

snn-qapb-obz (2023-06-21 16:06 GMT+2) - Transcript

Attendees

Alexis Guijarro, Beniamino Pozzan, Benjamin Ketterer NXP, Braden Wagstaff, Emanuel Buholzer, Gerald Peklar, Joe Dinius, Jonathan Pelham, Kimberly McGuire, Kimberly McGuire's Presentation, Ramon Roche, Ryan Friedman, Théotime Balaguer

Transcript

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Kimberly McGuire: All welcome everybody for the second. June meeting of the Aerial Body's Working Group. So that it's a discussion or slash developer meeting. So we're picks a topic. Last time we had a nice presentation for drone for bats from mpx and XP, Semiconductors and there we picked that we're going to talk about swarm communication management storming within UVs and that's going to be the main topic of today. And so, just the agenda, just some very short, very tiny introduction. Into the topic. And then I've selected a couple of Discussion Topics. Let's say that we can discuss but of course we can add any more if we like. And then after that, because we only have a small hour.

Kimberly McGuire: We'll talk about some technicalities for working groups. How are we going to deal with The presentation next meeting. Yeah. Yeah. Because for the summer perhaps you would like to reduce the amount of because now we have a meeting every two weeks perhaps you want to kind of reduce that rates Yeah, so that's kind of the idea. So yeah, so first of all, I would like to go into the introduction. And somebody. Yeah, it was you Very, very nice it.

Théotime Balaguer: Yeah, it's not me.

Kimberly McGuire: Yeah, of...

Théotime Balaguer: It's not me. It's from papers, right?

Kimberly McGuire: What's like you gave a very elaborate answer on the discourse threats, that I opens, I fought a secret preparation, that nobody answers until you did and...

Théotime Balaguer: Yeah, I so right.

Kimberly McGuire: you had a couple

Théotime Balaguer: I thought you were a bit alone and I wanted to feel that we were here.

Kimberly McGuire: Yeah, I very much. Appreciate it. Yes, I felt very no but it's fine. it's always a try out, and if nobody answers them, I'll just have the discussion here, So you had A couple of definitions of what is a swarm exactly? Because swarms is in indeed a controversial term. It's either a swarm of you, He's a set of arables that work together for specific goal. That makes sense. I would say or swarm is generally defined

as a group of behaving entities that coordinates to produce a significant or desired results. Which are I would say already quite goods.

Kimberly McGuire: Definitions of the name, swarming for UAVs in general. But of course, what we're going to talk about in this discussion is more about swarm for UAVs and what's difficulties, what kind of challenges we face with that, so that's Kind of more of the practicalities of swarms. so, I actually during my PhD,...

Théotime Balaguer: Sure.

Kimberly McGuire: I actually worked on some sort of swarms myself. Although I'm not sure if you would call draws six, tiny drones to swarm. But during my PhD, I had to have a swarm of these, very tiny crazy flies had to explore completely by themselves through and indoor environment without any Let's say Global Positioning System, so they have to do those completely by themselves. They have to communicate peer-to-peer but I also had to get data back to the graph to the ground station. In order to be able to make a nice boat for the paper. purely mostly academia And academic research in this. But I've struggled with a lot of challenges with just six of them so that was quite

Théotime Balaguer: It's actually impressive and just a curiosity when using aftermap for Tslam. Algorithm or

Kimberly McGuire: No, no slam, no. They're using book algorithms, which is just like in combination of algorithms, and wall following and goal, reaching and making sure that they don't. So it's not an exploration in the sense of making a map is an exploration. Let's say of being able to disperse in an indoor environments and it's all on the scm32. So it's couldn't be slam. Unfortunately. Also,...

Théotime Balaguer: Mmm.

Kimberly McGuire: because sometimes they would actually lose connection with the ground station, that was only there for telemetry and the ground station wasn't doing for anything. So I sometimes feel I have experienced the pain of Also doing swarm research restaurants but for indoor purposes only in small subset of that. But of course this, then in the sense of expiration, perhaps, or searching rescue, the fields. you can use swarming in this, Of course, all yeah. Shows obviously, crop surveillance biology research for actual forms, like flocking. So that's also what they sometimes. You see for, perhaps anybody can name any other fields as well?

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Kimberly McGuire: Where swarms of ufc's might be used?

Théotime Balaguer: I don't know an application for me to UAV. Regressions.

Kimberly McGuire: Yeah, so indeed, it's in warehouses and things like that?

Théotime Balaguer: Warehouses bridges and also, I don't know how you create an English windmills, or large vegetable turbine.

Joe Dinius: Yeah.

Kimberly McGuire: Yeah. The devil's,...

Joe Dinius: Or power lines.

Kimberly McGuire: the drones for better. Yeah. Power lines powerline in. Yeah,

Théotime Balaguer: yet power line, inspection is also very envision because actually, these are used helicopters now Of course. And 30 captors on better.

Kimberly McGuire: So I guess a infrastructure inspection perhaps that maybe In frost structure inspection.

Théotime Balaguer: Yeah, infrastructure inspection is I think?

Kimberly McGuire: So the piston is a very good one.

Kimberly McGuire: You mentioned one more.

Ramon Roche: There's also drawn light shows.

Kimberly McGuire: Yeah, I guess I had light shows on top already. Let Joe's. Yeah.

Ramon Roche: Sorry.

Théotime Balaguer: But for instance, I don't follow closely light shows,...

Joe Dinius: There's

Théotime Balaguer: technology evolution, but From now on, it has only been centralized control. So, from what I know of it's really

Joe Dinius: I would say natural disaster including relief efforts so wildfires hurricanes.

Kimberly McGuire: Mm- Yeah, search and...

Théotime Balaguer: Fine.

Kimberly McGuire: Or it's more like, just to kind of assess the situation or something like that.

Théotime Balaguer: It's also telecommunication infrastructure.

Kimberly McGuire: The scraps also.

Théotime Balaguer: Where you actually have? Multiple Jordan findings, the best position to provide network connection for, I don't know. Network really establishment after natural disaster. For instance, when the antenna goes down and you want to recover. The network accessible.

Kimberly McGuire: Yeah, the communication network recovery or something like that recovery or I'm just going to write.

Théotime Balaguer: Yeah, it can be recovery or it can be in a place that usually doesn't welcome as many people as they use. for instance, I don't know large event in the desert, and you would like to have more

playstations and you actually don't want to deploy fixed base stations displays and images. The 5g gateway in make it right all day.

Kimberly McGuire: Yeah, those are very I think probably the communication networking with the cover. That's a little bit. In these, but those are very Good possibilities in these. anything else? I think this probably covers, one of those things is burps. in the future. There might be more Applications popping up here. And there's always a possibility but at least we kind of

Théotime Balaguer: I mean delivery, we didn't good delivery there.

Kimberly McGuire: delivery. Yeah. Is that something that is?

Kimberly McGuire: Warm related though or yeah.

Théotime Balaguer: What? I don't know if it's warm related. This is lastly smooth to UAV related because for large package delivery, some people are investigating multidrone cable, charginlifting, ...

Kimberly McGuire: Yeah.

Théotime Balaguer: when you attach cable for a two strain, two large package and You're able to lift you wouldn't be able to live it with a single drone. That was multidrone. You're actually

Kimberly McGuire: Yeah, yeah, I've seen a couple of papers and I prefer that's indita. And research topic as well. Haven't seen any industrial applications yet? No no,...

Théotime Balaguer: it's most likely to make for. Now.

Kimberly McGuire: So that's always good if people already starts researching if it's possible.

Kimberly McGuire: All right, so let's just go ahead in discussions. Perhaps Ramon do you have access to this? Slide by any chance.

Ramon Roche: Yeah, I do. I was I know, sorry, I don't do, but I was gonna ask if you could send the link.

Kimberly McGuire: Yes, I will. Thank you. The link.

Ramon Roche: And I can take a minute notes for you.

Kimberly McGuire: Yeah. Yes.

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Ramon Roche: Thank you.

Kimberly McGuire: Because I'm very bad at doing two things at the same time, unfortunately. so, Yeah, that's why we're used to. So I guess the first topic is about ...

Ramon Roche: Yeah.

Kimberly McGuire: okay, why is I guess we referee talked about why multiple vehicle management is important for UAVs. We've already established quite some research fields, that are currently being

Whereas here currently being used. I guess also maybe the other sub question is students. Yes, or management, be more of a topic of a separate working group. Yeah. So any faults any ideas about that?

Joe Dinius: I mean, it is a really good question, but

Joe Dinius: I think maybe where's the novelty in the area, working group, from a robotics perspective. If we don't consider coordination of multiple agents, Because there's a lot of available platforms, like Px4 and argue pilot for achieving kind of the control piece of autonomy. So, I think that where this work in group could really have an impact is in the planning and coordination piece.

Kimberly McGuire: I guess is what perhaps accounts or arguments like, because you do have the open RMF software that this kind of okay, it's not really meant for UAVs, but it's meant to kind of handle heterogeneous, leads of robots, let's say to be able to coordinate maybe with each other so for instance, this could be a ship part of that, just as a counter for instance, but why I wouldn't be want to use, open RMF for the coordination of multiple UAVs.

Joe Dinius: I mean in its current state, it seems so hyper focused on building automation and warehouse automation. I'm just not sure that they have the scope for You...

Joe Dinius: that the types of open-ended environments that UAVs operate in versus the highly constrained environments a building or a warehouse defines.

Ryan Friedman: yeah, when I looked at open RMF to try to look at wheat management, it seemed like it was from the ground up designed for warehouse type applications, and that they hadn't, In their design had it really considered situations like aerial swarming. And so, I mean, I think it's worth looking into but I do worry that trying to use something like that would involve a significant refactor of it.

Joe Dinius: And it's by design a centralized scheduler, right? so,

Ryan Friedman: Yeah.

Kimberly McGuire: That's true. Yeah.

Kimberly McGuire: yeah, but it's just the kind of like, of course, I guess when we were started this working group We already realized that there's going to be quite some overlap with other working groups, for instance, with the navigation working group or perhaps the embedded System, Working Group. So that's why I'm just kind of like boasting the question. There's Why is this sport potentially? So Would be something that we would in the future specifically developed for. But I guess we're

Joe Dinius: That's not necessarily a bad thing though, UAVs is a very interdisciplinary domain and shouldn't we just expect that it's natural. that there will be overlap in other working group, areas that are more generic in their definition.

Kimberly McGuire: Yeah, I think that's something that we actually want to. Perhaps no. Not necessarily encouraged but with it's something that to be aware of that, we're not going to

Kimberly McGuire: Yeah, try to develop things in separate fingers only for your fees. there's already something that's already exist for ground robots. That we don't try to integrate you a more UV Tools but I guess that's more of like an enlarger discussion. I would say for this working group,

Ramon Roche: if all we're doing it for now is building a landscape of what's already there and mapping out the aero landscape. I think we should be fine once we get more into discovery and what's actually

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Ramon Roche: Problems that we need to develop together. I think that's when we might come into conflict with other work groups or where we can coordinate with other workers to work together.

Kimberly McGuire: It doesn't mean that we have to wait until that. I think Ryan you're probably already talking with Steve in the navigation working group already. Perhaps for that's the third dimension

Ryan Friedman: I mean. I show up but I don't have any active plans right now on working with them. we're at least for Already pilot stuff. I'm not there yet or...

Kimberly McGuire: Yeah.

Ryan Friedman: work stuff. I'm not there yet either.

Kimberly McGuire: But perhaps like May the near future.

Ramon Roche: Okay.

Ryan Friedman: Yeah, yeah definitely. I mean I'm keeping it on the table for sure.

Ramon Roche: By the way, quick. Commercial. I'm going to the Broadway debate Meetup. If anyone's in California, would love to meet you there. And I'm gonna meet Steve there.

Joe Dinius: Where is it?

Kimberly McGuire: That's really nice. Yeah.

Joe Dinius: It's in San Francisco.

Ramon Roche: Yeah, enteric offices.

Ryan Friedman: That's coming up, right?

Ramon Roche: It's on Just tomorrow.

Ryan Friedman: Okay.

Joe Dinius: Okay.

Ryan Friedman: I can't get a plane out.

Kimberly McGuire: I have to book a ticket guys. I am adding the meeting now. Yeah. No. Unfortunately I won't be able to but do say hi.

Ramon Roche: Yep.

Kimberly McGuire: All...

Ryan Friedman: It really go to.

Kimberly McGuire: Okay, so I think probably it's good to go to the next page...

Ramon Roche: That we discuss.

Kimberly McGuire: then there's no notes Ramon.

Ramon Roche: Whoa s***, I was into the conversation.

Kimberly McGuire: It's fine. We're going to have a transcript so technically we don't even have to make notes but it's a few

Ramon Roche: But that means I need to work in this later then which I don't like, that's why. I like taking notes. one question though,...

Kimberly McGuire: Yeah, sorry. But what you

Ramon Roche: that I don't think They said in the definition, I didn't read How many drones is a swarm?

Kimberly McGuire: Ah yeah,...

Théotime Balaguer: so, Do yeah. Agreed.

Kimberly McGuire: good question. To.

Kimberly McGuire: Yeah, that's heavily debated. I think anything below four is a team. About five. where's the limit?

Joe Dinius: a swarm.

Théotime Balaguer: I honestly, nobody. In the literature to.

Joe Dinius: but that,...

Théotime Balaguer: Sorry in the literature to.

Joe Dinius: but even

Théotime Balaguer: Nobody knows exactly. Where to place. The threshold of, what is this warm? Which is a team? What is a flock? What is A fleet everything is different from one order to the other. So I don't think. It's Relevanting.

Joe Dinius: But The mission defines what's the minimum number of vehicles? You need to achieve the desired effect. So the definition of a swarm is tightly coupled to the mission context.

Kimberly McGuire: True but you can also have something like Too many agents in your swarm because then you will have what's the candle of diminishing returns. That's actually their

Joe Dinius: It depends on...

Ramon Roche: .

Joe Dinius: what your objective is. If your objective is to deploy more drones and get revenue from it, then it's in line with your goals.

Kimberly McGuire: Yeah, that's true. I guess for my research. I kind of found that for instance, for the 40 area of that I was using during doing these experiments were already pretty enough to cover most of the area and when I added six or eights, it didn't really add that much to the total coverage and actually, reduce the rate of 300 returning because sometimes it will pop up to each other. It's a problem. So it's at least in it, that's the goal that I was achieved to cover as many rooms as possible. I definitely hit the law of diminishing returns. but yeah, if you have a clear sky and you can pack us with so many drones that you like. Then of course, you should go for it, but then you have to deal with the communication issue, which is the next discussion I think.

Théotime Balaguer: Yeah.

Joe Dinius: Right.

Théotime Balaguer: And I think in terms of missions, and what you can actually see in those academia and what's been done with the industry, I think the highest number of drones in the air, in the same time, it's Intel record. The Guinness book and it's for light show and it was all centralized control. And on the other end from what, I know, the highest number of turns was 32 in the decentralized manner, control, like insurance, but I've never seen something higher than 32 at the same time. It's the same place. And usually, it's more about like 4 to 10 drones.

Joe Dinius: What was the record for the centralized one that you said?

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Théotime Balaguer: I don't know. It's like hundreds, I think.

Joe Dinius: Yeah, if you've seen I think it was last year's one of the Formula One Grand Prix. They had an amazing drone light show. It was either at Singapore. It was one of the night races. Maybe I can look that up.

Théotime Balaguer: Yeah, the inter record is 500 turns.

Joe Dinius: Okay.

Gerald Peklar: No. it's thousands isn't it?

Kimberly McGuire: I think they passed that already.

Ramon Roche: Yeah, Intel is doing.

Gerald Peklar: It's about,...

Gerald Peklar: it's thousand.

Ramon Roche: Yeah, it's 1500 at least. For the Olympics that they're 1500.

Ryan Friedman: More than a unit. So I think that one of the main limitations was made a link itself, only supported 255, unique IDs, and so that, They have other layers on top of navelength that they're using for doing more than 255, which is pretty interesting. To get around.

Kimberly McGuire: So Intel is actually using muffling.

Ryan Friedman: I don't know about Intel, but I know talking to Trade Charter pilot. I was curious how they were handling more than 255 in the swarms, and he said that, they do other things on top of it.

Gerald Pekar: Yeah, I like to add to that. The communication protocol is at the moment, the biggest ation. Being With this Numbering and not using unique IDs, as it is used usually in the iot world.

Kimberly McGuire: I guess that's a good point. We were actually discussed it, the previous. I'm now moving to Ghost, Ramon communication because now we're actually talking about storm communication. So In that case, we be able to support more than 250.

Gerald Pekar: Why is depend with issue coming up?

Kimberly McGuire: It's not necessarily a issue. It's just like a kind of a subtopic, but if you have other things that you think it's important. Also with this room communication,

Gerald Pekar: I'm just asking because of the used technology or

Gerald Pekar: Because for example,...

Théotime Balaguer: but,

Gerald Pekar: have a broadcast communication module that can run with up to 27m bits. So, On the 5.8 giga, from IP based link. We have tested it or we are using it on thrones. communication. So cooperative awareness We can reach up to an range of 1 kilometer. Are drawn to drone and three kilometers ground to drone. So it's in broadcast network. We do drawn dr to Crown Station over the same network.

Gerald Pekar: With it and test, we could handle. With one single entity and the requirement. That. all current muffling data should be sent through in real time over 200 weeks before partner. So, something like this might be an option to look at which communication technology to use

Kimberly McGuire: Mm- Yeah. That's Definitely a good points. a lot of things are related. Of course to hardware. So if you have to write hardware, the right protocols, then things can be also. Solved is there anybody else that's want to Kind of perhaps.

Gerald Pekar: Yeah.

Kimberly McGuire: Yeah I have some thoughts about this particular topic by itself. Perhaps we can talk about. maybe centralized versus decentralized or

Ryan Friedman: Yeah, I mean for me like that. One of the problems of a massive flea is if you have a single ground station, that's a single point of failure for an entire fleet drones.

Ryan Friedman: and a production system, you want to be immune, that. You can put as many I uses. You want your drones for redundancy but if you have a single ground station, then you're sort of asking for

stuff to fail. and there's no point to adding all this other redundancy if you're gonna have a single ground station, But I think that one of the main challenges in managing a large lead is the configuration management.

Ryan Friedman: So you like Madelink, You got to go The unique IDs and all the drones and then if you need to replace one in the field, how do you ensure that? I accidentally said it to ID 124 instead of 122 and now two drones have the same ID and I get trying to find behavior in my system. so, A way to manage a large fleet easily needs automatic configuration and discovery.

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Ryan Friedman: So, you can just Take a drone, can get on the network, it can figure out so an ID and not conflict that the other ones on the network.

Gerald Peklar: So that is going into the direction that an hardware dependent unique ID is available.

Ryan Friedman: Yeah.

Gerald Peklar: And used for the community.

Ryan Friedman: but,

Joe Dinius: Yeah, but It isn't that what IPv6 is moving towards addressing. But a lot of the and...

Ryan Friedman: Yes.

Joe Dinius: the radio vendors least, the ones that we've been working with don't support IV IPv6 yet. And so The limitations, imposed by the tactical data link or radio manufacturers is a big limitation.

Théotime Balaguer: Is it something rose to and DDS could achieve or on my completely up topic?

Joe Dinius: I mean this is a hardware issue because I mean a lot of times the radio network will assign an address to the radio that you're connecting to and I don't know of a way to get around that.

Ryan Friedman: DDS operates a layer higher than layer 2. And 3, which is where the addressing is, So you need to have a network with addresses and be able to ping each other to use DDS.

Théotime Balaguer: Yeah. Yeah.

Ryan Friedman: so that

Joe Dinius: So what level is DDS at then Ryan, do you know?

Ryan Friedman: Four and...

Théotime Balaguer: If application is,

Ryan Friedman: five. Yeah.

Joe Dinius: Four and...

Joe Dinius: five, okay.

Ryan Friedman: And as you want all these,

Ramon Roche: Then one question I've always had and...

Ryan Friedman: Yeah.

Ramon Roche: miss something that we built before at the Mapping level. How do we generate the unique? Identifier for the hardware? and does it's a tied to the flight controller to the modem, the radio link, at Pnpx4, we sort of generate the UID, From the hardware, but it's not always. 100% reliable. Hardworking change. And for fleet management that it does, it really matters because if you switch the flight controller on a drone now, that's a different drone. If you tie it back to the flight controller. So, in the storm communication,...

Ramon Roche: the storm network, we do need to know, What adronians at any given time. So that we treat drone a persistent thing over time. Or do we? Adapt permission, I guess. And at the mission time, we define uid's for everyone at the configuration level, Which we know can change from one day to another. when you get hundreds of drones and you're working with them daily, that becomes a real issue.

Ramon Roche: That's when automatic configuration matters and discovery of all things.

Ryan Friedman: So, I mean as far as

Gerald Pekar: I think we need to distinguish between session IDs and hardware IDs, because we need to keep in mind, what's a regulations are requiring. So we need to send out and direct remote In future, if you fly BB loss.

Gerald Pekar: you will get a flight approval for a certain mission, and the mission will be on flight plan together within the heat, you have specified to the airspace authority, or your Space Service provider. And that would require the most probably and session ID. For the combination vehicle plus mission. And you need to identify your vehicle accordingly.

Gerald Pekar: And also there's certification and security is playing a role because how you have to identify your vehicle in the network which of the both are using for that. So also Secure identities need to be applied somehow, so I think that needs a bit more thought root and Doing it quick. Answering right away.

00:30:00

Ramon Roche: Yeah.

Gerald Pekar: So, by the way, we had the government-funded project in Germany. Would be where we looked at that issue. And at the end, we came up with Hardware secure elements that at every flight, got in certificate loaded, and the certificate. Was used to sign. Then the network ID. To be able to verify that really the vehicle that was applied with the flat plan is used If you like this,

Ramon Roche: Does anyone know if UTM regulations? let's say you have a 30 drone mission when you want to apply for that? Do you have to send? The mission for each of the 30 drones or you send one only one for them. You have to send all of them.

Kimberly McGuire: Do you mean sorry? Ramon, do you mean that if you send A mission to one of them. That one particular drone is sending it to all of the other. Drones were.

Ramon Roche: no, I mean for the relation perspective, if you want to ask for authorization to fly this drum swarm pattern, above people, and you need to Authorize it. So typically it's a one-to-one relationship or one drone. It certified and you send the information for your drone. And you apply for that mission. But if it's 30 drones at the same time, when the storm How does that work?

Kimberly McGuire: Okay, you're talking about regulation.

Ramon Roche: Yeah, I mean, that just came up to my mind after the discussion.

Kimberly McGuire: Yeah, okay, yeah, yeah, that is a good point.

Gerald Peklar: My experience from talking to regulation bodies is that the swarm flying use case? Has not even before by regulations yet? So at the moment is one drone.

Théotime Balaguer: Yeah, that's what I said to.

Gerald Peklar: One flight plan, one approval,

Gerald Peklar: If you come with a bunch of drones, Then a bunch of Requests,...

Théotime Balaguer: From.

Gerald Peklar: the bunch of approvals. That's the current.

Ramon Roche: Yeah, it would be nice to...

Gerald Peklar: At least.

Ramon Roche: what the drone light show people are doing right now, how they get permission, because they are getting permission by FAA. But

Gerald Peklar: Yeah, but there are arguments, is that this is line of sight operation. And this line of site operation, you don't need to supply and flat plan. Yeah, you're just saying. And you even need to ask for permission. If it is in open space it only becomes a problem. For example, I can only speak for Europe in Europe. You have regulations, if you are more than 150 meters away from urban areas, If you are not closer than one point five kilometers to an airport, no problem, you can operate, whatever you like. Yeah, up to 100.

Ramon Roche: Thank I'm gonna take back the conversation though.

Kimberly McGuire: I guess it's easy to have me. yeah,...

Ramon Roche: Sorry, go ahead and

Kimberly McGuire: no. So I guess it's easier to have indoor shooting. Which they slowly are starting to says.

Ramon Roche: Yeah, in their storms.

Kimberly McGuire: So we have already moved a bit swarm management,...

Ramon Roche: I want to close communication though.

Kimberly McGuire: but Yeah.

Ramon Roche: I wanted to ask what type, so we kind of said that IP based networking would be better ideal for international networking. Yeah, but does any other network type work? For swarms.

Kimberly McGuire: Wi-Fi. Indoor.

Gerald Pekar: it doesn't need to be an IP based network for Also, you can work with any.

Gerald Pekar: Wi-Fi based solution that does broadcasting. Yeah and if you can make sure that all devices can receive the information, it can be any protocol, for example, in the first iteration of the hardware of mentioned before we were using directly nothing messages. Being sent out over Wi-Fi. And didn't make use of any IP based addressing.

Gerald Pekar: In the lower level. Yeah, there was some I be based but it was just broadcasting addresses used. And it's just broadcasting. What we're

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Ramon Roche: Thank you. Anyone else have any comments here before we jump into simulation?

Kimberly McGuire: Yeah, I guess the mostly comments about we're an hour talking about particularly in protocols and the practicalities of communications the community the other communication medium, let's say, so that's also very important but at least when I was putting this one down, I also kind of looked at it's was thinking about in a level. But above that you have to communication. They're already what to communicate? So you can instance, look at for an indoor scenario. But that's if for instance, you have a molecap system and you want to sense the position of each drone from the mocam system computer to each of the drones. While they also have to communicate even more or communicate with each other, that is also kind of like, what is

Kimberly McGuire: And you cannot for instance, put in a hundreds Position broadcast to all of the drones at the same time. that's practically. Quite difficult to do that at a very low latency out scheme. So it's and how there are some kind of correlation

Meeting ended after 00:52:40 🙌