

WEBVTT

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00:00:00.000 --> 00:00:00.900

Thanks for

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00:00:02.610 --> 00:00:10.469

Pavan Yedavalli: Thanks for joining the aviation data science seminar today it's brought to you by Berkeley and NASA and NASA academic mission services.

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00:00:11.670 --> 00:00:17.760

Pavan Yedavalli: I'm just going to go through a few quick logistical notes and Vish will go ahead and present our speaker for today.

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00:00:19.260 --> 00:00:23.550

Pavan Yedavalli: Just logistically next week will be our last speaker for this semester.

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00:00:24.600 --> 00:00:33.840

Pavan Yedavalli: For those of you who are taking the seminar as a course will announce the end of semester assignment and all of its details next week.

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00:00:35.250 --> 00:00:37.650

Pavan Yedavalli: And regarding questions during the talk.

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00:00:37.800 --> 00:00:38.700

Pavan Yedavalli: Is there any quick

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00:00:38.820 --> 00:00:51.630

Pavan Yedavalli: clarifying questions peels, please feel free to put them in the chat box, otherwise we would like to take all the questions at the end. And during the presentation itself, please keep your mics muted.

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00:00:52.980 --> 00:01:03.690

Pavan Yedavalli: And if you choose to your video off as well, just to make sure we have a good communication line. And with that, I'll hand it over to fish will introduce our speaker for today. Thanks.

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00:01:04.650 --> 00:01:09.660

Vishwanath Bulusu: Hey, thanks Paul. Good morning, everyone. Thanks for joining us for this penultimate seminar.

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00:01:10.920 --> 00:01:15.630

Vishwanath Bulusu: It is with great pleasure and honor that I would like to introduce today's speaker, Dr. Garner Chatterjee

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00:01:17.160 --> 00:01:31.080

Vishwanath Bulusu: Ghana is a very good friend colleague and mentor for me at NASA Ames. He has he has been there for almost three decades and contributed to the field of air traffic management immensely.

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00:01:32.340 --> 00:01:35.910

Vishwanath Bulusu: Especially with focus on, you know, machine learning pattern recognition and find dynamics.

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00:01:37.560 --> 00:01:43.830

Vishwanath Bulusu: Or most of the best simulators there at Ames, you know, pretty much gonna has a big part to play in it.

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00:01:45.330 --> 00:01:54.660

Vishwanath Bulusu: He just a good background here it has be Tech in IIT Kanpur in India and his master's in Mississippi and PhD from Santa Clara.

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00:01:56.040 --> 00:02:09.270

Vishwanath Bulusu: trained as a mechanical engineer. I feel like I mean we should have had this talk while earlier. But I guess later but not never so gone on with that, I'll hand over to you and enlighten us.

17

00:02:11.640 --> 00:02:12.090

Okay.

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00:02:13.230 --> 00:02:13.590

gchatter: Okay.

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00:02:15.570 --> 00:02:24.360

gchatter: So I'm going to start with the, you know, just a little bit about the roadmap of Internet of Things, and beyond. So where we are

and where we are headed

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00:02:25.440 --> 00:02:33.630

gchatter: Talk a little bit about, you know, three different types of transportation systems, just to tell you the transportation systems are pretty similar.

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00:02:34.080 --> 00:02:42.660

gchatter: In the way they behave and the controls that you apply. So you can actually borrow ideas from one type of transportation system and apply it to another one.

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00:02:43.560 --> 00:02:49.110

gchatter: That I'll just briefly say that, you know, for air transportation, you know, we have used

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00:02:50.070 --> 00:02:59.580

gchatter: It. So it's basically an area of multi disciplinary research. So we have borrowed ideas from various domains and applied it to air traffic control.

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00:03:00.210 --> 00:03:16.080

gchatter: Then I'll talk a little bit about the history of flight brief history of flight I described the National Airspace System and talk about things that are really relevant to data science, which are the airspace geometries all the data associated with the airspace geometries important

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00:03:17.130 --> 00:03:20.430

gchatter: Knowledge of Federal Aviation regulations as important

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00:03:21.960 --> 00:03:30.000

gchatter: As the understanding of what the air traffic controllers do their roles and responsibilities equipment that they use.

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00:03:31.230 --> 00:03:41.010

gchatter: Then I talked about wind and weather, briefly, which is basically when data is very important for trajectory prediction and things of that nature and WEATHER IS SEVERE WEATHER IS SOMETHING THAT airplanes have to avoid

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00:03:42.810 --> 00:03:50.070

gchatter: Then I briefly talk about separation assurance, although there is a whole field, which deals with separation assurance, but I'll just give you a

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00:03:50.520 --> 00:04:06.120

gchatter: very preliminary idea what separation assurances, and then I'll talk about traffic flow management with a simple example, if I if I get to the by the time the talk is done. Okay. So currently we are we are in the mobile internet

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00:04:09.000 --> 00:04:13.440

gchatter: Age in the sense that we can do streaming, we can do

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00:04:14.880 --> 00:04:22.650

gchatter: Why server IP, we can do, you know, remote conferences. What we are doing now. So those kinds of things we can do today.

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00:04:23.070 --> 00:04:30.450

gchatter: We are moving towards Internet of Things, which is the urban mobility or package delivery drones. So basically,

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00:04:31.230 --> 00:04:37.980

gchatter: You know, you will have billions of connected smart devices including your mobile phones and you will have

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00:04:38.370 --> 00:04:45.270

gchatter: machine to machine communications, it will be low latency and latency tolerant and security and reliability.

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00:04:45.840 --> 00:04:56.760

gchatter: Will be address. So, that is what where we are headed towards are we are close to, that's what we are working on. So all the five new technologies 60 technologies, etc. They are all related to this.

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00:04:57.690 --> 00:05:05.280

gchatter: The cloud folks are also focusing on the Internet of Things, and eventually we will be headed towards tactile internet

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00:05:05.670 --> 00:05:13.140

gchatter: So what that means there's somebody in Washington, DC, you know, having a joystick or a controller and a robot in California.

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00:05:13.620 --> 00:05:27.750

gchatter: And the person will be able to get tactile feedback from the machine as the machine moves, you'll be able to feel on his joystick what the you know whether the surfaces raw for smooth so that would be basically human to machine inter interaction.

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00:05:30.150 --> 00:05:38.490

gchatter: Okay, so there are three transportation systems that I'm just briefly going to talk about. So there's air traffic. There's highway traffic that has data traffic so

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00:05:39.120 --> 00:05:46.650

gchatter: You have the notions of origin, destination source nor destination node, of course, the speeds are quite different in the

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00:05:47.250 --> 00:06:06.540

gchatter: Air traffic you're going at approximately 5500 miles per hour highway traffic you know 65 to 70 miles per hour. And of course, the data traffic you're doing at speed of light, and you have the notion of routing. So in the air traffic or highway traffic, you know, from one

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00:06:07.710 --> 00:06:16.560

gchatter: Road segment or the IV segment to another highway segment the driver actually switches it in a data traffic you're right router that switches that

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00:06:17.250 --> 00:06:24.180

gchatter: You have ideas of physical things that transport. So for example, you have airspace, you know, road segments with links.

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00:06:24.720 --> 00:06:32.820

gchatter: There is network topology wrote apology airspace layout and of course there are vehicles and there is this notion of route that you are following so

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00:06:33.270 --> 00:06:44.400

gchatter: There's a flight plan around and of course in a data traffic that is route, then you have notions of capacity and bandwidth. You

have also transit time trip time processing time

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00:06:44.850 --> 00:06:51.870

gchatter: And of course you apply these kinds of controls like metering and routing and even in data traffic, the notions of metering

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00:06:52.380 --> 00:07:00.330

gchatter: And rerouting are applied. So basically when there is congestion, there is something called transfer control protocol TCP, which actually comes back.

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00:07:01.020 --> 00:07:06.420

gchatter: To to slow down the traffic when when there is congestion and then of course you have

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00:07:06.900 --> 00:07:19.950

gchatter: Notions of delay and in package traffic. You also have notions of delay and packet loss. So by showing you that these systems are pretty common. You can actually take ideas from one area and

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00:07:20.400 --> 00:07:28.110

gchatter: Into another area. I've actually taken ideas from air traffic and I've applied it on package traffic also

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00:07:30.180 --> 00:07:43.050

gchatter: OK. So the purpose of data science and data traffic is principally, it actually behaves like a control system. So there is an objective that you're trying to meet beat. So for example, you want to reduce delay or you want to

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00:07:44.070 --> 00:07:45.600

gchatter: You want to increase throughput.

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00:07:46.680 --> 00:07:52.380

gchatter: So that is your objective, then you have a decision support system which is like a controller and

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00:07:53.010 --> 00:08:03.750

gchatter: The then you basically do some action so either you communicate by voice and then the pilot flies it or or or you instruct the machine, and the machine does something

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00:08:04.440 --> 00:08:16.260

gchatter: And then of course the plant or the processes. The air traffic control system that changes. So, for example, aircraft are either slowing down or they're sitting on the ground or they're moving so that affects the

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00:08:16.830 --> 00:08:22.710

gchatter: The air traffic. And then of course you need to have some sensors which is like radars or

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00:08:23.820 --> 00:08:34.410

gchatter: Some sort of a communication mechanism so that you can collect the data about what is going on. And then the estimation is essentially estimation or prediction is something that you

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00:08:35.340 --> 00:08:41.910

gchatter: You do. So for example, you see an airplane at one location and you say, in the next 15 minutes where, where is it going to be

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00:08:42.240 --> 00:08:52.050

gchatter: So you predict that. Similarly, if there is whether somewhere, you say, How's the weather moving and where will this weather be in the next 15 minutes or 20 minutes

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00:08:52.500 --> 00:08:57.990

gchatter: And then of course decision support. So most of the data science is basically applied to the

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00:08:58.560 --> 00:09:14.520

gchatter: Decision Support function prediction function sensors and also a little bit into the activation parts activation part is, for example, what was commanded. And what was actually implemented. So if there is a discrepancy between those

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00:09:15.660 --> 00:09:21.390

gchatter: Especially during accidents and incidents, you use data science to actually investigate some of those things.

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00:09:21.810 --> 00:09:31.260

gchatter: So here, traffic management, when I talk about air traffic

management. There are basically two components to it. One is called air traffic control and the other is called traffic flow management.

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00:09:32.490 --> 00:09:43.980

gchatter: Okay, so why is idiom challenging it is challenging because of data complexity. So you have a whole bunch of data flight data radar data geometry data when data.

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00:09:44.340 --> 00:10:03.690

gchatter: weather data and then on top of that you have different models or aircraft models that you use to predict predict trajectory, for example. So those so flight data, data, data, data, data, data weather data models. These are the kinds of things. These are the primary inputs for your data science.

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00:10:05.160 --> 00:10:16.290

gchatter: Algorithms. Of course there is. Then there is interaction complexity, you have human to human communication, you're human to machine communication, you have to machine your machine to machine communication.

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00:10:17.010 --> 00:10:21.540

gchatter: Then you have communication complexity, a wireless radio based and then you have

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00:10:22.440 --> 00:10:33.690

gchatter: So you have both wireless and wired wireless and digital communication with the aircraft and geographically distributed sensors and decision support systems. So you have got computers.

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00:10:34.200 --> 00:10:45.600

gchatter: You have got basically sensors and of course governing regulations and directives, so there are letters of agreements, there is standard operating procedures, all those things have to be followed.

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00:10:47.220 --> 00:10:54.510

gchatter: And later on I'll talk briefly about the regulations. Of course there is conflict infrastructure, your radar systems, other kinds of

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00:10:55.350 --> 00:11:12.570

gchatter: Dependent surveillance systems, your radio beacons your landing systems lighting systems computer systems and of course you have uncertainties, you know, whether when severe weather fog, then you have equipment failure you have airline

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00:11:14.400 --> 00:11:23.910

gchatter: Airline issues. So for example, the baggage get stuck somewhere or the passenger don't show up or the pilot is on a different flight and it's going to show up.

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00:11:24.900 --> 00:11:31.260

gchatter: And then you have emergencies. The patient suddenly fall sick or something like that. So, all those things, the system has to deal with.

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00:11:31.740 --> 00:11:37.050

gchatter: And then there is operational complexity, like you're dealing with safety, efficiency, fairness.

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00:11:37.470 --> 00:11:46.980

gchatter: So you don't want to give preference to one airline as opposed to another one. So the FAA has to worry about those kinds of things. Then there's a certain quality expectation

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00:11:47.460 --> 00:11:56.340

gchatter: So when you take off. You're supposed to land and you're supposed to get there in a certain certain amount of time. So, quality assurance has to be guaranteed in some sense.

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00:11:56.820 --> 00:12:10.020

gchatter: And then there are multiple stakeholders in the system and they are diverse different needs. Then of course we have certification requirements and FA also has the responsibility for advocacy for air traffic.

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00:12:11.910 --> 00:12:29.430

gchatter: So there's multiple multi multi disciplinary research, you know, we use ideas from dynamics estimation guidance navigation control operations research queueing theory optimization methods communication networks you have used notions of controlled land, which is like our outcome competent

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00:12:30.750 --> 00:12:40.260

gchatter: And data plan, which is like switching type of models, we have used ideas from Highway Transportation computer science like networks graph theory databases.

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00:12:41.430 --> 00:12:44.250

gchatter: Computer Vision machine intelligence robotics.

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00:12:45.300 --> 00:12:56.040

gchatter: So, for example, for computer vision. If you look at whether you know you can think of it as an image and you can use the same kinds of ideas that people use in computer vision to process, some of that data.

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00:12:57.030 --> 00:13:01.860

gchatter: hybrid systems because that a continuous more and then there are discrete modes.

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00:13:02.280 --> 00:13:11.280

gchatter: You can use ideas from fluid mechanics, like for example, if you want to avoid a certain area, whether you can solve the laplace equation to compute. For example, streamlines

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00:13:11.730 --> 00:13:19.290

gchatter: Which is the representation of around and then people have used ideas about like Lagrangian models oil area and models.

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00:13:20.220 --> 00:13:26.100

gchatter: Then of course you can use ideas for economics like but you know optimal and things of that nature management.

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00:13:27.000 --> 00:13:36.990

gchatter: So basically you're from multiple domains, you use ideas for traffic management. OK, so now this is a picture of

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00:13:37.470 --> 00:13:47.460

gchatter: Our Chief William league at Lewis Lambert Municipal Airport in 1929. He was the first air traffic controller. He was a pilot and engine and an aircraft mechanic.

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00:13:47.850 --> 00:13:53.730

gchatter: So basically early morning he would go with this. This wheelbarrow with two flights a chair and

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00:13:54.390 --> 00:14:02.160

gchatter: Umbrella. He would sit at one end of the runway and he had two flights and as and one was a red flag for holding position. The other was a checkered flag.

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00:14:02.700 --> 00:14:12.630

gchatter: You will wait for the airplane to come and land he had a degree in engineering from Washington State in St. Louis, and he retired as a system administrator of the FAA

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00:14:12.960 --> 00:14:19.080

gchatter: So from the humble beginnings. This is where the air traffic system kind of evolved from those humble beginnings. Okay.

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00:14:19.680 --> 00:14:31.620

gchatter: So history of flight in 1903 right flyer flew for 12 seconds. And if you are distance of 37 meters. The Air Mail act of 1935 five. It allowed the Postmaster General to contract.

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00:14:32.670 --> 00:14:45.000

gchatter: Private companies for transporting mail boying Douglas Pratt and Whitney were born during that time, then in 1926 to 34 Charles Lindbergh flew across the Atlantic.

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00:14:45.570 --> 00:14:55.230

gchatter: Is aircraft was called Ryan and VoIP and whi P is for New York to Paris during this time or two way radio and radio control tower was was

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00:14:56.220 --> 00:15:07.080

gchatter: Was invented and colonial. This is American Western express Tw and northwestern United were formed 1930 4055 bureau of air commerce into line agreements.

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00:15:07.620 --> 00:15:18.840

gchatter: Or form to coordinate the traffic and newer Chicago and Cleveland. They were afraid that airplanes would run into each other so they fall into line agreements and that is the really the beginning of air traffic control.

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00:15:19.350 --> 00:15:26.070

gchatter: Civil Aeronautics Administration was formed in 1940 visual flight rules and instrument flight rules were were

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00:15:27.330 --> 00:15:35.370

gchatter: Initiated and I'll talk a little bit about the visual flight rules and instrument flight rules English was adopted as the common air traffic control language.

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00:15:35.760 --> 00:15:45.540

gchatter: And International Civil Aviation Organization I think was formed an instrument landing system was developed to assist aircraft landing on at least a major airports.

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00:15:46.950 --> 00:15:53.940

gchatter: I need 55 to 65 water which is called the very high frequency Omni range and tak tak and as a

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00:15:54.450 --> 00:16:08.430

gchatter: Military system and this is basically a radio beacon system that aircraft with equipment onboard can follow than the air route Surveillance Radar which is ASR as our as our was developed an air traffic control.

102

00:16:09.810 --> 00:16:23.340

gchatter: Compute compute so installed at the end center air traffic control radar be consistent. We just called it etc RBS, this is a long range radar. This was developed and the commercial jet aircraft was also

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00:16:24.420 --> 00:16:39.480

gchatter: developed during this era separation standards and sectors were developed sector is a smaller area of airspace and I'll talk about it a bit later and Federal Aviation Agency was created in 1958

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00:16:40.740 --> 00:16:51.150

gchatter: The Department of Transportation. Do it was created in 1967 and federal agency was brought under the deal duty as Federal Aviation Administration.

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00:16:51.960 --> 00:17:03.150

gchatter: The National Transportation Safety Board, which is called NTSB was created to investigate transportation accidents and radar data processing RDP was developed.

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00:17:03.690 --> 00:17:15.540

gchatter: So the flight data processing, which was the which is the business card the FTP FTP and RDP became part of the host computer. So this was IBM 360 host computer

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00:17:17.040 --> 00:17:24.900

gchatter: For processing all the radar data and the flight data automated radar terminal system arts was actually

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00:17:25.440 --> 00:17:36.150

gchatter: Create a developer and the Android arts was also developed. This is the tray icon system, which is the terminal radar approach control which is determined area. So when the these are near the airport.

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00:17:37.620 --> 00:17:48.780

gchatter: They are like Deregulation Act of 1978 that allowed the airlines to form hub and spoke Bible operations and the professional air traffic controllers Association tackle.

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00:17:50.100 --> 00:17:57.480

gchatter: went on strike in 1981 and President Reagan actually fired a large number of controllers during this period of time.

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00:17:58.170 --> 00:18:05.370

gchatter: And then in 1987 the current national air traffic controllers association that covers was farm.

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00:18:06.360 --> 00:18:18.960

gchatter: Okay, so this shows the these graph show the air traffic activity between 1960 and 220 10 so the black line on top actually shows you the number of operations, which is the sum of

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00:18:19.380 --> 00:18:30.150

gchatter: arrivals and departures and you see this big dip around 1981 and then you see that blue line, which is the number of aircraft that that were handled in the

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00:18:31.470 --> 00:18:33.510

gchatter: In the centers, which is in the airspace.

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00:18:34.560 --> 00:18:49.950

gchatter: This other purple line basically shows the flight services that were used. And as you know, people have electronic flight bags and other ways of getting weather information. The demand for flight services has kind of continue to go down.

116

00:18:51.360 --> 00:19:11.100

gchatter: Okay, so you can see that, you know, in one year. Of course, you know, part of the reason for this appeal. But, you know, bigger jets being introduced. So you can see about in one year. You have approximately like 50 million takeoffs and landings into that 2010

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00:19:11.760 --> 00:19:12.810

Sarasina Tuchen: Hey, Donna.

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00:19:13.140 --> 00:19:24.330

Sarasina Tuchen: Yeah, I just wanted to tell you that we just got the stats for air traffic right now. During the code pandemic. It's down 97%

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00:19:25.710 --> 00:19:29.730

Sarasina Tuchen: And we're down to, I'm sorry 1954 levels of air traffic.

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00:19:30.750 --> 00:19:31.080

gchatter: Okay.

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00:19:31.680 --> 00:19:33.960

Sarasina Tuchen: I just wanted to tell you. Okay.

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00:19:37.290 --> 00:19:38.040

Jeremy Coupe: Okay, so

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00:19:38.130 --> 00:19:39.780

Jeremy Coupe: Passengers not flights, though.

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00:19:40.050 --> 00:19:45.990

Sarasina Tuchen: Yeah, yeah. That's how I met passengers not flights were down 67% and flights, I believe.

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00:19:47.940 --> 00:20:04.680

gchatter: Okay, so that when people talk about National Airspace System. They mean like it's a network of airspace air navigation facilities equipment services airports in an article charts Information Services rules and regulations technical information personnel.

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00:20:06.150 --> 00:20:14.190

gchatter: And the. It includes. So basically in the nice the NASA system also shares components jointly with the military.

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00:20:15.000 --> 00:20:24.120

gchatter: That are over 100 and 609,000 active pilots in the United States and the operate more than 280,000 aircraft.

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00:20:24.810 --> 00:20:32.340

gchatter: And this is from anything from a large commercial aircraft to small airplane. So helicopters gliders balloons and experimental aircraft.

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00:20:33.270 --> 00:20:42.570

gchatter: Okay, so these are 5233 public US airports and you can see they're spread all across the United States.

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00:20:43.230 --> 00:20:52.890

gchatter: That are IFR airports. So these airports can support low visibility landings and takeoffs then there are VFR airports, which means that only

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00:20:53.850 --> 00:21:06.630

gchatter: Good weather proper visibility conditions, you know, you can laugh at those airports and then there are VFR landing facilities which include health reports and things like that. So, all these airports.

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00:21:07.560 --> 00:21:20.220

gchatter: You know, for urban mobility, you could use, you know, a lot

of these public use airports and, of course, you see that there's a lot more concentration in the in the East compared to the west.

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00:21:21.360 --> 00:21:34.830

gchatter: Okay, so there are about like 19 about 20,000 airports in the US, which includes the military and private fields public use like I just showed you about 5000 of those that private user approximately

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00:21:35.400 --> 00:21:45.930

gchatter: 15,000 and then there are certified airports about 604 certified airport so certified airports means that they can they can support.

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00:21:46.320 --> 00:22:00.960

gchatter: Your carrier operations, which means the aircraft with more than nine passenger seats. So these are called the far which the Federal Aviation regulations part 139 operations. So the 604 civil airports can support.

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00:22:02.070 --> 00:22:03.510

gchatter: A bit larger aircraft.

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00:22:04.590 --> 00:22:23.640

gchatter: landings and takeoffs ok so the air traffic control system, you know, consists of several facilities. So the TCT is the air traffic control tower that is that originates. It goes through the terminal radar approach control area which is the tray icon.

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00:22:25.560 --> 00:22:40.890

gchatter: For our arrival arriving and departing aircraft go through this airspace as they climb to the Android airspace and during that time there talk to the trick on controllers. Then they go through the the Android airspace to go through the artsy, which is the route traffic.

139

00:22:43.680 --> 00:23:01.830

gchatter: Which is the air. Air Traffic Control air traffic control center and then again the go to drink on and the air traffic control tower. So this air traffic control system command center is kind of is it coordinates with all these different

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00:23:02.940 --> 00:23:13.230

gchatter: Entities. So you have air traffic control tower. Then you have the recordable rate on approach control. Then you have the air traffic control center then you again it goes to track on and the

141

00:23:15.540 --> 00:23:17.160

gchatter: And Lance again at

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00:23:18.660 --> 00:23:23.130

gchatter: The airport invited is what and during that time. He talks to the tower controllers.

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00:23:24.210 --> 00:23:32.580

gchatter: Okay, so these are the different types of air traffic control facilities, your flight service facilities. These are 76 flight service stations.

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00:23:33.030 --> 00:23:42.930

gchatter: And these are under contract with lighters so initially the contract was with Lockheed Martin. So these guys actually provide weather information so pilots.

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00:23:43.470 --> 00:23:51.330

gchatter: On the ground and in flight can actually call them and they can also submit their flight plans through these flight service stations, so

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00:23:52.140 --> 00:24:03.810

gchatter: The terminal facilities that I just talked about, which are like there are 517 air traffic control towers that are 185 terminal radar approach controls for

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00:24:04.560 --> 00:24:18.330

gchatter: inter-terminal area for supporting terminal area traffic and the Android facilities that are 21 air traffic control centers and three combined center and radar approach control. These are called syrup's

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00:24:20.220 --> 00:24:29.970

gchatter: And that is one air traffic control system command center. It is located in Washington. Washington. Washington in Virginia.

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00:24:32.250 --> 00:24:40.440

gchatter: Okay, so this is the US airspace. So essentially, like I said, these are the 21 centers so Oakland center.

150

00:24:41.250 --> 00:25:00.720

gchatter: Is basically the one that serves the Bay Area. Then you have the Los Angeles center here. This is the Fort Worth center. And so these are the 21 centers and this anchorage is also artsy the Honolulu Guam and send one these are syrup's

151

00:25:01.890 --> 00:25:03.300

gchatter: Which which basically

152

00:25:04.710 --> 00:25:05.280

gchatter: I don't know why.

153

00:25:06.360 --> 00:25:10.380

gchatter: Okay. The so these regions inside the Fort Worth.

154

00:25:11.820 --> 00:25:20.880

gchatter: Center that I'm showing these are called sectors, so the the RC airspace is essentially partition into sectors.

155

00:25:21.270 --> 00:25:28.980

gchatter: And inside these sectors. So basically the air traffic as it flies through the sectors that are controlled by sector controllers.

156

00:25:29.730 --> 00:25:40.800

gchatter: So the sector controllers control traffic and the handler traffic as they transition through the different centers as they go across the through the different sectors as the go across the center's

157

00:25:43.860 --> 00:25:55.500

gchatter: Okay, and the sectors are are basically partition that into three levels. So these are low sectors which go up to 24,000 feet altitude. The high sectors.

158

00:25:55.920 --> 00:26:07.380

gchatter: Begin at 24,000 feet altitude and go up to 33,000 feet altitude and super high sectors go above 33,000 feet altitude and they go up to 60,000 feet altitude.

159

00:26:08.250 --> 00:26:19.170

gchatter: And inside the law. Did you sectors, you have approached control areas and you have VFR tower or uncontrolled area. So these regions like the box and the cylinder shows

160

00:26:19.650 --> 00:26:34.530

gchatter: Those are determined area so airplanes, you know, fly through the low sector and then eventually go inside this process control areas and land they take off and leave these approach control areas and then going to be low sectors and the high sectors and super I sectors.

161

00:26:36.660 --> 00:26:39.810

gchatter: And air traffic controllers work in all these areas.

162

00:26:41.490 --> 00:26:47.610

gchatter: Okay, so these are high altitude jet route so they are like the highway. So you can I talked about the

163

00:26:48.630 --> 00:26:56.550

gchatter: commonality between transportation system. So these are jet routes. These are, how did you get routes and there are lower altitude Victor airways.

164

00:26:56.910 --> 00:27:02.700

gchatter: And you can see that there are some gaps you see some gaps and these are basically areas.

165

00:27:03.450 --> 00:27:20.940

gchatter: These are special user space. This area is closer to the Edwards Air Force Base, so you cannot fly over it. So there are many places in the US where you cannot fly over especially that activated or they are when they are active. And I'll show you the special user space in the US.

166

00:27:22.410 --> 00:27:35.010

gchatter: One of the pictures. Okay. All right. So this is a bit more detail inside the airspace of this is the Oakland center airspace and these are so for example.

167

00:27:37.980 --> 00:27:51.120

gchatter: One zero j five or one. These are all airways. So you can think of them like a highway 101 or two at and these are either radio beacons like MBA.

168

00:27:52.290 --> 00:28:04.530

gchatter: Or or Sacramento. This is Oakland airport. So these are either air. These are either lab aids or their fixes are

169

00:28:05.190 --> 00:28:13.140

gchatter: Are they could be intersections of airways. So these are well defined locations that you can put into your flight plan and that

170

00:28:13.980 --> 00:28:27.030

gchatter: So basically the computer system system can accurately parse and say where this airplane is flying. So like for example, this is when you put it into a into your

171

00:28:28.140 --> 00:28:39.180

gchatter: Into your phone navigation system you have a route. So this is like a route and these are, this, this is like the shows the detailed view of of of the route.

172

00:28:43.500 --> 00:28:53.970

gchatter: Okay so governing regulation so code. There's something called Code of Federal Regulations CFR, these are the general and permanent rules, published in the Federal Register by the executive departments.

173

00:28:54.540 --> 00:29:07.020

gchatter: And agencies of the federal government. It's divided into 15 titles. So title 14 covers the aeronautics and space and it includes numerous, numerous parts, also known as far as

174

00:29:07.710 --> 00:29:20.250

gchatter: A Federal Aviation regulations. Some examples are part one, which is the definition. So, it defines everything part 71 is the designation of classes and of airspace and I'll talk briefly about that.

175

00:29:21.000 --> 00:29:33.300

gchatter: Then there is part 73 which talks about special user space

that I mentioned briefly. Then there is part 91 which talks about general operating and flight rules that is part 121 which is the

176

00:29:33.990 --> 00:29:40.290

gchatter: Operating Rules for domestic flag and supplemental operations. So these are the large carriers like

177

00:29:40.950 --> 00:29:58.860

gchatter: American and United Delta, Southwest, and then there is part 135 which is operating requirements for commuter and on demand operations. So for example, if you talk about urban area mobility type of an aircraft then part 135 type of regulations would be applicable.

178

00:30:00.000 --> 00:30:09.330

gchatter: Okay, so this is part 91 which is the general operating at flight rules. So here I've highlighted two of them. The visual flight rules.

179

00:30:09.840 --> 00:30:28.710

gchatter: And the instrument flight rules visual flight rules for example, it says fuel requirements for flight in the VFR conditions VFR flight plan so information required basic VFR weather minimums. So you can only operate VFR flight if the weather and the visibility is is of a certain

180

00:30:30.210 --> 00:30:40.410

gchatter: Kind. So basically if you cannot if the visibility is poor, you cannot do visual flight. You cannot fly under visual flight rules. Similarly, the instrument flight rules field requirements.

181

00:30:41.790 --> 00:30:43.350

gchatter: You require a flight plan.

182

00:30:44.700 --> 00:30:59.310

gchatter: View our equipment check for for instrument flight rules, air traffic clearances required. So, so basically 14 CFR Part 91 describes the details of what they should be what they what they are.

183

00:31:00.090 --> 00:31:10.410

gchatter: Okay, this is the airspace classification. This is 14 CFR Part 71 so the airspace is divided into class A, B, C, D, E, and G.

184

00:31:10.920 --> 00:31:19.500

gchatter: So plus a is 18,000 feet above sea level up to flight level 666 hundred, which means 60,000 feet altitude.

185

00:31:20.250 --> 00:31:39.120

gchatter: Then you have class B, class C and Class D which are basically terminal areas so Class B is around big large airports in the US. So if you look at the 30 quarter airports Class B airspace around that. It's typically up to 10,000 feet above ground level.

186

00:31:40.200 --> 00:31:55.170

gchatter: Class C is up to like 44,000 feet above above ground level and Class D is about 2500 feet above ground level and Class G can go up to 14,500 feet.

187

00:31:55.950 --> 00:32:16.620

gchatter: below sea level, but it depends in different places. It could be 700 feet above ground level or 1200 feet ground level. So class. Geez, the uncontrolled airspace. So this is the airspace, that the new entrance would fly through and most, most of it is located in the western US

188

00:32:18.480 --> 00:32:20.790

gchatter: So these are the

189

00:32:22.020 --> 00:32:32.430

gchatter: Basically conditions for the different airspace classifications. So for example in class A, you can only do instrument flight rules in class B, C, D, and E

190

00:32:32.970 --> 00:32:53.040

gchatter: And F. You can do both instrument flight rules and visual flight rules the visibility is not applicable because this guy can fly in zero visibility conditions, but the other others and PC D you require three miles visibility in Class G you require one mile visibility.

191

00:32:54.660 --> 00:33:00.510

gchatter: And then you require a clearance in class, a class B.

192

00:33:01.740 --> 00:33:07.470

gchatter: Class C, D, and E you require clearance. If you are instrument flight rules.

193

00:33:08.790 --> 00:33:13.200

gchatter: in Class G. You do not require any clearance. Similarly, there are

194

00:33:14.520 --> 00:33:22.650

gchatter: You know, tells you that whether you read need radio or Dart. So for example in class D. You don't need radio communications with the with the ATC.

195

00:33:24.030 --> 00:33:33.870

gchatter: Okay, so these are the special US airspace spaces in the United States, and they are not active all the all the time. So,

196

00:33:35.280 --> 00:33:50.220

gchatter: They include restricted airspace to include military operations areas and things of that nature. So this is like for example around here you have Edwards Air Force Base out here you have Kennedy.

197

00:33:51.120 --> 00:34:07.530

gchatter: Space Center to there's a launch launch taking place, it'll kind of this, this, this will be active. Similarly, you have, you know, you cannot fly over the White House, you cannot fly over the Capitol building and and you cannot fly over certain areas in the Great Lakes because of environmental

198

00:34:08.760 --> 00:34:28.140

gchatter: Constraints. So a lot of airspace if everything was active you know you you would you would you know your your your flight routes will be more constrained. So some of the patterns that you observed that is also driven by these these reserved and restricted airspace. Okay.

199

00:34:29.490 --> 00:34:40.170

gchatter: So this is 14 CFR parts 73 there are all on listed in there. Okay, so visual flight rules. This is 14 CFR Part 91 which says the flight plan is optional.

200

00:34:40.830 --> 00:34:52.800

gchatter: radio contact with etc is voluntary, except in class B, C and D airspace pilot must see an award and can only fly and good visibility and acid of interior of clouds.

201

00:34:53.280 --> 00:35:00.450

gchatter: VFR cloud clearance and visibility minimums vary with the type of airspace. So basically I showed you either three miles or one month.

202

00:35:02.610 --> 00:35:11.370

gchatter: Okay instrument flight rules is 14 CFR Part 91 flight plan is required contact with etc is mandatory separation with other traffic.

203

00:35:12.450 --> 00:35:22.140

gchatter: So UTC separates the iPhone aircraft from other if our aircraft and if our aircraft from VFR aircraft, but they will not separate VFR aircraft from VFR aircraft.

204

00:35:23.220 --> 00:35:39.090

gchatter: They can fly in instrument meteorological condition. So basically if you have zero visibility that you can fly the airplane just with instruments, the IFR clearance is required for operating in class airspace, which is above 80,000 feet altitude.

205

00:35:41.190 --> 00:35:49.170

gchatter: Okay so flight plan says that you have to provide the description of the flight, which is the call sign

206

00:35:49.800 --> 00:35:59.520

gchatter: The aircraft type cruise speed cruising altitude, you have to provide the origin and destination, you have to provide the procedure that you are going to use. So basically procedure means

207

00:35:59.970 --> 00:36:09.210

gchatter: The route that you are going to use to depart the the airport. You're the provide airways waypoints fixes novick's intersections

208

00:36:09.570 --> 00:36:20.070

gchatter: Fix radial distance which is basically like a distance and the radial from unknown location to describe your route and then you

are also provide the

209

00:36:20.850 --> 00:36:25.740

gchatter: The arrival route that you're going to use for landing at the at the arrival airport

210

00:36:26.490 --> 00:36:34.980

gchatter: So this is flight plan. This is a form in which you file a flight plan. So here you show you, Mark, whether it is a VFR IFR flight.

211

00:36:35.520 --> 00:36:42.420

gchatter: Then this says. It says this is American Airlines 278 it's a Boeing 767 are says that it is

212

00:36:42.930 --> 00:36:50.520

gchatter: Capable of area navigation, it's going to fly through airspeed a 468 knots. It's going to take off from from Dallas, Fort Worth.

213

00:36:51.300 --> 00:37:00.960

gchatter: And it's good to leave at 1909 Zulu, and it's going to fly argued of 33,000 feet or attitude. It is headed for Washington Dulles

214

00:37:01.380 --> 00:37:12.450

gchatter: Is going to take three hours and 15 minutes. That's the estimated time on route and it has got fuel for four hours and 30 minutes so basically it is compliant with all the regulations.

215

00:37:12.930 --> 00:37:30.630

gchatter: And the alternative airport is JFK. So if there is some bad condition in Dallas. It's going to fly to JFK. So it needs to carry fuel, all the way from DFW to Washington to and from Washington to JFK last 45 minutes of additional en route fuel.

216

00:37:31.770 --> 00:37:37.650

gchatter: So this is what a flight plan looks like and then the weather briefing, so that these flight service station that I talked about.

217

00:37:38.400 --> 00:37:50.040

gchatter: 76 of those, they will provide aviation rather reports forecasts and advisories to the pilot all the notice to airmen, for example, of whatever conditions are there in the airspace.

218

00:37:51.450 --> 00:38:03.900

gchatter: Will be provided to the pilot when they call them. They can also take your flight plan and file it for you and you can get all this information through in flight services via radio communications.

219

00:38:04.560 --> 00:38:15.780

gchatter: The National Weather Service also provides further information. So that's weather.gov 1800 weather briefing.com is another place where you can get this is actually

220

00:38:16.500 --> 00:38:30.090

gchatter: Provided by lighters, and then there is aviation weather.gov that you can get information from and also these days using iPads and Android based electronic flight bags, you can get weather information.

221

00:38:31.260 --> 00:38:40.800

gchatter: OK, so the different types of etc equipment that is used your airport surface detection equipment that's actually a radar based system for the airport surface it detects

222

00:38:41.400 --> 00:38:48.690

gchatter: Aircraft is and it can track as the aircraft taxi and from the gate to the to the runway and take off.

223

00:38:49.170 --> 00:38:56.070

gchatter: That is airport Surveillance Radar. This is like a spinning radar. You see some near near airports. This is basically a track on radar.

224

00:38:56.760 --> 00:39:05.850

gchatter: Then you have the air traffic control radar beacon system. This is a. It has a primary radar and the secondary beacon system and this is basically the Long Range radar.

225

00:39:06.270 --> 00:39:18.570

gchatter: Automated radar terminal system. This is the trick on computer. It's called art. And then there is the Iraq, which is the Android automation modernization. This is again a computer system.

This is used in the

226

00:39:19.140 --> 00:39:32.010

gchatter: route traffic control center, then that is direct access radar channel, which is basically just takes the radar data displays it for for you if basically the computer systems fail. So this is the backup.

227

00:39:32.790 --> 00:39:46.500

gchatter: Than the Omni very high frequency on the range. This is radio beacon, I talked about TAC end which is the tactical error navigation systems as a military system and the view ours and the back ends are co located

228

00:39:47.520 --> 00:39:55.350

gchatter: In several basis and that system is called War tak then your aircraft aircraft communication with addressing and reporting system.

229

00:39:55.890 --> 00:40:02.580

gchatter: Which is called a cars, which is an email type of a system. It's a digital link by which you can send messages from the ground to the airplane.

230

00:40:03.000 --> 00:40:16.950

gchatter: And from the airplane to the ground and then there is wise communication. This is called a party line. So it is open. So all pilots can hear when when when the air traffic controller communicates with one pilot other pilots can here. So this helps with the situational awareness.

231

00:40:18.240 --> 00:40:22.560

gchatter: Okay, so this is the different all the different kinds of data, you know,

232

00:40:23.970 --> 00:40:31.950

gchatter: Are part of the data that is generated in the system. And a lot of this data is provided via the swim feed that if you remember

233

00:40:32.670 --> 00:40:55.110

gchatter: Dr. Jeremy cool you know mentioned in his stock market some some data. So a lot of the data produced by these systems is fact for for consumption by the public and the other stakeholders. Okay, so,

so, air traffic control tower. They basically use the the as the feed.

234

00:40:56.730 --> 00:40:57.660

gchatter: So, which is the

235

00:40:59.280 --> 00:41:19.110

gchatter: Switches the airport surface detection equipment and then the airport. Surveillance Radar that that gets position data from the attracts the aircraft and feeds the position data. The trick ons, the Long Range radar, the Arab Surveillance Radar that gets that feeds position data into the

236

00:41:20.430 --> 00:41:24.960

gchatter: Air Traffic Control Center. So the EDA gets data from

237

00:41:26.130 --> 00:41:31.410

gchatter: The long range radar and the airport. Surveillance Radar provides data to the

238

00:41:32.700 --> 00:41:34.260

gchatter: To the credit card system.

239

00:41:37.200 --> 00:41:47.220

gchatter: Okay, so basically, once you get all the position data you process it. And these are the so the 11 arts computers essentially process.

240

00:41:47.790 --> 00:42:03.330

gchatter: All the raw data, data in the compute the latitude, longitude, altitude ground speed hiding rate of climb descent for every aircraft in the system. So this is another set of data that you use for for Data Science

241

00:42:04.680 --> 00:42:16.110

gchatter: Okay, so when the aircraft flies. There are basically four types of people who essentially communicate with each other to manage the aircraft.

242

00:42:16.500 --> 00:42:21.990

gchatter: So the controller talks to the pilot and the pilot talks to the controller. So that is the air traffic control part

243

00:42:22.680 --> 00:42:31.800

gchatter: Then there is a traffic flow manager who talks to the controller and make sure that the controller is not overwhelmed by traffic. So he actually applies.

244

00:42:32.280 --> 00:42:38.190

gchatter: Different kinds of traffic flow management initiatives you also talks to the dispatcher, who is the airline representative

245

00:42:38.640 --> 00:42:47.370

gchatter: Who essentially communicates with the pilot and give some information about weather, etc. So when the airplane. So the pilot is kind of flying the airplane.

246

00:42:47.790 --> 00:43:01.080

gchatter: The controller is making sure that the he doesn't run into any other aircraft dispatcher, make sure that you know that the schedule is maintained and make sure that assist the pilot with maintenance issues answers questions.

247

00:43:02.340 --> 00:43:12.180

gchatter: In flight. And he also talks to the traffic flow manager manager, based on what they were concerned see has and the traffic flow manager talks to the controller. Make sure that the controllers.

248

00:43:13.980 --> 00:43:25.560

gchatter: So traffic flow management and an air traffic controller are parts of the Federal Aviation Administration and airline operations control part basically includes the pilot and the dispatcher

249

00:43:26.970 --> 00:43:34.740

gchatter: Okay so airline operations control has different functions that they do. And again, a lot of it. They do a lot of data science also

250

00:43:35.190 --> 00:43:45.690

gchatter: So they developed the schedule, which is the main product of the airline. So in the in the community said they say that the pilot flies, an airplane the dispatcher flies the schedule.

251

00:43:46.920 --> 00:43:52.170

gchatter: They do flight planning. So they figure out the most efficient route of flight to figure out alternative airports.

252

00:43:52.800 --> 00:44:08.310

gchatter: They compute the amount of fuel required the weight and the balance of the airplane. They, you know, they keep track of maintenance requirements. So you are going to change the tires here and you are going to look at the user to change the seats there.

253

00:44:10.590 --> 00:44:14.820

gchatter: You're going to inspect the airframe at some other location. So they plan all that

254

00:44:15.240 --> 00:44:22.080

gchatter: And then there is a minimum requirement. This requirement which that, for example, if you do not. If you have to oxygen canisters

255

00:44:22.410 --> 00:44:33.360

gchatter: And one of them is not working, then you can apply to certain altitude you to fly below us or naughty to so they have to make sure that they comply with all the regulations and then of course they have to manage the

256

00:44:34.500 --> 00:44:53.550

gchatter: To manage the resources, which is the aircraft. The crew and the passengers, they get together at one point and then they all go away at another location right so you have a pilot coming on one flight, he comes and learns and gets on to another airplane. And then, you know, fly that airplane.

257

00:44:54.690 --> 00:45:07.200

gchatter: And so on and so forth. They also do flight flop following. So as the airplane flies through the airspace, they follow it using their displays and they advised aircrew different options gate availability.

258

00:45:08.130 --> 00:45:20.160

gchatter: Gate changes all those kinds of information they provide. And they also separate the aircraft from weather and if the pilot experiences turbulence or something evil concerned the dispatcher to see if the turbulence is going to go away or not.

259

00:45:20.850 --> 00:45:24.960

gchatter: And things of that nature. Okay, so, air traffic controller that are

260

00:45:26.040 --> 00:45:36.030

gchatter: Our controllers that are trained on controllers and there are central controller. So there are the tower. You have clearance delivery, you know, ground controller, you have local controller.

261

00:45:36.480 --> 00:45:40.050

gchatter: And basically, to the ground control and actually stretch the pilot

262

00:45:40.440 --> 00:45:48.450

gchatter: To taxi to the active runway and the local controller sequences. The flight into the local flow and make sure that the aircraft separated from inbound and outbound traffic.

263

00:45:48.810 --> 00:46:03.030

gchatter: The traffic on controller, you know, he did. He did receive traffic from local controller and he flies the airplane through the Greek on and and then or enhance it off to the to the to the central controller.

264

00:46:04.470 --> 00:46:16.410

gchatter: So this is a flight progress strip that the US supplied progress that has information like aircraft identification type of aircraft says a certain kind of so this one as a collision.

265

00:46:16.980 --> 00:46:23.400

gchatter: Avoidance equipment which is the gas, the computer identification proposed departure time requested altitudes.

266

00:46:24.000 --> 00:46:36.540

gchatter: And remarks and basically they're right on the paper strips the right so this is this used to be the ultimate backup in case of radar failure or something that would still keep the information. If the computer system failed.

267

00:46:37.440 --> 00:46:42.600

gchatter: There would still be able to track it and and and know where the airplane was

268

00:46:44.490 --> 00:47:00.930

gchatter: OK, so the central controllers, you have a radar controller. There's our side. That's the data controller than there is a system controller decide and that is a controller tracker. So the data controller is the one who basically looks at the plan view display and sort of separates aircraft.

269

00:47:02.010 --> 00:47:09.900

gchatter: The assistant controller, he updates of like process progress strips that I just showed you and provide separation under non radar environment.

270

00:47:10.890 --> 00:47:19.470

gchatter: Then you have the traffic management unit and this guy ensures that the sector controllers workload stays within liberty and coordinates traffic flow management with the neighboring

271

00:47:20.910 --> 00:47:31.260

gchatter: Centers and he uses the traffic flow management system, which is a which is the computer based system for demand prediction to make sure that the traffic controller would not be around.

272

00:47:31.620 --> 00:47:40.440

gchatter: And he places restriction to old aircraft on the ground or to put modern trains type of restriction to to slow down the

273

00:47:41.460 --> 00:47:44.130

gchatter: The inbound traffic into into sector.

274

00:47:45.240 --> 00:47:58.470

gchatter: Okay so ATM provides two types of services primarily safety and efficiency. So the air traffic control center it ensures that the IFR aircraft are separated and ensures that the throughput is maintained.

275

00:47:59.070 --> 00:48:18.360

gchatter: The central flow control maintains safety and efficiency by preventing congestion and they coordinate the actions of the different air traffic control centers to make sure that then that national flow

which is the flow of traffic in the in the US is basically safe and efficient.

276

00:48:19.980 --> 00:48:32.700

gchatter: Okay, so for separation aircraft have to be separated both an attitude and and laterally. So either they have to be separated by five miles or by thousand feet so

277

00:48:33.840 --> 00:48:45.900

gchatter: There is you can be separated by three miles. If the aircraft is within 40 nautical miles from an antenna or when using a single non mosaic radar source. So usually

278

00:48:47.340 --> 00:48:57.330

gchatter: The aircraft is tracked by several radars and then either am or arts, would that would actually fuse that data and and sort of say that okay this is where the aircraft is

279

00:48:58.140 --> 00:49:06.000

gchatter: So if the aircraft is observable from a single radar and he's within 40 nautical miles, then you can have a three mile lateral separation.

280

00:49:07.710 --> 00:49:11.040

gchatter: Okay and this is based on the FA

281

00:49:13.620 --> 00:49:20.190

gchatter: Fa order 71 10.65 which is basically the air traffic control, control owners manual

282

00:49:21.900 --> 00:49:34.380

gchatter: Okay so conflict detection methods you can you can resolve aircraft through altitude control. You can command the aircraft to climb or descend so vector means you asked the aircraft to change heading like change adding the 30 degrees.

283

00:49:35.760 --> 00:49:43.230

gchatter: And then speed controllers, you can ask one of the aircraft to speed up or slow down to separate and of course you can use combinations of these

284

00:49:43.590 --> 00:49:53.610

gchatter: These controls. Right. So although I've just stated, it looks quite simple and straightforward, but that's not really the case there is a whole plethora plethora of literature.

285

00:49:54.030 --> 00:50:01.680

gchatter: Which describes how to actually detect conflicts and how to resolve because part of the problem is you have to use when whether to essentially predict

286

00:50:02.100 --> 00:50:15.180

gchatter: Where the aircraft is you have to use the aircraft performance model to predict where the aircraft is detected, and then you have to have to be to prior planning to ensure that the conflict is resolved, and then you communicate that to the back to the pilot

287

00:50:16.290 --> 00:50:28.980

gchatter: Okay so traffic flow management. The basic idea. The input to the traffic flow management is the traffic demand and your flow constraints like airport capacity airspace capacity and the objective of this optimization is to

288

00:50:30.690 --> 00:50:37.260

gchatter: maximize or minimize delays distribute delays equitably and also include user preference.

289

00:50:37.710 --> 00:50:44.940

gchatter: So the traffic flow controllers, you, you, you can impose ground delay, you can do miles and trails from Highland trail means that

290

00:50:45.360 --> 00:51:02.700

gchatter: Two aircraft are separated by that's a five miles 10 miles and then minutes and trail is that the leading aircraft. The, the following aircraft are separated from the leading aircraft by five minutes or 10 minutes that's like milestone trail and you can reroute so you can change.

291

00:51:03.810 --> 00:51:15.270

gchatter: Or you can hold the or you could put the airplane on a whole so that the airplane is actually spinning around till you actually let it continue on its route. So these are the control mechanisms that are frequently used an air traffic.

292

00:51:16.380 --> 00:51:27.390

gchatter: Traffic flow management. So this is an example of weeks. So this is you can, it can be pretty high. So you can even have areas where the winter like hundred 220 darts.

293

00:51:27.840 --> 00:51:33.870

gchatter: 60 to 65 so so whether so when the information is important for predicting

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00:51:34.530 --> 00:51:42.660

gchatter: Where the airplane with will be. So for example, if the airplane is flying a certain airspeed and it gets a tail. Then, then the ground speed will be faster.

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00:51:42.990 --> 00:51:56.400

gchatter: So for separation assurance. You have to do it based on ground speed not airspeed so that that is the reference that you use for conflict detection or dissolution. So then when data is very important. Right.

296

00:51:58.830 --> 00:52:01.950

gchatter: So that is another data source that causes

297

00:52:03.360 --> 00:52:13.080

gchatter: Data science problems right and then you have better. So this is collaborative convective forecast product. So this is showing you severe weather. So you have

298

00:52:14.490 --> 00:52:28.350

gchatter: You have, you know, reasons which are green. You have reasons which are yellow your reasons which are red. And basically, you cannot fly through some of these areas. And not only that, you have to also maintain some distance from these regions because there is turbulence.

299

00:52:29.490 --> 00:52:40.500

gchatter: Around these areas. So now, if you think about this as an image. You can also imagine how you would how you could apply image processing kind of techniques to figure out what regions are

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00:52:41.940 --> 00:53:00.540

gchatter: You know you can. So for example, you can use something like a block, block coloring algorithm to fill in the gaps that the airplane cannot pass. So basically you can grow them into bigger regions and then eventually, you know, think of them as obstacles around which route has to go.

301

00:53:01.770 --> 00:53:09.780

gchatter: Okay so DFM rerouting so there's something called playbook routes which are in the system and playbook routes or canned routes which are

302

00:53:10.200 --> 00:53:22.710

gchatter: You know, which the air traffic control has. So those are documented. This is an old route. It does not exist anymore, but it's still a good example. So here there was a route called West Watertown playbook route.

303

00:53:23.250 --> 00:53:29.790

gchatter: And that goes to the Minneapolis center. You see the highlighted region. So basically,

304

00:53:30.810 --> 00:53:44.190

gchatter: You know, if you take off from Los Angeles, you would go through Bryce Canyon and then wrap and then go through Aberdeen and that essentially go through the media policy center and then go through it. So this playbook route is designed to

305

00:53:45.510 --> 00:53:57.570

gchatter: To go around weather around the weather in the Minneapolis center, for example. So here is a UL one at flight. That was the flight plan actually went through that area of

306

00:53:58.800 --> 00:54:09.180

gchatter: Severe weather. So basically the air traffic control uses the playbook route to reroute him around this region of better right

307

00:54:10.350 --> 00:54:21.540

gchatter: Okay, now when they tried to read out. So this is sector 16 and 17 when they tried to read out around sectors through sectors 16 the the

308

00:54:22.440 --> 00:54:37.860

gchatter: traffic count is the instantaneous traffic count in SEC SEC sector 16 goes over that or the value that the controller can handle. So essentially you they cannot go through this. So you require a local reroute to go around.

309

00:54:39.420 --> 00:54:46.980

gchatter: Sector 16 so this shows American Airlines, kind of going around sector 16 so that the

310

00:54:48.090 --> 00:55:04.110

gchatter: So, so that sector 16 is not congested. So by this example obvious showing is that, you know, just the rerouting doesn't work sometimes on top of the routing, you have to use other initiatives. So in this case, it says that originally, you know, bread.

311

00:55:05.280 --> 00:55:13.920

gchatter: And butter. So then basically shows an hour long for gas. So at 10 minutes, you would have the second account would exceed in sector.

312

00:55:15.660 --> 00:55:25.920

gchatter: 16 and the maximum number of aircraft that you can have in that sector is 18 so when you apply a playbook route the the the

313

00:55:27.270 --> 00:55:36.870

gchatter: The air traffic, the number of aircraft in sector 16 in exceeds 18 at some point in time. So you have to apply miles and trail on top of that.

314

00:55:37.650 --> 00:55:44.340

gchatter: at Aberdeen. So you're saying pretty miles and trail. That's the other constraint, you do. And then you apply a local reroute

315

00:55:44.700 --> 00:55:49.440

gchatter: And when you do the local reroute everything kind of balances out so you can see that everything is green.

316

00:55:49.920 --> 00:55:55.830

gchatter: And basically the controller would not be overwhelmed. This one shows that if you just did a local reroute and you did not imply

317

00:55:56.370 --> 00:56:11.280

gchatter: A postmodern trail constraint. The these your solve the problem in sectors 16 but sectors 17 the the monitor alert parameter which is the measure of the workload of the controller that would get exceeded so

318

00:56:12.300 --> 00:56:18.210

gchatter: So this shows that you have to apply multiple controls to manage the traffic flow.

319

00:56:19.020 --> 00:56:26.220

gchatter: Okay, so to end my talk. I basically described the National Airspace System. I talked about the air traffic control facilities.

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00:56:26.610 --> 00:56:33.180

gchatter: I talked about air traffic control equipment I talked about aircraft air traffic controller roles and responsibilities.

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00:56:33.570 --> 00:56:42.330

gchatter: I talked about regulations and directives, I talked about separation assurance. I talked to our traffic flow management and from the ATM data science.

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00:56:42.900 --> 00:56:57.510

gchatter: From the EDM data for Data Science, I talked about airspace geometry data I talked about flight plan data I talked about surveillance data and I talked about wind and weather data. Thank you so much for being patient

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00:57:00.780 --> 00:57:09.870

Pavan Yedavalli: Thanks so much guys. That was fantastic. Very informative for everyone. Um, are there any questions for gonna

324

00:57:11.370 --> 00:57:12.330

sguha1: Get the slides.

325

00:57:13.830 --> 00:57:16.680

Vishwanath Bulusu: I can we get all the information the store.

326

00:57:17.460 --> 00:57:21.600

sguha1: And this is a really good, it wouldn't be published as a book.

327

00:57:27.000 --> 00:57:30.120

Pavan Yedavalli: I think Gary can definitely

328

00:57:31.200 --> 00:57:34.020

Pavan Yedavalli: send out the slides at some point gun. Oh, can you

329

00:57:36.150 --> 00:57:36.420

Hear me

330

00:57:37.620 --> 00:57:41.940

gchatter: Okay, yeah. So basically these are you know these have been approved by NASA

331

00:57:43.050 --> 00:57:43.740

gchatter: So,

332

00:57:44.880 --> 00:57:49.470

gchatter: NASA has agreed to put it in public domain. Right, so I can provide it.

333

00:57:51.930 --> 00:57:52.230

Thank you.

334

00:57:53.580 --> 00:57:59.700

cfreedma: I think they get posted on the website on the on the data sciences website too.

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00:58:03.570 --> 00:58:03.900

gchatter: Yes.

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00:58:03.930 --> 00:58:08.190

Pavan Yedavalli: Yeah, the, the presentation itself will will definitely be posted the recording.

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00:58:09.270 --> 00:58:11.910

Pavan Yedavalli: And then maybe the slides themselves can be awesome.

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00:58:15.270 --> 00:58:18.000

sguha1: I think this should have been a two hour session.

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00:58:24.150 --> 00:58:25.380

gchatter: Either you want me to work more

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00:58:26.460 --> 00:58:28.770

sguha1: Oh, definitely. This is actually very good

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00:58:29.790 --> 00:58:30.720

sguha1: I really like it.

342

00:58:31.170 --> 00:58:33.870

gchatter: Yeah, I skipped over a lot of things, but you know

343

00:58:35.400 --> 00:58:38.100

gchatter: If I went into details. It would take longer.

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00:58:39.480 --> 00:58:40.500

Vishwanath Bulusu: Quick suggestion or

345

00:58:42.000 --> 00:58:42.960

Raja Sengupta: One hour view.

346

00:58:43.830 --> 00:58:48.540

Raja Sengupta: Of the whole ecosystem, which is extremely insightful for a person like me.

347

00:58:49.860 --> 00:58:52.830

Raja Sengupta: Who likes to do his favorite drone and UN stuff.

348

00:58:53.700 --> 00:58:54.930

Raja Sengupta: But it's very often not

349

00:58:55.080 --> 00:58:56.520

Raja Sengupta: Fully aware of the bigger picture.

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00:58:58.980 --> 00:59:00.030  
So thank you, thank you, Roger.

351

00:59:01.710 --> 00:59:16.650  
Vishwanath Bulusu: He I have a quick request going, I don't know if we can do it for everyone, but at least for internal folks, you know I would. It would be nice to have another follow a presentation about detailed of applications like you know what all kind of a summary of all the

352

00:59:18.360 --> 00:59:23.730  
Vishwanath Bulusu: The application work that has happened at NASA, for example, with data science in aviation right

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00:59:25.110 --> 00:59:26.220  
Vishwanath Bulusu: Yeah. Just, just an idea.

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00:59:27.690 --> 00:59:31.470  
gchatter: So Berkeley is planning a course for that right

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00:59:32.760 --> 00:59:40.920  
Vishwanath Bulusu: Yes, Berkeley is planning a course. I mean guys I can fill the class. More on that. Um, but yeah, that could be another platform for that.

356

00:59:48.330 --> 00:59:51.390  
Pavan Yedavalli: Right. Um, are there any other questions from any of the

357

00:59:53.400 --> 00:59:54.180  
Pavan Yedavalli: Participants

358

00:59:59.850 --> 01:00:08.520  
Pavan Yedavalli: Okay, then I think we can give a virtual applause to gone. Oh, thanks so much for presenting this is fantastic. Thank you.

359

01:00:09.330 --> 01:00:10.350  
Pavan Yedavalli: Thank you. Thank you. You're

360

01:00:10.350 --> 01:00:12.120

Pavan Yedavalli: Welcome and

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01:00:14.220 --> 01:00:15.120

Pavan Yedavalli: Obama. Yes.

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01:00:15.300 --> 01:00:17.100

gchatter: Do you have no yeah

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01:00:18.690 --> 01:00:19.320

gchatter: A bond over

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01:00:22.050 --> 01:00:22.290

Pavan Yedavalli: Hello.

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01:00:24.270 --> 01:00:26.010

Vishwanath Bulusu: Hey, go ahead. We can hear you.

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01:00:29.370 --> 01:00:30.870

Pavan Yedavalli: Oh, maybe he can't hear us.

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01:00:32.160 --> 01:00:33.330

Vishwanath Bulusu: Maybe muted himself.

368

01:00:33.690 --> 01:00:34.110

Yeah.

369

01:00:36.150 --> 01:00:36.540

bsridhar: Hello.

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01:00:36.570 --> 01:00:37.110

Pavan Yedavalli: Maybe he could

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01:00:37.470 --> 01:00:37.740

gchatter: Yeah.

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01:00:38.730 --> 01:00:44.190

bsridhar: Go ahead. Yeah, again, are a lot of this stuff. I ve had written

373

01:00:45.990 --> 01:00:53.790

bsridhar: You know, something called aircraft technologies. So if somebody is looking for the written part of it.

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01:00:55.260 --> 01:01:00.240

bsridhar: Some, some of the stuff is in there but you have added a lot of new stuff to it.

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01:01:01.500 --> 01:01:06.240

gchatter: But well bar. Yeah, you're right. I mean, I forgot about it. This is the

376

01:01:07.620 --> 01:01:08.070

gchatter: The

377

01:01:09.390 --> 01:01:10.830

bsridhar: It's in psycho.

378

01:01:11.610 --> 01:01:13.230

gchatter: Yeah, this is the dawn lightly.

379

01:01:13.860 --> 01:01:16.710

gchatter: Yeah, is it by the is widely it's

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01:01:16.800 --> 01:01:17.580

gchatter: Called the

381

01:01:18.480 --> 01:01:20.820

bsridhar: I think it's quite an aircraft technologies.

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01:01:21.210 --> 01:01:24.960

gchatter: It's I have that I have that paper I can actually

383

01:01:25.590 --> 01:01:32.070

bsridhar: That would, that would give a you know a lot of detail for what you're saying, but you have lots more stuff. Yes.

384

01:01:33.810 --> 01:01:42.210

gchatter: Yeah, so that that people kind of talks about air traffic control and it even talks about the different types of additional equipment and

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01:01:44.130 --> 01:01:45.690

gchatter: Yeah, so that's a good article, I think.

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01:01:50.100 --> 01:01:53.220

Vishwanath Bulusu: Well, okay, everyone, for joining us. I'm

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01:01:54.630 --> 01:02:09.720

Pavan Yedavalli: Tom as as we were mentioning earlier before the talk next week will be our final seminar for the semester we do obviously appreciate everyone's patience as we went through the semester.

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01:02:10.920 --> 01:02:13.800

Pavan Yedavalli: And for those of you who are taking the course, please.

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01:02:14.970 --> 01:02:24.360

Pavan Yedavalli: Stay tuned next week for the assignment details. And with that, we hope to see everyone next week for the final presentation. Thank you, everyone.

390

01:02:25.230 --> 01:02:26.730

gchatter: Thank you. Thanks.

391

01:02:26.910 --> 01:02:27.270

Pavan Yedavalli: Thank you.

392

01:02:28.740 --> 01:02:29.250

You're welcome.