar with it, there are two houses and they both authorize and they finally get together and come up with a conference bill. The House armed services bill did what

was asked. They extended the DARPA prize authority to FY 2010. No other changes. The house voted on that and approved the bill.

However, on the Senate side the Senate has not. In the putting together of the bill, basically removed DARPA. So DARPA, in the Senate side, does not have a prize authority and I'll show you what the difference is in the language, and added other DoD organizations. Now, let me tell you this bill is not official yet. The Senate hasn't voted on it and they won't vote on it until July and then, because there is a difference even if this came through the way it is, there is a difference that would go to conference so forth and so on. And so we don't really know what the output of that is going to be. Let me have the next slide. Here it is today, again, where is it today? The Secretary of Defense acting through the director of the DARPA, has been changed. They now have given authority once again to the secretary of defense but now have told him if he wants to carry out this authority he can only act through the director of the defense research and the engineering and the service acquisition executives of military departments. Now, this causes some problems, right? I mean, the problems are that if this were the past we would no longer be able to give the prize. And, in fact, the Secretary of Defense couldn't even say wait a minute.

I want those guys in DARPA to do that because it's clear that the will of Congress said no. So we are in a funny situation here. Now, when you get into these situations, the only thing, quite frankly, you can do is look at the absolutely worst case. What is the worst that can happen if the language ends up being exactly as the Senate staff have proposed it? Remember, we still haven't gotten a vote by any Senator on this yet. Next slide. Well, we're still going to have an Urban Challenge. That doesn't go away. We're still going to have this Urban Challenge. The problem is, we're not going to have any prize monies.

So if the worst case is that we still have the Urban Challenge but we don't have any prize monies. Instead of prize monies we'll give you trophies. [LAUGHTER]

I promise -- I promise that the trophies will be given because I'll personally buy them myself. Because I don't have to have anybody authorize that except for my wife. She said it was OK. (laughter) So I can guarantee you the trophies.

Now remember, this is at the beginning of a process but any of you who can't stand this being the outcome, and this is why I'm making a big deal about it especially for the track B part, any of you who can't stand this being the outcome should enter into this very carefully because this is Washington and logic does not prevail although we're outside the beltway today and it tends to here but it's hard to understand -- we tried by the way, this only happened in the last week. I really have not had anybody explain to me why they did it. I've been unable to find out why they did it. There is no language that usually goes along with this and says they're

clearly pissed off at somebody. (laughter) I mean, there is no way hiding that. I asked Ron, I said, what have you been doing? [LAUGHTER] And he said he hasn't been doing anything. So I know I really don't know why. Normally with something like this they usually let us know. They knew we were going to be here today because the announcement for being here today has been out for quite a while. I don't know. I thought it was a mistake. I thought John Jennings, who is our legislative guy. I said they made a mistake. What they meant to say was that in addition to the director of DARPA these other guys can -- the secretary can act through them, too, which seemed to be the more logical thing to have done but apparently -- I still it might be just a simple mistake. We'll find out. If it's a mistake by July 4 that will be corrected. I'm done. I'll be around for questions later on. I really welcome you, glad to see you all again and remember, we'll have some questions and see you along a way and if not here we'll see you at the undisclosed city in the western part of the United States. (audience comment, inaudible) Oh, yeah, I'm not really sure if Ron isn't the problem, you see. So just in case, as you know Jose Negron was the first program manager, the first Grand Challenge. Ron is the program manager of the second Grand Challenge. Ron is still my Chief of Staff doing a thousand other things. We have a new program manager Norm Whittaker. You'll see him in a little bit. Stand up. [APPLAUSE] I think he went and bought a suit just for this occasion. I've never seen him with a suit on before. But Norm will be the program manager and we'll answer all your questions and get you through this. [APPLAUSE] Ron Kurjanowicz: So as you can see, Can you put the agenda back up again? Just to talk through a few things. I'll cover through the Grand Challenge 2005 and tell you a couple of inside stories that maybe you weren't aware of before from being there on the inside where I did have dark hair before it started and it's now gray hair. So, we're watching Norm's hair.

Then Norm will come up and go through the program plan. We'll take a break. As you can see we'll do the rules. Kristen Fuller, would you mind standing up Kristen, she's the contracting officer. She'll give you a brief on the proposals particularly for the track A and then we have a period for questions. So what I would like to recommend is that you probably hold some questions until the break and then to the question area and then we'll all sit up here and answer your questions. Next slide please. It's hard to believe but that's a history slide.

Next slide, next slide. There. Not even a mother could love. That's where it all started. 195 applicants. Almost two years ago in August we gathered on the west coast for a similar type of event, the participants' conference. We didn't expect we'd have that many applications applying to participate in the Grand Challenge 2005. We had to have a video. All these teams had to submit a video and then we would do a site visit. Out of 195 we got nearly 140 videos which is absolutely incredible. Next slide. That moved them off to the site visits. We looked at

the videos and selected nearly 120 teams for site visits. A lot of you when we looked at the comments later on were very impressed with the site visits. But you don't realize we are not professional site visit people so we brought out the program managers out to a Reston park about two months before and trained them and I think you'll see the results. One point we always tried to make to them was don't go near the vehicle when it's moving down the road and we just looked at the film the other day and sure enough there is one of our ambitious program managers neck and neck with a robotic vehicle running down.

But it was a terrific -- we found it to be a terrific milestone to determine the capabilities of team. I think you felt it was fair. We'll do the same thing again with having a site visit and Norm will talk about the details of what that will look like later on. Next slide. Out of that site visit we chose 43 semifinalists. You remember the real number was 40 and then we picked alternates, which surprised everybody. But I think the alternates were pretty pleased to concur. One team went all the way to the final. That worked out OK.

As you can see what surprised us the most when we looked at this chart is that it was equally divided between the western part of the country and the eastern part of the country. There is no dominance at all in any part of the country about building the systems and the science behind autonomous vehicles. Next chart, please. Then we went off to the National Qualification Event. That name (on the slide) is not the right name. It's not the California speedway, it's the California wind way for people who were there. For the first couple of days we had 20 or 30 knots of wind. Dust blowing off the mountains and into our eyes and the whole bit. What you don't know is that we set it up to open the thing up I think it was at 10:00 in the morning and we had spent hours getting everything organized. We knew we were on track ready to go and we put the team names in front of the garages. How many of you know we put the wrong names in front of the garages? At the last second five minutes prior to opening the gates we raced around with all the trucks and moved things around. You thought DARPA is playing tricks again changing garages at the last minute. We raced around and did that.

Next chart. Some of you remember that. I think \_\_\_ you did this just to prove they that did it in 2004. They are going to do that again. They like to roll vehicles. We looked at this for a second and we honestly thought this has to be the same picture from two years ago -- nobody could do that twice in a row.

It was exactly that. They did this seven days before the national qualifying event. Congratulations to that teams and every other team who obviously had vehicle problems that they worked until the last minute to get ready for the national qualification event. Next chart, please. That's what we set up as a track. We picked that as we said before, to mimic some of the conditions that you would eventually see on the course and we changed it from 2.2 miles

to 2.6 miles depending upon the event and we had the start chutes. We mentioned earlier that given the first National Qualification Event when it occurred for the first Grand Challenge some vehicles had a hard time getting out of the chutes.

When we stood on the track after spending days getting organized and we're tired and you're tired as well and Mojave was the first one out and they completed it and they completed it with a couple of minor infractions on some of the cones and stuff. We knew at that moment we had a race on our hands. And for the next few days we continued and we had, as you can see on the lower left-hand side we had Terramax and Ghost Rider. We were wondering if Terramax was going to give it a lift at times off the track and drop it off the back. We also introduced something new. We took away GPS and that will be key to the next race with the tunnel and we tested it ourselves and sure it knocked it all out. Next chart.

Here were the people who made it through the National Qualification Event. It was a tremendous accomplishment for all the teams that participated in the national qualification event and in particular for these teams whose vehicles made it at least once around the track and in some cases a lot more and they came from around the country. No one owned the rights to these autonomous vehicles. Next chart, please. Off to Primm, Garden spot of Nevada. We drive there 6:40 in the morning but we all know that the night prior we had the barbecue party, we had the singer and as we get up in the morning 4:00 in the morning handing out the disks. Nobody really slept. Next chart, please. I want to tell you something as the race started. See the fellow on the phone at 6:40 in the morning. This is the first call I get into the command post. There are 12 loose cattle on the route and we don't know where they're at. [LAUGHTER] Now, this is where I also discovered that female cattle can have horns. So everybody looked puzzled and looked at me and said what do you want to do? I said "Let's try to get them and recover them". We had people on horseback and land rovers out there and recovered those things within two hours and penned them up. But that was the first call we got in the morning. Next chart. That was the route. It's easy to look at this chart now but it took us months to get this route together. \_\_\_\_ had a flat on the day of the race, I had three flats putting this course together and there were a couple of scary moments where it's like Thursday night, I am in the truck alone, it's getting to be 5:30 and 6:00 at night and you get a light on the dashboard saying you're losing air and you're in the middle of the desert. I had three flats on that route. We had a number of challenges. Each one represented different things. Even on the wake beds where you couldn't use your sensors very much and that actually played a part in the race itself. The close obstacles in the lower right that's where Dr. Tether worries that's the power lines of Los Angeles. If somebody hits those and knocks them out we're in big trouble. [LAUGHTER] He had his ticket, where are we going? We were on our

way to South America. Howard Steers who is here and worked a lot on the route in helping get it ready went back and took a picture. One vehicle, a very large vehicle, passed within one foot of one of these poles. One foot. But that was part of the philosophy we had for the event. Dr. Tether was clear about talking to all of us in chase vehicles that we were going to let the vehicles go.

We realized there were obstacles out there and we were not going to be overly cautious. And I want to tell you, having talked to a lot of folks that chased vehicles afterwards. Everyone got a fair shot and in particular getting close to the poles where a lot of guys said my heart is racing like crazy, 10 feet to the pole. Do I hit the pause switch and the vehicle would turn away and they let it go so everybody had a fair shot. In that case it was within one foot.

The other thing about this route inside stories that you may not know we were out working in this area because we had problems with tortoises in California.

We think we had a route and lo and behold, Clark County buys a piece of land to make an airport and they shut us out. They bought a big section in the middle of this and we had to negotiate to open that up again. The other thing that scared us and many of you were out there and saw it were the rains. Unbelievable how water can collect and we were lucky. We were able to hold the event in between drenching rains two weeks prior and drenching rains that occurred a week and a half after. Next chart. That's the one that got us all nervous, Beer Bottle Pass, Mile 123, a narrow road with a cliff. We would drive down as we were testing the route and we drove it a number of times testing route and we would drive down as human drivers and we would inch our way down pieces of this road because it was a huge sheer drop off to the left. And all the guys we talked to in following the robotics didn't care. They just went right down, unafraid. So it caused some of our professional drivers to push it up a bit because they weren't going to be outdone by a machine. (laughter) They went down. We also had many discussions, OK, if a vehicle goes over what do we do to recover it? How do we get it out? Do we worry about fires? It proved to be challenging and very rewarding to see the vehicles get through. Next chart. What I would like to do is show you a video some of you may have not seen this. This is about the Grand Challenge experience itself and I think it captures all of the key moments.

Run the video please. (video plays) We have the 23 finalists come up here.

It is going to be a very interesting, very challenging route. All of you are winners. This is not meant to be easy. It is meant to prove that autonomous vehicles by the year 2015 will actually be part of the military inventory by a total of 30 percent. Ladies and Gentlemen, Highlander. And we have movement from Stanley, Ladies and Gentlemen. [APPLAUSE] Bot number 19, red team's Sandstorm.



Ladies and Gentlemen on the ground, Challenger. Ladies and Gentlemen, TerraMax. That's what it's all about. Military vehicles being autonomously driven from point A to point B and beyond. It's going to be interesting as the bots come through beer bottle pass. Beer bottle pass has a 200 foot drop-off on one edge.

We're seeing the fruition of the dream that Dr. Tony Tether had about autonomous vehicles moving across the desert within a time frame. Once again showing that DARPA turns dreams into reality. [APPLAUSE] The check goes to Stanley.

[CHEERING AND APPLAUSE] Another page will be added to the history books, the DARPA Grand Challenge. [APPLAUSE] Ron: Congratulations to all of us. What a great experience. These are the results. Somehow the line got turned around.

The 2004 distance seven miles was the first time and everybody just got past that. We're often asked what was the key difference between the two events?

How come so much progress in 18 months? And certainly, we talked about now the teams had a better understanding of what the route would look like after the first event. Some more teams got involved. More integration, more testing.

But I think for me personally what it really boils down to is one simple sort of adage which is never underestimate the power of people willing to take on a challenge and that's what you're all here for, the next challenge. The next chart, please. The vehicles, Stanley came in first, the average speed there was 19.2 miles. Our objective was to get it up to those speeds because those are military relevant speeds and that's exactly what happened. Next chart. Sandstorm. Fairly high at 18.7 miles. Absolutely phenomenal performance. And next chart. Highlander, again fairly high at 18.3 miles. How many of you saw the Nova film about robots and Kevin Peterson, I still remember this one shot he's sitting there with a keyboard and his hair is all fluffed up he's got maybe two hours of sleep. He has this wry smile and he said I'll sleep when it's over. He worked so hard on that thing. Congratulations to them. Next, Kat 5 Wall Street Journal has taken a number of stories on this team coming back from the tragedy they suffered in New Orleans and actually have a vehicle finish. This was late in the day when they were coming on and they met with the chief judge and had a discussion this is a nighttime recovery or do you want to let us stay overnight?

The chief judge said what do you want to do? They said let it run. And sure enough if you look at the films this thing came in and was pretty much almost pretty much dark when these guys came in. They weren't worried. We were more worried about the drivers having to follow them but they made it all the way through. You can see the headlights in the lower left-hand picture. Next chart. TerraMax, the first, in history, the first overnight operation of an autonomous vehicle. We shut it down when it got dark. It then spent the night out in the field

staying in pause all night long, engine still running and low and behold in the morning at first light put it into run and the machine moved Unbelievable. Unbelievable. It continued down the track and this is the one that kept our hearts pounding. Another one the team met with the chief judge he said okay it's getting late do you want to tackle beer bottle pass? Yeah we came to go all the way. We're going all the way. The next chart. That is a tire track.

That's beer bottle pass tire track. Living on the edge, close to the edge.

Some of the spots going down beer bottle pass were too tight to make a turn so it had to back up, reorient itself and go back down the road. In that one case the folks chasing them said the rear left wheel was absolutely in the air spinning and the front wheels grabbed and pulled it forward. Living on the edge but it made it. Next chart. That's it. That's the Grand Challenge 2005.

Great experience but I'm sure that it will be well outdone by the Urban Challenge that you are all here and interested in participating in. So what I would like to do now is introduce Norm Whittaker, the program manager for the Urban Challenge and good luck to all of you. [APPLAUSE] Norm Whittaker: That video always makes me cry. It's nice to be here. There is no place I would rather be on a Saturday afternoon than talking about a robot race. The game plan today is we'll start talking about the program up front and then we'll take a brief break and go outside with we set up an incredible art show in the street to take a look at that. [LAUGHTER] Then come back in and we'll go through some of the technical criteria after the break and a lot of time for Q and A and try to answer the questions. We'll hold most of the questions until the end.

The program objective is safe autonomous driving in traffic. What we're really thinking about is no collisions. We are focused on this but we aren't trying to take all the problems on at once so we're focused on vehicle to vehicle interaction. We're taking the pedestrian issue out of it. In addition we've partitioned the problem so we are focused less on the computer vision aspects. We are putting some information in the database like location of stop signs and so on. We've tried to put a box around the problem to make it a little more tractable and make is so we have a little bit of success by the end of the program. So no collisions, that's really the game plan here. Capability is the other issue -- turns, stops, stopping at stop signs, queuing up at stop signs, proper behavior at intersections, detecting other vehicles at intersections, observing precedence order, passing, we're going to have a lot of passing in this one, merging, stop at a stop sign and merge into moving traffic, parking maneuvers, and safe following in traffic. All those things. It's extremely challenging, we know it is. We'll try to lead you step-by-step and test the bugs out of the vehicles by the end. So we really hope we'll get vehicles who can run the event. Robustness is the third issue we're looking for, blocked roads

so we'll purposely block roads. It won't be in the road definition. It will happen in the morning of and you'll need to be able to dynamically replan the route. Erratic drivers. It's one thing to test in a sterile environment where you know what is going to happen. The vehicles are in the middle of the road, they are coming at certain speeds, they are sort of doing predictable things. But we know the real world is not actually like that. So by the end of this program we'll have at least some components of that erraticity in the test and your vehicle will need to have an algorithm to cope with that and succeed. Sparse way points. That's another issue. We're not looking for bread crumbs but on the other hand it's an urban area and you will be relatively confined so it's a good chance you'll be out there putting down sparse way points if we don't. So we'll look at the roads that aren't on any map or in any database. We'll give you the database, we'll give you some sparse way points on there. You won't be able to see the road in imagery that you buy because it won't have been there. Sparse way points could be on-road or a dirt road, GPS as well. If you work with GPS, especially differential GPS, you know outages are frequent. You get blockages and we can't have vehicles simply stopping in the middle of the road for 10 minutes and waiting to recover signal. So we need those INS up and we need the markings so we can continue driving. What you're going to see is a tension in the program between the need for safety and the need for effectiveness. Safety on the one hand leads you the cautious solutions. But we really can't have people stopping on the road. We need effective solutions with enough aggressiveness that you can get the mission completed. As we go through you'll see some of the technical requirements are sort of pushing one way or the other to try to make the best vehicle possible. Next slide. Program scope. This isn't a full statement of the program scope. We will have passing, we will merging into traffic. Every road won't be a paved road. There still could be dirt roads. It won't be challenging terrain it will simply be a dirt road.

You'll need to be able to detect that road, visually or using some other sensors. As far as speeds go. Speeds greater than 30 mile-per-hour. When we look at 30 miles per hour it is a pretty scary speed for the vehicle a speed for the vehicle so that is really the max, it should be quite a bit less than that.

Highway driving is out of scope as well. There are no on ramps or off ramps. They will be multi-lane roads. Traffic signals are ill-timed. Some times when they work into our pictures we show intersections but there will be no red lights, no stop lights. Intersections will be a stop sign intersection. Sometimes multi-way stop signs. Sometimes stop and pull into moving traffic. Not difficult terrain, as I said it's just out of the picture. Next slide. Okay, Rules and the PIP. One thing that Tony didn't tell you was the format for this, the reason it's confusing is that it's being invented before your eyes.

There aren't other programs that have been done before which have a prize track and you contracted track and so this great experiment takes us a little while to get all the pieces exactly right. The rules will apply for both tracks.

Certain parts of the rules will apply only apply to the prize track and it's laid out in the rules. What we've published so far if you've looked at the website, we call them draft rules. We have a two-week comment period and we welcome your comments. Read them carefully and send in and we'll consider everything you send in. We won't guarantee it gets in there but we'll consider it. The PIP, the program information pamphlet that was published on May 1 it has some of the same criteria and it has all the rules you need to participate on the track A. The technical parts of those two and some of the eligibility parts that are intense but they are consistent. Right now there are certain inconsistencies with the rules and we have better information. Right now the rules are better than the PIP in that regard. Our intent is we are going to publish modifications to the PIP bring it in exact alignment with the rules. That will be the next couple of weeks. It won't be a grand change, it will be small things. You saw the change, for instance in vehicle qualification rules. It's something like that, we tried to more specific with some items that people have brought them up. So the objectives will be the same. Next slide. This is just a general statement – We are not making new rules today. So If I say something and it doesn't sound quite right or if you talk to somebody afterwards from DARPA and if you think that they told you something it's not permission to go do it. The thing to believe is what's written. We're going to give you heads up on some of the writings that will change and I'll give you a heads up today so you'll see some new things but really at the end of the day it is what's written down that counts. Next slide. I want to introduce a few folks to you sitting down at the table: Harry Berman, Jon Hahn and Sean O'Brien. They know where the information is in the PIP and in the rules are in the RNDF document.

They are pretty much the authorities on that stuff so If you can catch them. Put your badge back on (laughter) Get these guys with their badges on and corner them after this is over and ask them questions. There are a number of other people in the audience from DARPA. These folks are two grand challenge veterans so they know how it goes in the Grand Challenge. If you're new in the audience find one of those DARPA people and ask them, they have a lot of knowledge. Next slide. The game plan. I'll give you an overview slide, more or less an overview of how to participate in the grand challenge. We'll go through that soup to nuts and then we'll start going over some of the programmatic details. Kristen will get and talk about track A, I'll give you track B and then we'll be ready for a break. Next slide. It's six simple steps. First form a team. I realize they aren't exactly in order. Then select track A or track B. The flow chart in the in the FAQ on the website, that may help. Even on track A you have

more decisions to make but we'll try to help you with those as well. Then submit an application or a proposal. An application for track B, a proposal for track A.

When you submitted that proposal or application you already have selected a platform for your vehicle so you needed to know. But that's an easy step, a single bullet, simply develop a vehicle that can qualify with the different criteria. (laughter) Go through the qualification process, how hard could that be. And then compete, final step. Next slide. We're going to break it open and –drill point by point. First form a team. In the rules it says there is – no, let me talk about track B first, the prize track. You need a team leader. The team leader has to be 21 years old at the time that he signs the application. And needs to be a resident of the United States. That's a new rule. The residency requirement we'll talk about what it takes to be a resident. I apologize it is not in the rules. We'll try to catch that up as soon as possible. It's additional paperwork you'll have to turn in. You need to be, In addition to the team leader the next components are the team members. We don't test anything having to do with the team members. The only rule is that team members can only be on one team. We have been looking for distinct entries, not merged teams or multiple entries from joined teams. We are looking for individuals that are only on one team. In addition to that we're looking for sponsors. You may have sponsors, we'll list them on the website. And I'll give you an example of how that plays out for a typical team. There are no restrictions on sponsors unless you are using assets that are government assets. For example using money from a government contract and apply it to the grand challenge. We need to get more information on what you're up to there. You'll see that in the application.

Next slide please. Documentation Requirements. There are two kinds of documentation that will be required. One is for the citizenship. Second is for the residency. The citizenship requirement, you can either make a photo copy of your passport. It turns out that an expired passport is also legal citizenship documentation. We'll take that as well. Alternatively a current driver's license, can't be expired, or birth certificate. Make a copy of those and send it in with your application. That's all sufficient and you're checked off. When you have a site visit later on at the site visit you bring the same documentation to the DARPA people who are there. In addition to the residency requirement, Before you get too worried remember this is part two of the application. If you read the rules. You know it's due on October 5. If you're outside the United States you actually have time to come back to the United States and establish residency before that time. What we need are two of the following pieces of paper. A payroll stub issued by your employer in the last two months and it needs to have your name on it, a utility bill not more than two months old issued to the team leader. An example of the different things that are acceptable: receipts for personal property taxes the last year; a

current automobile life insurance bill; a voter registration card from a US state; a mortgage, a monthly mortgage statement; residential or rental lease agreement. The people who are watching this on the -- off site they don't see this slide, I apologize. This slide will be on the website on Monday. These requirements will be on the website on Monday. This is more or less what it takes to establish residency in almost any state. All these things are sufficient. Make photocopies of two of them, put them in the application and you are good to go. So the PIP and the rules will be changed to reflect that. I know the FAQ on the website now says residency doesn't matter. That's a mistake and it will come out, we are going to fix that. Next slide. A lot of the questions we have are from people who work for small companies. A small company says I want to enter a vehicle in the Grand Challenge. I don't understand the team leader and all this stuff. So how do I do this? Well, in that case there is an individual who is selected, Mary Engineer in this example, who is going to be the team leader and she satisfies all the requirements that we talked about. She is the team leader, the team members are the other employees or others who are not employees who are selected and put on the team. The company becomes the team sponsor so the company does not enter the vehicle, DARPA has a relationship with a single individual, the team leader. We do allow -- we did last year allow the company to sign some of the legal forms, for example, the liability waiver and things like that. The team leader didn't want to do it, we had somebody from the company do it. We worked with you guys to make that all happen. Next slide.

Step 2. you've got your team formed, it's time to select track A or track B?

This slide is intended to show that really except for the upfront part there isn't that much difference. There is a little more green in the top track than the bottom track. More dollar signs. You did a lot more work up here writing the proposal than you did in the application. The top track the proposal is sent in.

If you're selected, if the proposal is selected you go through negotiation, the announcement happens. In the fall, in September you'll be on track A you'll have a milestone meeting in September there will be milestone one. You will need to submit a plan. Your development plan for that, there is a first payment, about half of the contract award. Half the contract award is all upfront money. The rest of the money you actually have to go earn. The first milestone really is a meeting. The second milestone corresponds with site visits. Site visits takes place on track B and track A we go to milestone two. If you make it through the site visit and selected to go on you get 50k. When the 50K comes when you arrive at NQE the money is not because you did a good job at the site visit but the money is because you're bringing a vehicle to the NQE and and participating in the NQE. You need to get to the next level to get the

money. At NOE it's the same deal. If you make it to the National Qualification Event and participate in the in the final event that's when you get your hundred k.

Also payments on track A are more typical. 50% and then 25% and then -- make sure I get it right 15% and then 10% or 10% and 50% for the final milestone payments. Money at the end is the same for both tracks eligible for the three prize slots. From there it's all the same. The final milestone payment from track A comes when you turn the final report in, and that's due Dec. 31, 2007.

So just because you finish the race -- you know the big check that you got, that you can cash but the final milestone payment you can't get that until you turn the final report in. Next slide. So comparing tracks. The tracks are actually similar to this. Proposals on track A this application is on track B, track A has an optional video that you should be making right now because it's due June 23. Track B has a mandatory video but it's not due until April 3 of next year, and that is used for selection. The rights are different. The government claims government purpose rights to any technology that's developed on track A. If you are not familiar with government purpose rights, it probably shouldn't be the deciding point for going track A. They are not very strong. You still own all the rights to your technology. You can pepper Kristen with questions about what those rights are. For most people in the industry it doesn't scare them off. The government claims no rights at all to technology on track B. so the technical criteria on each track is identical. Next slide. So step 3. In track A you send the proposal in the required format with the optional video. In track B there is a four part application that you need to fill out. We had to break it into parts because some of them are mail in and some are email in. the first is due on October 5, 2006. the reason we pushed the application date up so far is so that people can get through the process on track A. Even if they were selected and couldn't get through the negotiation process in September there is still time to get an application in on time. So if you are on track A and not selected we'll take your paper work and talk to you to get you over on track B and the video is mandatory. Next slide. Government Participation, this is kind of inside baseball for government organizations. We have had quite a few questions in the mail box from state universities. They say 'you put something in the rules about government participation, can we participate on track A. And the answer is yes. When we use a big G for Government That means Federal Government. We neglected to tell you that but below the federal level it's unrestricted participation, either track. So with state universities there is no issue there. And at the federal level only on track B and only if it is consistent with your charter. Some \_\_, some national labs, they are allowed to participate in competitive events like this where they compete against commercial, some of the DOE labs can do that while other labs can't. So they really need to look at their charter

and come back and tell us whether they are able to do this or not. Next slide. As far as funding restrictions this is another question that comes up in the mail box. People say 'you know I'm in track A and I am getting a million dollars. Can I spend other money in addition to the million dollars to develop my vehicle? The money from the government isn't intended to be the only funding source. You can raise as much money as you want in addition to that. Now the use of government program assets, I touched on that just briefly. If you have a government contract, a SBIR, small business contract or you for some reason have a government vehicle, a government robot and you've been given permission to use inside the Urban Challenge we need for you to tell us about that inside the application because there is a question there about and we need to get in the POC, the phone number and name of the government program manager who is giving you permission to do that. We're just trying to connect all the government dots together as far as the program goes. Next slide. OK, developing a vehicle.

Now, we've had a little bit of back and forth. We put the PIP out and the PIP said that we needed to have a full sized commercial vehicle, a production vehicle or a vehicle with a documented safety record and what we were looking for when we said production vehicle we have concerns about experimental vehicles for the Urban Challenge. Vehicles that are production vehicles if they get in a collision there is a certain amount of collision testing done with that vehicle and it's unlikely the accelerator would be stuck on or that you would rear end it and it would blow up or something like that. A lot of the testing that has gone in the production vehicles have taken out those bugs whereas in the experimental vehicles we're less confident that has taken place. We went through and looked at last year's participants and looked at the weights and did a lot of analysis. We didn't come up with numbers -- 2,000 to 3,000 to 30,000 pounds is the unladen weight, the manufactured weight as delivered from the manufacturers with a full tank of gas. Some people have come and told me that the vehicle manufacture comes with a whole bunch of sensors, do those count with the weight? The answer is yes. If they were manufactured like that, that's part of the unladen weight. Wheelbase issue is another one, 72 inches is what we chose for the minimum. The maximum is set by practical concerns. If you take a two lane road which is 30 feet wide with curbs on either edge you need to do a U-turn inside that curb. It can pull 3-point turns but it needs to be able to do the U-turn. So if you're fire truck or a school bus or whatever it is you want to enter can do the 3 point turn, go out and do that test without climbing the curbs at either end, then it meets our needs. We don't have any other requirement past that. We looked at last year's vehicles and the criteria. It cut out a few of them. Most of them had an alternative vehicle already they talked about on their websites and we think this is a pretty inclusive rule.



So we talked about the production vehicle and the documented safety record. You might ask what is a documented safety record? We would be willing to talk to you about that if you have a vehicle that's a specially manufactured vehicle but has been used in races around the world and survived collisions and so on.

That may pass the test. If you have a military vehicle that has safety testing that may pass the test as well. So we would be happy to work with you on what it means to enter a safe vehicle. Another requirement for the vehicle, this is the same as last year, a manual E stop is required and the manual E stop is something that would be on the vehicle for the entire event and is something you want to have on there. It is basically the panic button on either side of the vehicle that will disable the vehicle if it is getting away. So it needs to be visible and labeled on either side of the vehicle. You can read in the rules exactly what the requirements are. We've taken off the requirement that it's labeled in Spanish. It just has to be labeled in English this year. Similar to last year, wireless communication with the vehicle is prohibited. That's a good rule. I put "see the rule" there because it is a complicated rule. I understand that GPS reception, that's wireless communication. I understand that our tracking system is doing wireless communication. If you're receiving navigation signals that's wireless communication, all those things are allowed. you can emit with sensors and receive returns. What you can't do when your vehicle is autonomous on the course is receive any kind of guidance or control signals and you can't download data. You can't stream video from the vehicle or do anything like that. If you're wondering whether it's doable, send me an email on the bots and we'll help you figure it out. Warning light and audible alarm those two are the same as last year. You need a police, bubble gum machine on the top with a yellow light that goes around when its autonomous. Look carefully at the requirements and rules. It's changed slightly. We have some safety concerns.

Right now the horn, the audible alarm that beepss intermittently and the warning light need to be on when the vehicle is in run mode only. But when it's in pause they need to go off. Ron actually very cleverly caught a safety bug in that.

In addition brake lights, that was in there last year but directionals weren't in order to tell the people watching what the vehicle is about to do you don't expect the vehicles to see each other's directions. If you want to try to do that that's fine. For the people watching, we have many observers, it helps to interpret what the vehicle's intended path is to see the directional go on and to see it turn. We need to see the directional turn go on to make the turn and then see the directional go off. That's a new this time. By directionals, you know it's the signal light in front and back. Now, this is a new requirement this year, last year we let some teams at their site visit have a rider in the vehicle. It wasn't recommended but if they didn't have a way

to do an emergency stop with the vehicle we would let a rider go in there, put his hands like this and hit the brake if the vehicle started to run amuck. We're more sophisticated now. We've got a much more capable community as we have gone through this process. We're requiring you to have a wireless E stop for the site visit and you want to have it for testing anyway. It doesn't have to be a government E stop. It doesn't have to be one of the omni type ones that we buy. Those are multi-channel and have expensive radios in them and cost \$10,000. You can get it cheaper you can get \$1,000 version if you look around. If you don't know that, shop around and get something that will work for the site visit. It needs to be able to ride in a vehicle behind the robot and stop it. That's a real requirement. As before, we will, once we pass the site visit, we'll ship you our E stops, GFE, government furnished equipment. We're fixing the switches on them.

I don't know if you had experience with them before. We're trying to solve some of the bugs. They still work pretty well and are pretty reliable. We'll soldier on, probably the same design. That hasn't been fully decided yet. The vehicle requirements that you have in the PIP and in the rules will change slightly.

They'll become more specific in the PIP and be the same in both. Expect that over the next couple of weeks. Next slide. We are already up to step five. This was easy. You've developed your vehicle. You have made it through the application process. We'll talk about this in a little more detail. The application process included the part 4 of the application, the demonstration video. I'll tell you all about that. The next section. The qualification process informally includes the site visit, milestone 2 for track A and NQE which are milestones three and four. Why are there two milestones at NQE? (inaudible) It will be a little bit different. So stay tuned. Don't make assumptions about how it worked before. It is going to be different. Next slide. Here is the site visit detail and I almost used a slide from last time because it really is similar. The dates inside the PIP are a little wrong. I think they say June 1 – July 15. We're trying to help you schedule your vacations so we've nailed down a time July 11 is, June 11 is the start. We tried to get them in the first two to two and a half weeks and we needed to budget more time for make-ups that's the rest of it. Most of us these visits won't be in July. They'll be in the end of June in 2007. As before, you will choose the location, the location will be in the United States. If you want to take us to Hawaii that's fine, we'll go.

Alaska, we even did that one last year? We don't have really the budget to do international travel so everything takes place in the United States. You choose the location, we choose the time. We'll choose the time when we can work with you to a very limited extent. You will drive DARPA crazy because there are so many teams that need to be scheduled and we have just a limited number of site visit teams to come there to visit. We'll need you to block open a

morning or afternoon in that time for us. When we tell you which morning or afternoon to block out. Last year they were 2 1/2 hours max. It is more complicated this year so we're leaving four hours for the site visit. It doesn't mean you need to fill four hours. It could happen pretty fast but we're budgeting more time because there is more set-up involved. I haven't told you what an RNDF is but if you read the rules you know that's the route network description document file. The RNDF gives the route. The team will produce an RNDF for their site visit. They will send it to us in advance and we'll look at it. We need that RNDF when we show up to know what we'll be facing. That's actually, I think, a March 2, 2007 requirement. We're asking the team, when we arrive, our DARPA guys will show up with a vehicle. We're asking the teams provide two vehicles in addition to their autonomous vehicle. One of them we're calling the traffic vehicle. If a vehicle gets crashed into by the bot it will be the traffic vehicle. Don't use mom's car. Use somebody else's car. [LAUGHTER] Younger brother is a good choice. In addition there is a control vehicle. The control vehicle is going to function like the DARPA control vehicle, it's a following detail. We'll lay out the details of how that's going to work so be prepared for this request. Two vehicles in addition to the autonomous vehicle. DARPA guidelines will be published with a full list of additional things we'll publish. So this is not the full description you heard today. The NQ selection announcement is on or before August 10 of 2007. As far as the format of the site visit if you haven't been through this before, typically two DARPA officials show up, they meet with the team leader. The team leader shows them, remember, he needs the documentation of his citizenship and residency. Send photocopies and we need to see the original at the site visit so put it in a file and save it for the site visit. He verifies all that stuff. In this case he'll give an MDF, a mission data file that will tell the vehicle what to do on the RNDF. So we will be controlling. We'll be setting the track of the vehicle inside your route and you won't know until five minutes in advance. You'll need to be able to read the files at the site visit. That's an early requirement in the process. Next slide.

MQE. I think it says October 20 – 31. In the PIP it's 21 to 31. The location to be announced. Don't make the assumption that it's a track again. Teams must arrive prepared, that's a good assumption. Don't assume that there is going to be practice areas to finish your integration. Assume that you'll have to get on the course and go. The first step always is that safety test. You'll test the integration of the government E stop, we'll need to see how that works. We did that by -- we first inspect the vehicles the pause and disable modes of the E-stop. It's kind of a standard thing. I think everyone passed last time.

The NQE we broke into two pieces, you'll understand a little bit better. What we'll do first is called the advanced navigation test, a non-traffic test, no collisions except with static vehicles.

The vehicles will be given an MTF and once or twice there is a complex route they'll have to run successfully within time to actually qualify for the second half of NQE. If you pass the first half and you are on track A, you've passed milestone three and you get your payment.

Milestone four is different. The second half we'll talk about that. It's not going to be run a route and if you make it through you passed. Because of the traffic and the nature of traffic we can't really afford to let vehicles that are not fully competent. It will be more like 20 times repeated tests of merging into traffic, 20 iterations. We'll need to see how you do again and again and again and again to prove that you're actually competent in NQE. A little different than last time. If you make it through this you have a very good vehicle. That's the repeated test in moving traffic and it is all intended to prepare you for the final event. The tests we put are not just arbitrarily chosen except when we put hay bales on just for fun. We love to watch what happens when we put hay bales on the NQE courses. Except for the hay bales everything we put there is directly linked to something that's in the course in the final event. So our goal, let me say that, is really no collisions. This is not a demolition Derby. We'll see very capable bots and if we don't get capable bots we just won't have the event. That's an option that's on the table. You must be able to pass the second half of the NQE in order to move to the next step. The next slide. A question that always comes up is how many teams? This number has been released. How many teams go to NQE on track B? The answer is, there could be 20. We can hold 20. There could be fewer. Once again, you have to be capable to actually qualify. It is not worth anyone's effort to bring the vehicle there if it is not going to effectively compete with the other vehicles. If track A passes we'll do as many site visits as we need to. If we get good videos from you we'll come. If you have a qualifying vehicle and you check the boxes we'll be there for a site visit. We'll pick something like 20 to move to the next level to NQE. In Track A, the 10 teams that, or fewer teams, selected in the beginning will be automatically given site visits. If you pass the first milestone, you wrote the plan, you are going to get a site visit anyway as the director pointed out and so some fraction of those teams will actually move to the next level. Only fully competent vehicles will move to the final event.

I'm not a betting man but it will be tough to actually make it to NQE to the final event this year. It may take a few iteration of Urban Challenge to actually make this work. Be prepared. We aren't going to dumb it down and just let the vehicles in there who seem to be pretty good. Let me tell you how the final event is going to work at the Urban Challenge, This is a schematic thing so you get an idea of what we're thinking. If you read the documents you know what an MDF is, you know what an RNDF is, you know that you have a route network which has been defined. Doesn't have a start or endpoint really but it has checkpoints a defined checkpoint. A check point is an identified way point someplace on the ground out

there that is achievable by a vehicle. You'll be able to drive over it. It's not mixed with a telephone pole or something. This example shows five checkpoints, I think they should be labeled 1, 2, 3, 4, 5 instead of A, B, C, D, X, but that's a bug. Whenever one of these stars comes up, that's a checkpoint. Here is the urban route number. It's shown as a grid.

It doesn't mean the actual thing will be run on a grid but that's what Power Point made me draw. (laughter) All vehicles will be on the course at the same time. They will start almost simultaneously, the time difference we're going to measure that to compensate for it but they will be on the course at the same time. These will be very competent vehicles going at modest speeds and they will be completing equivalent missions by visiting checkpoints. I use the word visit, that's the one that ended up in the rules. Visit means achieve the checkpoint and I will tell you how you do that in a minute. The first question that comes up is see the checkpoints, what is the actual event look like? How do you create equivalent missions? Let me give you an idea how you might do that in the next slide. If you were to erase a bunch of those blocks and take them out of the route network and leave the four corners, connect them in the middle by something that is a traffic circle or it could be a four-way stop, by connecting them like that I can set up routes that ping-pong across the center point.

So I send you to a checkpoint up in the corner and bring you back to the center point. You have to go through that intersection or around the traffic circle in the middle. I take you to another corner then you and bring it back to another corner, bring it back to another corner, bring it back. All the teams are doing that. So there is sort of a guaranteed traffic load in the center and you're achieving the same checkpoints but in a different orders. The example shows four in between there, that's the checkpoint. In order to drive you back to the traffic circle every time I need to use checkpoint four, so that's in between, 1, 2, 3 and 5. I can send you the same track more than once. This sort of guarantees that the minimum distance how I tell you it is going to be 60 miles.

If you look at it with a relatively modest number of vehicles it's a relatively small size route area in order to get any kind of traffic interaction.

This kind of guarantees me some tense traffic interaction at the center point.

Next slide. Many equivalent routes are possible. Next slide The final -- here is another really fun thing about the final event. The route network first of all, the RNDF, we'll tell you about that at least 24 hours in advance. We've made it 24 hours in advance originally but I wanted to do it a month in advance. At the last minute we find bugs in the network where there is dangerous places or things we want to take out so we've given ourselves a day beforehand to get the work out. But you'll get an early look at exactly what the route is. The challenge is the traffic, not what the route is. You'll know all about the route. And teams will perform multiple

missions. A mission is a set of checkpoints you have to visit in order. Remember the idea here is the mission is a set of checkpoints that you have to visit, in order. In this case the missions will always start near the start area and visit a lot of places and bring you back to the start area. So when you come back to the start area I'll show you how it works. You will get another mission. And the clock will be running when you get your other mission. So you are going to need a pit crew with your team who will be at the start area to take custody of the vehicle, load the new mission onto it and get it launched back out into the route as soon as possible. One of the vehicle requirements we've put in there is a five-minute requirement on loading and MDF. You don't even have to test that. You can do it much faster than five minutes. To help you know the expectation is that you don't have a chance to get the route and study and analyze it. The vehicle has got to do all that and do it fast. So you're going to get a memory stick from us or a flash drive, plug it in and you'll go. Next slide. Let me paint that picture for you.

This picture shows the big box in the middle. It's labeled start area. That's where the start and finish will take place. On the right-hand side there is a big blue blob which is the route area. That includes all the checkpoints and everything. What you see is six, and that is just a random number, six start chutes identified there. Our intent in this case is that every vehicle that is running gets its own start chute. What you will do is your vehicle will come up there. There it is bot, Robot 12. Robot 12 is coming off the route on the right-hand side. It will come to the final mission way point up there. That was in its MDF that was the final point so it knows it has to stop at the final way point.

DARPA will take custody of the vehicle, E stop/pause it and turn it over to the team. The team's job will be to load the vehicle back inside the start chute.

You need to transport it over here and they need to load the new MDF in it and there are a limited number other mechanical things they can do at the same time. By mechanical things I mean they can wipe off the sensor if it's covered with dust. If they have a flat tire, if they want to take the time they can change the tire. They can't download information from it and study it and use it for future mission, no. It's just mechanical things to keep the vehicle going. Mechanical things that take 30 minutes or less. A minor repair you're able to do. You shouldn't take 30 minutes here. You can do that because you're not really blocking anybody else because you're in your own start chute. So you reload, you'll launch. You'll be back out and starting the next mission. And so the last grand challenge we see you guys just lazing around in the big tent drinking and eating so we said let's get those guys to work. You'll have to stay ready at the start area. Next slide. That was the overview. You get an idea of how the Grand Challenge is going to be run. We'll now drill some of the programmatic details into track A and

track B. If you looked inside the PIP we invented this job called contracts and agreements officer, the CAO. Kristen Fuller is going to come up here. She'll tell you about track A and lead you by the hand through the PIP and after that we'll go back and do track B and then be ready for a break. Thanks. [APPLAUSE] Kristen: Good afternoon, everyone.

As Norm said I'm Kristin Fuller and I am the contracts and agreements officer.

I could stand up here all day and talk about contracts but I know the rest of you wish I wouldn't. I'll make it as quick as painless as possible. Track A as Norm pointed out is the track that you'll propose to get a contract. This chart shows the basic information. Some that Norm pointed out to you, like when the proposals are due. Where the amendments, the BAA amendments will be posted, things like that. We can move on to the next chart. My title gave you a clue because under this BAA we're only going to be awarding contracts or other transactions for prototype agreements. So you need to keep that in mind as you're deciding what type of contract vehicle you wish to propose. All of your proposals must be entered into the DARPA T-PIN system prior to the proposal due date and we have instructions for that on our Grand Challenge website. And don't wait until the last minute to enter your stuff into T-PINS because you will need to get a password and there may be technical difficulties so you don't want to wait. OK. This is the part Norm said you'll pepper me with questions about and I'm ready. Not to worry. We do want government purpose rights to all the milestone reports and your milestone meetings and technical interchange meetings minutes and documents that come out of those. Anything that is intellectual property that was created whole or in part with government funding we'll need government purpose rights for that as well and require unlimited rights to your vehicle technical paper. If you bring in some existing IP to the table and you don't want us to have any confusion about whether you created it with government funds you'll need to submit this list as attachment E to your proposal that documents all the pre-existing non-commercial components of IP that you're asserting a claim to. That means you'll ask for limited or restricted rights to that data and there is more discussion of that in the PIP at paragraph 3.2.13.

OK next. And foreign access to technology. You need to notify DARPA if any of these arms export laws apply. And if you have an organizational conflict of interest we'll need to talk about that, too. We want an affirmation either describes one and how you'll mitigate it or that you do not have one. And the waiver and release of indemnity and liability. A copy of that is in the PIP at appendix C and you will need to sign and notarize that and include it as proposal attachment D. Any contractor agreement proposal that you submit should not address profit as an independent separate element. We're attempting this project to stimulate research and development and we're not acquiring goods or services. Those are two distinct things that

apply to profit. So what we want you to do with this money is actually apply it to your technical effort and use this money to promote your R & D. If you're interested in another transaction agreement there will be a model. There is a model included in the PIP, that's at appendix B, in the PIP. You should include that model, tailored as you see fit as attachment B to your proposal. If you're proposing a FAR contract you don't need to submit that document. Here is kind of an overview of the difference between a contract and other transaction. A contract you're buying, you're acquiring by purchased, lease or barter a property or service for the direct benefit or use of the federal government. That is a pretty broad definition.

Other transaction for prototype, however, is a little more narrow because you must be actually building a prototype project. You have to be working on a prototype project in order to qualify for that. So working on DARPA Urban Challenge is definitely putting together a prototype project. So if you're interested in that you may use that type of agreement.

There are three requirements forward -- you have to meet one of these three requirements in order to get a prototype. However, there are three requirements. You have to meet one of these requirements in order to actually get an OT for prototype. The first requirement is that you be a non-traditional defense contractor performing to a significant extent. And that means that either you as the prime contractor or as is subcontractor on your team, who is performing to a significant extent, doing a very important part of your project, is a non-traditional defense contractor. If you can't meet that qualification you could provide a 1/3 cost share and that 1/3 is of the entire agreement value. The other time that you could get another transaction would be when the senior procurement executive determines an exceptional circumstance exist but we don't intend to permit any of those in this particular solicitation. I mention that cost sharing was a possibility if you wanted to receive another transaction. Just anticipating there will be questions about that, we've come up with this chart to kind of explain what type of costs you would be able to cost share if they weren't actual cash contributions. We want to make a distinction between current costs and sunk costs because current costs would be something that you are acquiring once you receive the award a new piece of property you want to bring to the table and use as part of your cost share. For example, if you are going out to your local Ford dealer and buying a truck that you're going to install all of your sensors and other equipment on, you could say you bought that truck with your money and that's part of your cost share. Now, a sunk cost would be something that you've already purchased in the past and for example like your existing DARPA Grand Challenge 2005 vehicle. That would not be considered adequate cost sharing because it already exists and you would be getting the recognition for the value of that vehicle as part of your performance evaluation when we're evaluating your proposal. The best forms of cost sharing that you could actually propose would



be cash or independent research and development dollars, that would be because we can put a value on them. That example I made about the Ford truck, that would be -- we would have to determine that based on an amortization over a five year depreciation schedule technical contracting garbage. It would not be the full value of the truck. It's easier if you come to the table with cash or IRD contributions.

These are the evaluation criteria in the PIP. You'll find them in section four. They're listed in descending order of importance. The technical approach.

The management and funding plan and the strength of the team. We'll score each of those topics on a ratings scale from one to four where four is the highest rating and one is the lowest. OK. Now I need to ask Norm clarification because I want to make sure I say this right. In his presentation he told you only individuals can be on one team. But I believe the PIP says companies can be on multiple teams as subcontractors, correct? If you're a company, or university or the overall entity and you're proposing on Track A, you can only have one proposal per prime. And that is true for Track B also. Correct? But your overall team can be a subcontractor on more than one team. Just the individuals can be on only one team each. Teams selected under track A may not enter any other vehicles for either track. And, you notice I use the big G (Federal Government). Oh it is there. Government agencies may not respond to the BAA and that's the Big G, federal government organizations, not state organizations. The next bullet is that only a duly authorized contracting officer may obligate the government. So while all these guys are working on the program are great and they know a lot, if you have a contract that's awarded to you under Track A you should be taking your directions from a contracting officer, it should come to you in writing from the contracting officer. All the proposals that we receive are treated as competitive information, source-selection sensitive. So we will not disclose that information to anyone outside the government except we do hire support contractors to help us in this process but each of them will have signed a non-disclosure agreement. And that's it. Thanks. (applause) Norm: Okay, the quiz will be at the end. Next slide. If you don't understand the FAR track then it's probably not the right time to learn. You might consider the OT track. We are going to talk about team B for the next ten minutes, track B. The application is way simpler than the Track A process. The application is four parts. The first part is sort of the name, rank and serial number. We need a team leader. We also need a team leader alternate. That was very important last year. The alternate saved the day for more than one team. Doesn't have to be a US citizen but that's a key communications resource. Pictures and information that you send us we are going to post on the website. Look at last year's website, see what it looks like, emulate the template. We are going to use the same template this year. Vehicle technical information, that's all held

proprietary. We need a little information like wheelbase and all to make sure you are complying with the rules since we can check it later on at the site visit. We already talked about the use of government assets and the need to disclose that. Next slide. That part was submitted by email. This part is submitted paper copy. This is proof of citizenship but it's proof of citizenship and residency. We covered this part already, Part 2-B, waiver of indemnity and liability. It's the same waiver of indemnity and liability that's in the PIP. We've softened it up a little bit from last year. We looked carefully at what the language said and people had some reasonable complaints. So we have something that we think you shouldn't have any problems solving. It more or less says that you are not going to sue anybody because their vehicle crashed into yours on the course, in addition to a few other things. Signed and notarized. That needs to be notarized and stamped by October 5, 2005 so those are the two things you need to get in relatively early. Next slide. The third piece of the application is site visit information. That's easy stuff. March 2, we need directions and things like where is the nearest airport to the site visit location, remember you chose the location. We need that up front because we need to plan travel and try to get people some reasonable tours around the country.

We also need the route network definition file for the site, we already talked about that as well. So that's March 2, 2007, April 13 is when the video demonstration is due. Back in January, we guaranteed so there's a date in January we'll have the format for the video demonstration, we'll get it up earlier if we can. There is a drop-dead date for us where we're going to get all the format information for tech papers, video formats and so on off to you guys.

The video, a little bit tighter this time, .wmb. Five minutes maximum, we want it on CD, you can send it in on DVD. Just do it, don't ask. Last year we asked for three different formats, and then took a free tool from Microsoft and converted them all to .wmb. So why don't you guys get that free tool from Microsoft, download it from the website, and you put it in .wmb so we'll get them all in a compressed form. On track A if you send the video in with the proposal, there are some requirements on that video. There is a limited size, I think 100 Meg, it needs to be uploaded onto the (inaudible) website so you probably read the details there, and you realize that's true. There is also a five-minute limit on that. That's a free format on Track A. We are not specifying what needs to be in there. On Track B it will be maneuvers and activities that take place on the site visit test course. Next slide. We talked about E stops. I thought I would just show the picture so you know what we are talking about. The E stop is the emergency stop system. It's a wireless system. Two of the boxes go on the robot, one of them is the control. It's set up multi-channel so we can put lots of robots in the same area and have the (inaudible) step on each other. the two boxes, one of them is more or less a control box,

it's got digital outputs and it's got an analog output and if you activate it, it either makes low resistance or high resistance between the two wires. It's relatively simple, all the details on it are on the website. We actually put the reference, I think in the rules, so you can look up. It's simple to integrate and people didn't have a lot of problems with it last year. You are not laughing or anything. We lend you the E stop and you return it to us as soon as you leave the competition. It remains the government's property and it's returned to us. The E stop, as we said, actually has more than just two outputs. It's got disable outputs as well as pause outputs. We explain the difference in the documentation, more or less PAUSE is when we pause you. We put the brakes on, the engine stays running. DISABLE is when your vehicle is going to leave the race. And so we test both of those. Next slide. There is a technical paper requirements. It's slightly different for the two tracks. On track A, we'll send you the format of the technical paper by the date in January. Track A, the requirement is that you mail it in before milestone 2 visit, which is your site visit, okay. We'll tell you exactly what to do with it. You have slightly more time to write the tech paper because you came onto the contract later. The Track B site paper is due in advance of the site visits, due on April 13. I know what you guys like to do, I put the format up there of the things I want, you just take it and turn it into a form fill activity where you take everything I ask for and you give me a paragraph after it. This time we are evaluating the tech papers as part of the site visit, track B. So don't do that. Write a good paper this time. Professional quality. It needs to explain clearly how the bot runs. And we'll post it on the website and make you proud, when you win. The other detail about the site paper is this, about the tech paper is it's not posted until the entire event is over so don't worry about releasing information in it. Don't release proprietary information but competitive information no one will know about it until the event is over. This is a summary schedule, if you have binoculars you can probably read it. It shows track A at the top, track B at the bottom. The first full vertical bar says TODAY up there. You can see that says TODAY. This has all the dates on it. It will be on the website so you know what's expected. On the top you can see proposals and then awards, that's going to take place this summer, that's going to straddle this summer. So you'll start negotiation in September. Let me just lay one detail on you about that.

People have asked me about the sample agreement that we've got. We've got a Sample agreement, but we don't have a sample FAR contract, okay? If you're going down the OT track, if you're choosing to stipulate an OT track A, another transaction, take the OT agreement and read it and you look for things in there that you can't live with, and you mark it up, and you send it in to Kristen. Contracting people will negotiate with you to see if we can find some common ground as far as negotiating that contract. It will give you a little more

flexibility in negotiating that. FAR contract, if you're familiar you have a lot less flexibility so the people who know about FAR contracts already have sample FAR contracts in their possession. There's no need to mark up a FAR contract and send it in, okay? So track one up here shows milestone one that takes place in the fall, in October after the due date down below, after October 5th. Also only two of the site visits, there are two milestones. This chart is not to scale.

There are two milestones, three and four, that take place at NOE. NOE kind of straddles over. To really complete milestone four, you have to actually attempt the final event. You can't just take the money and run. You can't give up the last 100 k, the milestone four payment -- you have to be there at the final event. Down below, the one-two-three-four parts of the application, there's a 5/11, May 11, that's the announcement day of the site visit, and the site visits will take place during that time in the summer. Next slide. Okay, we made it.

Break is now, we're going to take a ten minute break, we're slightly off schedule. Go outside, see the yard. If you go purchase (inaudible) stick it up here in the front. Ten minutes, see you back here. Thank you.

#### Transcript of DARPA Challenge 2006 – Part 2 (after the break)

Okay. Here is the game plan. We are going to start with the rules definition. We are going to talk through the RNDF. I think a lot of you have seen the details of that. And we are going to give some examples of the technical criteria. Then we're going to start event operations. Okay, everyone. Let's get started again. Thank you. Okay, Here is the plan. We'll try to get to the questions as soon as we can. I'll give you the cook's tour of the rough definition. A lot of you have been grinding through that document, I know. Look at some examples of the technical criteria, and talk to those, and then look at the rules. We have some examples of the critical rules you need to know. Then we'll get to Q and A. Go to the next slide. Okay. You all know the RNDF, MDF. The RNDF, as we said, will be at least 24 hours out. There is one RNDF, multiple MDFs related to one RNDF so they are cross-linked and cross-referenced in the definition. And what this shows, multiple MDFs, at least five minutes. Next slide. Perhaps you have seen this chart. It shows the container class diagram for the RNDF. Basically if you've been through the document you know it's a consistent numbering for every element inside the RNDF. Segments and zones are numbered the same, sort of numbered consecutively so they tend to be in -- integer numbers -- and zones come last. Segments are basically, it's not a unique mapping to the actual physical road. So a road with the same name, like New York

Avenue, we name it as one segment. Segments contain lanes, multiple lanes in a segment and lanes contain way points. Zones are a little bit more complicated. Zones are defined by a perimeter. No way points inside, except points that belong to parking spots. We can answer questions on parking spots if you like. We'll show you a picture. Next slide. You have seen this in the document, there are multiple lanes. It's a segment M, and three lanes -- M.1, M.2, and M.3. We defined the markings. One question that has come up is "are the markings that you see inside the RNDF, are they always present on the physical ground? The road markings are. If we tell you there's a yellow line there, and your camera looks down there, it will see a yellow line. But, we'll put stop lines wherever we call for a stop sign, but there may be not a stop sign there, okay? But we will have the line on the ground. You can see the way points, they are the green dots inside the track. Next slide. Perhaps you have been through this one as well. There's the notion of exit points, those are all colored on the chart. One exit, exit to multiple entry points, on one other segment. This is how all the segments are patched together. Stop signs are called out, every stop sign is associated with a single way point, a stop line going through it. Next chart. And the starred checkpoints. Star dots are actually checkpoints. This shows in detail how to visit a checkpoint, what do you have to do? The rule is the front bumper of your vehicle must completely pass over the paint checkpoint marked on the ground. If there's an observer there, they will be able to unambiguously tell when you actually achieve the checkpoint. You have to be in the right lane going the right direction. You can't be in the lane and can't back up to it. You have to be going forward and reach the point that way. You can't go in the wrong direction and pull over and pick it up and keep on going. Okay, I know what you are thinking. Here is an example of some of the road markings, just sort of what we would do. This shows a double yellow, that would be in the RNDF. The white line there may not be in the RNDF. If there's curb there, we may leave that out. There may be lines on the ground which we don't put inside the RNDF. You can see the stop line, well put that in. The curb is not marked on the RNDF but may or may not exist in the real world, we don't know, you have to tell us. The way points are put inside the lane and you can see the line that we've drawn. The line extends for lane width from the curb to the centerline, we'll just bisect the line right down the middle, that's where we'll put the way point. It's not necessarily in the travel lane, we don't go from the white line on the ground to the yellow, we go from the curb to the yellow, okay? Next. Here is the other kind of creature we defined, a zone. Some of them have obstacles, some don't. Really they all have obstacle, some have parking spots and some don't. So the obstacle -- this shows an example, you can see the odd-shaped polygon in the middle is the zone. There are two red lines and that's marked K rail. Don't drive through the K rail. Next to one of the K rails we put an array of parking spots,

okay? Parking spots are not marked on the ground. There are no parallel white stripes. You can get a feeling for the spacing of the parking spots. I'm not going to tell you in advance. Just look at the distance between the way points and checkpoints it's something like the parking spot. Your job is to come in one of the segments and pass over one of the checkpoints and achieve the second one. If you don't, then you'll have a problem. For example, you can't achieve it by just going in from the side, saying there's a way point there, I'll just miss that other checkpoint go achieve the checkpoint, you can't do that because you will hit other vehicles in that are in your way. We'll have other vehicles, junk cars parked in the spots. You have to figure out what's inside the zone using your sensors and find the right path to go and actually achieve the checkpoint. It's not easy. Next slide. We talked about the RNDF, segments and zones. Here is the MDF. It's relatively simple. It's got an array of checkpoints, you knew that. The first checkpoint doesn't have to be one. If you want a good example look at the example we gave you, study that carefully. When we made that, we looked at the things on the road, it's hidden in there. It's like a real Da Vinci Code puzzle. Study that in great detail. We may repeat. If you notice the example here. We have given multiple instances of the same checkpoint. In addition, we put speed limits inside the file. Remember the multiple missions that we're going to give you during the final event. This gives us a chance if the vehicles are going too fast, to actually jump in there on the second mission slow everybody down, or speed them up. It gives DARPA a little control over the event which we otherwise would not have. The speeds are listed per segment as you see in the example. You see it in miles per hour. Somebody asked me is that 10 miles per hour, 10.1, 10.2, I said yeah.[LAUGHTER] Next chart. Okay, Technical criteria. We'll talk about some examples. This is a slide from the PIP. More or less we have partitioned the criteria into some batches. So basic traffic includes basic navigation, so on and so forth. This shows, for example, the site visit will only use basic navigation and basic traffic. But NQE, or the final event, that uses all of them. It comes into play. I'll show you an example of that. It's a little unexpected. Look at the criteria for advanced traffic, for example, and suspect only those things will be tested in the second part of the NQE, that's not a good assumption. Some of the things for basic traffic will be tested as well. Next slide. These are some examples. Look at the list. Over the next two weeks, we're actually getting more suggestions. We may add to the list, change some of the numbers, this is our state of thinking at the moment. Some of the things that are easy to draw on the chart. Basic navigation, the vehicle stays entirely within the travel lane around corners. I think this is pretty obvious. The corner aspect, it wasn't really required. You saw the video, the team did the landscaping job on the corner. Next chart. So there's the requirement that you stop within a meter, that's over or back, front bumper of a stop line and the ground. Next

chart. Vehicle exhibits less than ten seconds of delay when the intersection is clear. Remember I told you in the beginning, there's a tension between vehicles that are too cautious and those that are not cautious enough. Once the intersection is clear, you stop there, it's your turn to go, if you wait more than ten seconds you are not effective. Somebody is honking at you from behind. Not a good scene. So there's a few places where we talked about this ten second delay. We don't know precisely how it's going to be used at every time, but we'll whistle you dead on this, you will get demerits if you are thinking too much in the parking lot or some of the intersections. So this shows where the clock starts. The precedence was for the traffic vehicle, the other vehicle that wasn't the robot. It turned the corner as soon as it cleared the intersection, ten seconds, let's go. Another basic navigation, vehicle completes a passing maneuver in 40 meters or less, maintaining an 8 meter safety buffer. Where do we measure the 40 meters, where do we measure the 8 meters? We have a scheme here, I'll let you study it on Monday when it goes up on the website. It sort of shows, you know, once you are fully in the other lane, begin to leave the lane, that's where the 40 meters start right there. When you fully back in the lane that's where the 40 meters ends. We went out and did some experiments with vehicles and this is the numbers we came up with, well scaled to the picked vehicles so we may put a vehicle dependent element to this. It's kind of a work in progress but something like this. We need to see vehicles that can effectively pass stopped vehicles and continue to go. Next slide. Okay. That was tested at the site visit, all those things. You can expect that to be tested at the site visit, in addition to this. Vehicle exhibits correct precedence order in intersection. First guy into the intersection is the first guy to leave. You know the rule. It's extremely complicated. When your vehicle stops behind another vehicle at intersection, should it interpret that other vehicle as a stopped vehicle and decide to go around it, that's no good. If a vehicle clears the intersection and another pulls up and fills, you are going to have to track that and know that your precedence was less than the vehicle that cleared it but more precedence than the vehicle that just arrived. It's not just detecting a blob there, it will look like a blob there but you will actually need to do detailed tracking. Proper cueing at the intersection, you need to see the stop and go vehicle behavior as vehicles fill and then move. That's actually required. So let's go to the next slide. Let me just go through these. We have requirements on how far you should stop behind another vehicle. We can't have you stopping way far back and having you avoid collisions that. Too cautious behavior will get tested out of here. We can't see that. We're going to try to measure some thing that forces you to be effective when you tuck up next to other vehicles. Next slide. There is a front vehicle that's traveling at 15-miles-per-hour with the bot following. The bot

can get as close as 15 meters. But if there is a 20-miles-per-hour zone, the bot should be less than 40 meters away. That's the rule that I just said. You can't follow too cautiously.

Next slide. This is called out actually in the RNDF. It says that if we give you an exit and an entry point in the same road segment, one lane to the next, the implied behavior is a U-turn, which is just like this. It's written down there.

Here is a picture of it. It's not hard to figure out. The U-turn can be a three-point turn or multiple three-point turns if that's what you need to get around the corner. Next slide. Okay, we've been through the first two sets. That was the site visit. Here are some additional components we are adding for the first half of NQE, the advanced navigation. These are all either static vehicles or no moving traffic here. Here is the parking behavior, you know what that looks like. Has to be less than ten seconds of delay. How do you measure the delay?

Sort of a stop and stare issue. Go to the next slide. Excess delay, avoid jamming up roads and parking lots. People just need to move when the way is clear. Excess delay is time during stop and stare. Let's suppose you get a traffic jam inside the parking lot, it could happen. We are not going to time you ten seconds and get you in trouble. It's going to be a real world measurement we'll do. [LAUGHTER] This is a suggestion. When that traffic jam takes place, your vehicle can't just freeze and say I have no idea what to do.

We need some kind of solution. So Ron wasn't sitting here. When Ron was a teenager he used to drive a cab in New York City. He said "oh this is easy to solve, the New York taxicab algorithm is the one to use". The New York taxicab algorithm is simply inch forward and don't hit anybody and see if you can't get through this, okay? So we need to see sort of robust behaviors like this to get you out of the problems. We'll stage some of these problems for you to try and solve. This is not a sterile test where we give you, you know, the vehicles in the center of the lane, real world is like this, it gets all jammed up. Bot has to be able to cope with it. Next slide. Advanced navigation. Here is the dynamic preplanning. The robot is down in the lower left, there are three legs that the robot could take up to the checkpoint up there. And there is just a ton of behaviors that have to be done in order to achieve this correctly. If it tries the first leg, it needs to do a U-turn at that roadblock so it has to detect the roadblock. The roadblock is not in the RNDF. It needs to detect that roadblock, it needs to turn around, and it needs to make a left turn across traffic and it tries the next leg. Then it hits the next roadblock, it needs to find the right path back. It can't just follow a path back because it may end up in the other roadblock again, and stuck in, you know what I mean. Then it needs to make another left turn across traffic and find the third leg and achieve the checkpoint, okay? That's a required behavior. Next slide. Here was a, there's a little language in I think the PIP about low accuracy way points. We're kind of backing up on that a little bit but we're looking



at sparse way points. The example on the right-hand side is from the sample RNDF, it's the road on the far left. So there is an intersection there that isn't even called out in the RNDF, you can see it on the top. The Bot needed to see that the checkpoint was over here, and it sees an intersection that is close there and it knows to try and take that road to the right. If it continued to go straight, we would put a K rail there and it would eventually do a U-turn and find its back.

So there are sparse way points on a curved road. If you do a straight line you won't stay on the road. You have to be able to do road following. And in this case we put it on a one-way road, that's kind of what we are thinking. If you're doing U-turns we don't want U-turns on one-way roads. It can get hairy. Next slide. Here is sort of an example of the kind of road following your vehicle might need to be able to do. It may need to follow curves, berms for the urban case, or the vegetation on the bottom. Clearly a visible road that could be detected, and there are even slight berms on the side that could be detected.

Street lanes may be missing, and this is through the entire network in the RNDF and you have to hug to the right. It could be a two-lane road without a street lane, we are reflecting what the ground really shows. Winding roads that you saw, and the sparse way points may not be exactly in the center of the road but we'll do our best. Next. Okay. Advance traffic. Here is a fun one. This is something to pay attention to. There is actually two on this slide. First one says the vehicle should pull into traffic when oncoming vehicles leave a gap of at least ten seconds. Now this is ineffectiveness. If the vehicle is ten seconds away, the oncoming traffic, and you are waiting for those 10 seconds because you think it's still not safe enough, then you are not being effective, okay? The road here shows just how complicated that can be. This is actually a traffic circle and the radius of the traffic circle, this is a good number to think about, 150 feet. It's actually a pretty big traffic circle, but it's got a limited sight line, you can see the building up there at the top, which actually cuts the site line. You have the RNDF. You know the shape of the road. You'll see the vehicle coming. It's not just coming down a straight line. You need to detect vehicles that are other than simply directly 90 degrees off beam. The one at the bottom shows two robots, and 8 meter safety spacing. When you pull into traffic and cut off the other guy within 8 meters, no good. And if you come in too close behind somebody else within 8 meters, that's no good either. We need to see the safety spacing between vehicles. Next slide. Two kinds of left turns. We're going test you in detail on these turns. Both of the left turns are across moving traffic. You have two streams of traffic. One down the bottom you have to watch out for. Vehicles going in both directions. You have to detect both of those, pick a spot and pull out. And then the top -- simply watching the oncoming traffic and making the turn across. This slide shows another advanced traffic capability, and that is

operating in the parking lot with other vehicles present. There is a vehicle coming in from the top, a vehicle coming in from the bottom, they are both trying to achieve parking spots. Our guarantee is we won't assign you the same parking spots. Okay? (laughter) But there could be hay bales there. This is an example of a behavior, we'll probably test in advanced traffic which is one from basic navigation. It says don't collide with anything. This shows the robot coming along, accident avoidance, we'll roll a junk car out in front of you, we'll tell you what the spacing is, what the speeds are, you need to not collide with it. It's something that some commercial vehicles can achieve, we need to see our Grand Challenge vehicles and Urban Challenge do that as well. Next slide. That was technical criteria, that was examples, there are more, so read through those which are less pictorial in nature so read. Each of those tells a whole story. Then operations, this is really the rules section. Next slide. This tells how we are going to do it. So this is where you get to know the chief judge really well. DARPA will have official observers on the course. Causing a collision is grounds for disqualification. If you hit somebody, it's just out. There is no appeal process there. If you are driving dangerously, erratically, you are out. We can't have dangerous vehicles because you endanger the other vehicles in the road. If we start to see that type of behavior, the sensors are misadjusted, it's all over for you. For traffic infractions, we are going to use time penalties. We'll publish a table that tells you what the penalty is. If we catch you speeding or you have another problem, for example, you exceed the ten second delay, you could be whistled for that. We'll add the seconds to your accumulated time. So the document called rules of the road will be released, we'll tell you what the rules are. Next slide. Collision. What happens when there's a collision? We are not going to have chase vehicles because it creates extra traffic and too much hazard out there. We will have DARPA-generated traffic as well as vehicle traffic. If we have a collision, we need to stop everyone, so we'll do an all-course halt. Assess responsibility for the collision, and it can be a no-fault situation where they just sort of come together, and decide what the next step is. That's a job for the chief judge. A victim vehicle, clearly not at fault, and collided into, may be allowed minor repair and restart. Okay. Major repair, if you lose an oil pan or radiator, it's not going to happen. We are sorry. It's part of the event. But minor repair, a flat tire, pry the fender from the bumper, we'll bring you back to the start area and do the pry and send you on your way. What the time implication are, we'll let the chief judge decide that. DARPA will not use the E stop to prevent course collisions. Don't assume someone is watching the Bot, and someone is heading toward it, they are not going to pull the plug on it. Not enough reaction time. Fast maneuvers at the last minute. So we are just going to have to live with the results. Next slide. Time correction, we time it sort of like the last Grand Challenge. We measure elapsed time from the start to finish. There are E stop pauses, we take

that out. There is the start chute, some are further from the start than others are. The time it takes you to get to the start line, we'll subtract that out. Penalties assessed against you, the chief judge gives you time back because you were crashed into, or any other reason he decides, that will be the final time. And time between missions that time is not subtracted so the clock is running, so the pit crew has to be fast. Next slide. Pre-running. Let me just say something about pre-running. The key thing to know, it's not going to really help you. You'll know the course plenty in advance. The challenge is not to know where are we going to come at the event, it's to actually have a Bot that will be able to deal with the traffic on the course. The traffic is where the real challenge is. If we can work it out, we'll give you an image. Just like in the sample, you'll get overhead imagery, which is very well georegistered, and you can put your own way points in there. It's not about way points either. It's actually about the traffic and being able to navigate the course. The course area, just to help you stay out, will maybe closed before the event. We did it last time, we may do it again. Emphasis is on comparison of technical approaches using the same starting information. It's cheating, and it's not allowed, to try and do overflight or get information that everyone can't have. Actually this is a technical comparison that we want to do, so we need you to live within the rules. Use the information we give you. Next slide. We are going to publish a whole bunch of rules documents, all rules just like last time, give you the details in advance of the actual events. A couple of these were already out. There's an NRDF and an MDF which is already out there. We appreciate feedback, even when we publish these, if you find errors let us know. Next slide. Okay. Priorities. Just in case I scared you with all the penalty talk and all that stuff, your first priority for the Urban Challenge is no collisions. We just can't have you crashing into other vehicles. The second one is to complete the mission, not to avoid the penalties. I don't want to see the vehicle frozen because it's afraid to cross the double yellow to go around a stopped obstacle, okay? The vehicle needs to find a way to achieve the mission, even if it has to take a penalty. So minimizing penalties is tertiary, it has to do with whether you get caught and -- [LAUGHTER] Next slide. Okay. Rules, that's the end of that section. What we are going to do now is entertain questions. We have Kristen and I guess Ron went out. There he is right there. Well, obviously I hope those of you who know who you are, even non-trationals know who you are. So I'm sure you have a lot of questions. We'll try to get through as many as we can. This is prom week around here, so we really have to be out of here at 2:30, or we are going to have a whole bunch of high school kids coming through that door. So we'll just start with questions. If you could, there's microphones so everybody can hear your question. Audience: I asked Kristen a little bit earlier, what kind of a cost proposal do we submit if the price is fixed and there's essentially no fee? Presenter: I looked it up in the PIP, and it's addressed at

paragraph 3.2.8.3, (laughter) and if you want to know what it says I can read it to you real quick. Audience:: You've got it though, right? This information -- those this were not fortunate enough to come today, how will they be able to see this, I understand it's being recorded. Will this be on a particular channel on a particular day? Presenter: I guess we are copying it, right, this webcast, and -- Excuse me? Slides and the transcript? Slides and the transcript. Are we keeping the video itself? We'll post the video. Just have to check the file sizes. If it gets to be a terabit we'll have a problem but it will be posted and we'll let you know. Audience:: I have two questions -- here at the back, sorry. I have two questions, one of them is you mentioned that GPS outages. I wanted to know how they would interfere with achieving way points, or would there be GPS outage around way points, and the second question is concerning pedestrians, will there be pedestrians in the final test and how would we protect them? Presenter: The GPS outages are naturally occurring. Imagine a road with a row of tall trees down one side of it. You'll either lose all GPS or the differential corrections. And there are way points along there, too. INS will have to deal with that. Second question was? Audience:: Second question about pedestrians. Will there be pedestrians? Presenter: no pedestrians, other than the non-traditionals. (laughter) Robby got my pedestrian question. When you talk about an impassable route, that would be some common definition, like a roadblock? There's a vehicle stopped in front of you that shouldn't stop you from going but it might be impassable, depending on how you interpret it. Will it be something that covers the entire road? Presenter: If we introduce it, it will be a K rail across. You won't be able to get past it. It's going to cover both lanes. Audience:: RNDF files, two questions.

Is there a sense of how large the area is going to be? Is it going to be tens of roads, hundreds, thousands, millions? And second, you are going to have human-operated vehicles that are going to enter the area. Could the situation occur entering from outside RNDF, we don't know if they have a stop sign or not. Presenter: First question was the density of -- Repeat the first question. We really did not understand it. Audience:: How many road segments to expect in RNDF, tens, thousands, millions? Presenter: No, it will be -- it will be larger than the sample, but some small whole number times the sample. Okay. 3, 5. Right. Audience:: And if outside vehicles come, my team worries about if they come from outside, you might not know if they have a stop sign or not.

If they come from outside the RNDF, they might not even know if they have a stop sign or not because that's not specified. Presenter: Outside the RNDF the traffic vehicle will have to worry about entering traffic safely. Audience:: The goal is to cross the checkpoint, right? Can you game the RNDF such that, for example, when I was looking at it, there were several ways to get to different points, doing U-turns on segments of roads that were allowed U-turns. I mean

you -- it's not like you are going from point 1, point 2, point 3, point 4, over to, you know, left hand turn. You are really looking to go through the checkpoints. Are we free to game how we get to the checkpoints, as long as we stay in the RNDF? Presenter: As long as you follow the rules of the road, you can do it. The use of the word game is probably not right. Audience: Whatever you want to call it. Strategize. Presenter: You can go between checkpoints as you want to, yeah. I mean we are not going to restrict the way you get there. Other than there will be roadblocks occasionally. The whole U-turn and traffic situation, we may look at that. Yeah. So rules of the road would be a little bit more clear. You are allowed to take any legal path from one checkpoint to the next. Audience: Left hand turns, legal or illegal? Will we be going across double yellow lines or no? Presenter: You can cross -- we spec a double yellow line in a segment, you know, in a real segment it has a gap there. We didn't tell you about the gap in the double yellow. Audience: Will the gap be physically there or not? Presenter: Not physically there but you'll still be able to make the left turn. Audience: Will we have to pass slow moving vehicles or just stopped vehicles? Presenter: Slow moving vehicles. Audience: We have to pass slow moving vehicles as well? Presenter: The question is, do you have to pass them, you don't have to pass them. But there will be an area with a broken white line, which is passing, and you'll be able to pass a vehicle there. Audience: Thank you. Presenter: Audience: Just to follow up on that. In passing a moving vehicle, there will be two lanes of traffic traveling the same direction so you are not passing into oncoming? Presenter: That's correct. Audience: With regard to the site visit, I realize you said you were going to put out some more information. But can you give us any head's up with regards to the requirements, the physical area, the acreage of whatever needed, how many parallel lanes, what kind of surface texture of pavement, or do we have to have lane markings, things of that sort? The general idea will be two-lane roads, paved roads, you know, with lines down the middle. We need both lanes there, that's critical. I need two lanes. And roughly between 250 and 1,000 meters. Some kind of Manhattan geometry would be helpful. If you had a city block or two, that would be just perfect. Just perfect? (laughter) Audience: What about -- what about existing government-funded projects, say, for instance, DARPA, Logger, sharing algorithms, resources, people between that and the Grand Challenge? Presenter: Those are all separate things. You can certainly share algorithms.

But if you take Larry's funding and use it on the Grand Challenge we may need to have a discussion about that. Audience: Well we don't have it yet [LAUGHTER] That mostly answers my question. The other question I had is regarding way points, if you miss, if the robot thinks it made the way point but is judged to have missed it, does that mean the mission fails, or is it just a penalty? Presenter: We'll probably ding you for that but you will continue to run the

race. Audience: Are there expected to be any small obstacles on the lane that you need to avoid but still stay in the lane or is just being in the center of the lane sufficient? Like a cone on the side of the lane that you need to swerve around? Presenter: If there was a cone there you would be expected to swerve around it. We have not speced it in any of the documents saying you have to avoid cones. Audience: Are you sure that we will have those things there? Presenter: The key obstacles are things that are bigger than a cone -- traffic barrel, other vehicles. Audience: No obstacles which partially block the road? Presenter: It could, it could. Audience: In track A does using FAR give somebody a special advantage or is the FAR in the other same on the other track? Presenter: You can use whichever type of contract vehicles suits your preference best. There will be no preference given. Track A and track B, you can try for track A, and if you fail, for whatever reason, you can always back off to track B. that's one reason why we created track B. Audience: I understand. I meant within track A itself. Presenter: I don't think there's any advantage in that. Audience: Two questions. Will roadblocks be permanent for the duration of the final event, like if it is blocked at one point will it always be blocked? And do you have to drive on the right-hand side in a parking lot where there is really no lanes defined? Presenter: for the first answer I would not assume that obstacles is there or the configuration is the same. Second question is about parking lots? Audience: Yeah, do you have to follow the implied rules of the road, drive to the right-hand side and things like that. Presenter: There is not a requirement to do that. Audience: Okay.Great. Presenter: As long as you don't hit anything. Audience: Right. Another Audience Member: I had a question about U-turn across a double yellow line. If the vehicle encounters a blocked segment of road and it has to turn around, if it's following the rules of the road or the California driving rules or whatever was stated in the preliminary rules, it may have a preference not to go across a double yellow line, especially make a U-turn across a double yellow line. But if it's a bot segment it would have to do that on the fly. That would be at the risk of an infraction? Presneter: You know, it's a funny thing about that. We called up the California High Patrol and said "you know in the laws you can't cross a double yellow, what happens if the lane is blocked? They laughed. They said of course, cross the double yellow and keep going. It's just what you would do that the vehicle needs to do. Audience: I am wondering if the terrain will be relatively flat. Do we need to worry about limited visibility because of hills and having a vehicle stop on a hill and having to restart. Presenter: I think the trees and buildings will be more the visibility problems. Audience: I have a question about base platforms. The rules are fairly lenient on the upper side. What if you have a platform you think would be relevant that's, you know, 1996 pounds. And not 2,000 pounds. Presenter: Just add some weight. Presenter: Add some weight. (laughter) Add some weight. Audience:

How many track A proposals do you envision funding or alternatively what's your total budget for track A? Presenter: We won't fund more than ten. Audience Ten? Presenter: Yeah. We are not guaranteeing ten either, but not fund more than ten. Audience: Thank you. Another audience member: I was wondering Presenter: where are we, over here? Audience: I was wondering if you could enter what the weather will be like, during the day or night, can we expect inclement weather at all? Will it be postponed if there is too good a snow? Presenter: In November, western part of the United States, maybe not the western part of the United States, we are negotiating here. I don't think you need to worry about weather. Audience: Okay. Thank you. Presenter: I hope you don't need to worry about weather. There will be weather.

[LAUGHTER] Audience: In the comments about the contracts earlier, and I thought this applied to the other part of track A, it said you had to have an authorized contracting officer sign the document or something before you could start. Did I hear that right? Presenter: That's Kristen, she always reminds all of us she's the only one who is really in control. [LAUGHTER] And all of that, all of that was just her saying that, right? Kristen: That's right. It's good to be clean.

Presenter: So that's all that means is that you need to have a contracting officer. Don't -- if Norm comes up to you and says hey, do this, in other words you are in track A, okay? Do this and do that, and it's not part of your proposal, it's like extra, well, she's the one that you really want to get to say yeah, what he said is okay. Kristen: Particularly if you expect to get paid for it Presenter: Yeah. If you don't want to get paid for it, it's okay. Audience: My question is also a contracting question. Can volunteer labor count as a cost share in any way? Presenter: We haven't thought about that. Kristen, Yeah. We haven't thought about that. And traditionally the government is not authorized to accept volunteer labor. Presenter: I'm not sure. We need to think about that. It's a labor that's not being paid, I guess. It depends on how you can -- well, I guess we need to think about that. Audience: My other quick question concerns liability insurance. I think it's going to be really, really difficult to obtain. And if it's necessary to have someone sitting in the car during the site visit for liability insurance purposes, would that be okay?

Presenter: We are not going to let anyone sit in the vehicle during the site visit. Audience: I have questions in terms of the entering a team with two vehicles, multiple vehicles. Does the rule allow in a situation, you have a collision but it's not your fault, to swap the vehicle and enter the race? Presenter: I don't think so. I think once you got your car out on the track, it's there. So pick the right car. (laughter) You can use the parts, I'm sorry.

My wife says you can use the parts from the car that's not crashed. Audience: Just one clarification on the weight question. It's the weight as delivered by the manufacture of the vehicle that counts, and any customizations the manufacture has done it's okay? Presenter: The weight with the full tank of gas as delivered by the manufacturer. Audience: As delivered by the manufacturer to you. Presenter: That's right. Audience: I have a question regarding the multiple cars at an intersection. Would that, if the cars are stopped, determined by the first car stopped and then goes counterclockwise to the left? The car, the subsequent cars that can go? Presenter: What are the rules in California? Precedence order, the first to arrive is first to leave. And you know, there's a simultaneous arrival with one to the right gets precedence -- I don't know what simultaneous arrival means to the robot. Audience I guess one would determine, robot A would determine B was there first, and -- B would determine that A was there first. Presenter: One may interpret it as simultaneous arrival and the other may not. You could be in a situation where both may want precedence and neither one takes precedence. That's what the taxi cab rules are all about.

That's when the taxi cab rules take over. If both are in the intersection, one of the rules of the intersection is it's always a check and go situation.

You are monitoring very carefully when you go through. Audience: No blinking the headlights saying okay, you can go? [LAUGHTER] Presenter: That will get you in the news reel. Audience: Very quick question about the third or fourth slide you had up there. You had lines across the intersection to show where they should stop on the bottom and the right-hand side, and then striped lines on the left and top. Is there any -- and it's more fodder for thought. Will there be a standard stop line throughout the entire route, or will some be solid lines, some of them dashed? Presenter: You know what, I don't completely know.

We have to release that to tell you what they look like. Audience: We are driving around now filming and it may turn out that that's incorrect because of the way you line it up. So that's just to help us all out, that would be great. Thank you. Presenter: Okay. Over here. Audience: In order to preserve that prize money should we all be going home and writing our senators? Presenter: You have to do what you have to do. [LAUGHTER] I -- I can't recommend anything. Audience: A couple of questions. First question about the track A. Can you -- is it possible to divide the track A money and the money you might spend on your own, and how is that going to affect the intellectual property rights? I mean -- is it, do we have to show where we spend this money, how much we develop using track A money that we got from DARPA, and that's the IP that needs to be transferred, or how does it work? Presenter: I think you want to explain what you really mean by government purpose rights. It's not a big deal. All we are asking for is basically a fully paid-up license. So later on if you are successful and want to sell



it to the government, you can't charge us a royalty again. Audience: Okay. I see. Presenter: That's really – at the bottom of the day, all we are getting is a fully paid-up license. Audience: Second question was – Presenter: she may disagree, but that's what I think, anyway. Audience: My second question was, you mentioned that you let commercial production vehicles into the race and, but you also briefly mentioned that military vehicles might be allowed, and so is there a restriction on what kind of platforms you can use, apart from the specifications that you provided? Presenter: If you have a true military vehicle, that's when all those ITAR problems are going to start to pop up. If you are a defense contractor, so there's a limitation there in which you can do. Other than that, we require rubber tires. Audience: Do you require a safety record or safety -- you know that you should have a track saying whether you can avoid -- whether you have successfully shown that you've been able to avoid collisions. Will that be part of? Presenter: That's an or, that's an or.

If you have a vehicle that's not, you know, a Ford pickup truck, and you want us to consider it, and it is something that has been used in a road race across the world and has a documented safety record, that's good evidence that you would consider that vehicle. If it is something you made in the back yard and have not tested yet, that's weaker evidence. No tracked vehicles I think is another rule.

Audience: My question has to do with street legality, or licensing. Does our vehicle have to be street legal? is the first question. And then the other question is do we have to license it or should it be licensed like in the state?

Presenter: Let me answer that. We actually went into that. There is some question as to some of these vehicles whether it would be truly street legal with all the autonomous stuff on it, it's a complicated term. Because it's a fuzzy term we don't use it. There isn't a requirement it needs to be licensed with a license plate. We'll be operating in an area not open to the public.

Audience: Okay. Just one other question is GPS way point accuracy, what degree of accuracy or precision do we have on our GPS coordinates on that? Presenter: Its in the rules. I think six figures to the right of the decimal. Audience: And that is military precise accurate GPS, right?

Presenter: The unit we use is 15 centimeter, one sigma is the spec. We take multiple readings -- if you look, the accuracy varies at different times. So it can actually be larger, depending what the satellite configuration is. Audience: You mentioned three ways to qualify for the OT. Do we have to do all three or is it an or? Presenter: It's an or.

You know what, Kristen, you never really did say what a non-traditional was, why don't you give that definition. Kristen: a non-traditional defense contractor is someone who has not had a contract for a prototype or other R & D in excess of 500,000 in the last year. Prenter: So if

you have never had a contract with the government you are by definition a non-traditional. I see, over here, I guess.

Audience: I am wondering about a track A proposal. What would be the impact of having or not having an existing autonomous vehicle at the time you are making the proposal?

Presenter: Well, it won't help. If everybody doesn't have one, then it doesn't matter. But it won't help you not to have one. Audience: Okay. noticed new language to make it harder for single teams to submit vehicles.

But there is a gray zone, I think, in the end. Therefore my question, if two teams have separate people, for example, decide to share the software, or share significant parts of the software, would that then disqualify them? Presenter: Well, as far as selection goes, for example, in track A, we are looking for distinct technical solutions. Audience: Does that mean they can't share a fusion algorithm, no, they can do it. We don't want two teams coming together with one technology and entering that twice. We want different vehicle solutions and different software solutions for each entry. For the fellow that asked the last question. I don't want you to think if you don't have a vehicle you can't go on track A. But what you will have to do on your proposal on track A, is show the plan for doing that. So you don't really need to have it in track A but you do need to have a good explanation of how you will get it. And that will be evaluated. Obviously better if you have one, but you don't really need one. As long as you have a good plan. Let's see who is out there. Audience: As a Ford employee, I would like to thank you for using Ford pickups as the example every time. Our Ford pickup drives in reverse as well as forward. You showed a network diagram with three possible routes to a way point, two which were blocked.

Is it legal possibility to back up to the intersection and proceed, or do you have to do a three-point turn? What was your intention there? Presenter: Our intention was the three-point turn and long backups down the streets were discouraged. Audience: okay so you can't drive fast in reverse. Presenter: Reverse is required and you have to have sensors in the back because even the advanced navigation testing, backing up in the parking lot. Audience: Obviously.

But you can't go -- let's say the blockage was 100 meters down the street, you could not just back up 100 meters. Presenter: Let me put it this way. You need to achieve your mission. That's your first goal. Three-point turns are preferred because traffic may be coming. I hear the chief judge is a pretty good guy, actually. Go ahead. Audience: Is all your paint going to be reflective and is there going to be reflectors on your K rails? Presenter: If that's a suggestion, we'll take that suggestion. (laughter) Audience: I actually have two questions.

Is there going to be a situation where moving vehicle in front of you is going to stop, you have to know to go around it, or a stop sign with a whole line of cars, you have to know to ..

Presenter: There may be situations where there's a stop sign and a line of cars at the stop sign. Your vehicle has to figure out if there's a vehicle in front of you or a line of vehicles at a stop sign.

Audience: And the way points, how are they marked, is there going to be like paint?

Presenter: Way points are not marked. Checkpoints are Marked for people to see. The vehicle needs to know where the checkpoint is. We are starting to run out of time. Let's take, how

about up here. Audience: So there seems to be a little conflict with the separation between

vehicles. So there's a 15 meter gap to 40 meter gap when you are traveling at 15 miles an hour, and 5 meter gap when you are stopped. It seems like there is something where you

want a function based on travel speed as opposed to discreet speed? Presenter: We'll take

that as a suggestion. Audience: Will there be any feedback presented for the site visit for

proposal teams that don't get selected? Presenter: Sure, absolutely.

Audience: Like last time -- I think last time there was nothing. Presenter No, I don't think there was. There was no feedback last time. Not that there was any deliberate reason why

not, we just didn't have the people to do it. If you are not selected and you want feedback,

then ask us and we'll try, we'll try to give you feedback. On A track it's automatic. Audience:

It appeared from the presentation that there may not be road signs, or the vehicles will not be required to recognize the road signs. Is that correct? Presenter: That's correct. Audience:

Okay. So they'll basically be given in the data file. Presenter: Yep. They're in there. Okay.

Maybe two more here and I think that's about it. You two. Audience: In areas where there will

be sparse way points where you have to do road following, will there be lane markings on those roads?

Will there be curbing on the roads? Presenter: It's not a guarantee.

There will be roads that may have lane markings or may not. They could be dirt roads. It's,

you know, it's an urban area. Audience: I just want to drill down on the back-up vehicle for a

minute. It mentions the rules, I believe it's the rules, there's a back-up vehicle for the NOE.

Can that be used if you are a victim and your vehicle is determined to not be able to be repaired in the time required? Presenter: The answer is yes. What we agreed, if you can

integrate the E stop, we'll give you an E stop test. The vehicle crashed up the NOE perhaps through no fault of its own, the same software because this is really a software race, we'll let

you run the software on a different platform. Audience: Thank you. That's it. We are out of time. Thank you very much. See you in November.

